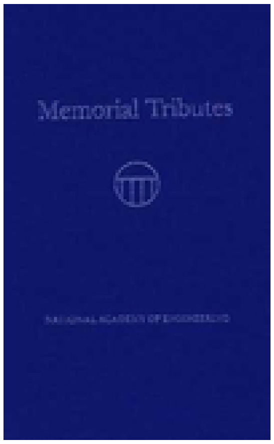

Memorial Tributes: National Academy of Engineering, Volume 1

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Memorial Tributes

NATIONAL ACADEMY OF ENGINEERING

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Memorial Tributes

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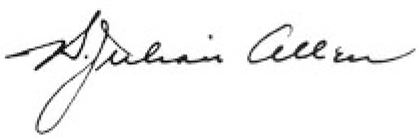
Foreword

This first volume of *Memorial Tributes* issued by the National Academy of Engineering covers the period from the beginning of the NAE in December 1964 through December 1978. It is the first edition of what is expected to be a series of such volumes to be published periodically honoring the deceased members and foreign associates of the Academy. Publication of this first volume of NAE *Memorial Tributes* contributes to the observance of the fifteenth anniversary of the founding of the NAE; this is considered especially fitting, as many of the distinguished engineers who are honored in this volume were associated with the Academy during its early formative years. It is intended that this and succeeding volumes will stand as an enduring record of the many contributions of engineering to the benefit of mankind. In each case, the authors of the tributes had a personal knowledge of the interests and engineering accomplishments of the deceased members and foreign associates.

The National Academy of Engineering is a private organization established in 1964 to share in the responsibility given the National Academy of Sciences under its Congressional Charter signed by President Lincoln in 1863 to examine and report on questions of science and engineering at the request of the federal government. Individuals are elected to the National Academy of Engineering on the basis of significant contributions to engineering theory and practice and to the literature of engineering or demonstrated unusual accomplishments in the pioneering of new and developing fields of technology.

HAROLD LIEBOWITZ
HOME SECRETARY

Memorial Tributes



Harry Julian Allen

1910-1977

By Nicholas J. Hoff

Harry Julian Allen, retired Director of the Ames Research Center of the National Aeronautics and Space Administration (NASA), died at the age of sixty-six in Stanford University Hospital on January 29, 1977. He had joined the research staff of Ames Research Laboratory of the National Advisory Committee for Aeronautics (NACA) at the time of its founding in 1940 and continued carrying out most original research there until his retirement, in 1969. It is not an exaggeration to state that no man has had as much influence on the work of this great research center as Harry Julian Allen.

Born on April 1, 1910, in Maywood, Illinois, "Harvey" Allen (as he was known to all his friends) received a Bachelor of Arts degree in engineering in 1932 and the professional degree of Aeronautical Engineer in 1935, both from Stanford University. The following year he was appointed to the staff of NACA'S Langley Memorial Aeronautical Laboratory near Hampton, Virginia (now NASA'S Langley Research Center), as a Junior Aeronautical Engineer. In 1940 he moved back to California as an Aeronautical Engineer at Ames Research Laboratory (now NASA'S Ames Research Center) at Moffett Field. From 1941 he was Chief of the Ames Theoretical Aerodynamics Branch, in 1945 he became Chief of the High-Speed Research Division, in 1959 he was promoted to Assistant Director for Astronautics, and from 1965 to 1969 he was Director of the Ames Research Center.

Harvey Allen was much honored for his professional accomplishments. He was a Fellow of the American Institute of Aeronautics and Astronautics, the Royal Aeronautical Society of Great Britain, the American Astronautical Society, and the Meteoritical Society. In 1966 he was elected a Member of the National Academy of Engineering. Among the honors he received were the Sylvanus Albert Reed Award of the Institute of the Aerospace Sciences (predecessor of the AIAA) in 1955, the Wright Brothers Lectureship of the same Institute in 1957, the Distinguished Service Medal of the NACA in 1957, the Airpower Trophy of the Air Force Association in 1958, the Medal for Exceptional Scientific Achievement of the NASA in 1965, and the Daniel Guggenheim Medal awarded by AIAA, ASME, and SAE in 1969.

Throughout his career, Harvey Allen combined the fundamental curiosity of the natural scientist with the practical thinking of the engineer. He devoted himself to the study of aerodynamics in the broadest sense and made original contributions to the theories of subsonic, transonic, supersonic and hypersonic flow. When after World War II the United States became interested in the construction of ballistic missiles, he began a study of reentry dynamics and thermodynamics, and of the effects of radiation and meteorite impact on space vehicles.

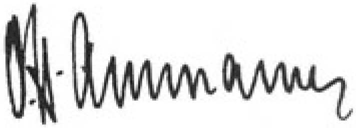
Among Harvey Allen's most original contributions to science and engineering was the development of the concept of the blunt nose for reentry vehicles. As is well known, the first ballistic missiles, both in the Soviet Union and the United States, were built with long nose cones having very small apex angles. They were designed to reenter the atmosphere at very high Mach numbers, and everyone knew that the drag of bodies traveling at hypersonic speeds is very high unless the body is thin and slender. With his typical combination of engineering common sense and superb scientific knowledge, Harvey Allen freed himself of this preconceived notion. He showed that the slender cone receives much more heat from the attached shock wave than the blunt body from its detached shock wave, even though the latter has the higher drag. But in the design of the early ballistic missiles the greatest worry of the designer was not drag, but the protection of the body from excessive aerodynamic heating, which can melt and burn the surface of the missile. Harvey Allen's blunt-body approach has been accepted as the solution of the problem all over the world; it has made possible such achievements as the flight of the Apollo to the moon.

Harvey Allen also found an ingenious new way of studying hypersonic aerodynamics when he observed the flight of meteorites. These objects are ballistic missiles of a nature that become visible when they begin to radiate light in consequence of aerodynamic heating following entry into the atmosphere of the earth. To obtain a correlation between astronomic observation and terrestrial work at Ames, Harvey Allen designed and built a most original piece of equipment. It consisted of a shock tunnel into which the model of a meteorite or of a reentry body could be shot upstream out of a gun. The superposition of the speeds of the airflow and of the specimen resulted in relative speeds as high as M = 45.

Aeronautics was Harvey Allen's lifework, but by no means his only interest. He was a fancier of old cars and owned at various times a Duesenberg, a Rolls-Royce, a Mercedes-Benz, an Isotta-Fraschine, and a Cadillac. He was also an accomplished archeologist and a great admirer of Far Eastern art. The house in which he lived alone in Palo Alto was a veritable museum containing beautiful furniture, statuary, and paintings from East Asia.

Harry Julian Allen's scientific and engineering achievements are best documented by his numerous publications, but his influence on aeronautical and astronautical development is much more far-reaching than the list would indicate. His successor as Director of Ames Research Center, Hans Mark, said that time and again when he talked to members of research groups in the laboratory he was told "Oh yes, Harvey started us out on this work ten or more years ago and we have been going strong ever since along the lines he had suggested."

This statement shows that the work of Harvey Allen, a very informal man revered by all his collaborators, has not reached its end yet. It will continue to produce useful results for many years after his death.



Othmar Hermann Ammann

1879-1965

By Thomas C. Kavanagh

Othmar Hermann Ammann, partner of the firm of Ammann & Whitney, Consulting Engineers, New York, and a Member of the National Academy of Engineering, died at his home in Rye, New York, on September 22, 1965, at the age of eighty-six. His passing brought to a close an active, sixty-three-year engineering career during which he came to be known as the "master bridge builder of our time."

Mr. Ammann was born on March 26, 1879, in Schaffhausen, Switzerland, where his family had been established since the twelfth century. His father had been a manufacturer; his forebears had been physicians, clergymen, lawyers, and government leaders. He studied at the Swiss Federal Institute of Technology, graduating in 1902 with the degree of Civil Engineer.

Following graduation he worked as a design engineer on reinforced concrete structures with a contracting firm in Frankfurt, Germany. In 1904 he came to the United States, where he undertook a design position with Joseph Mayer, a consulting engineer, which initiated his career-long involvement with bridges. He assisted Mayer in proposals for a cantilever railroad bridge to span the Hudson River at New York City. In 1905 he joined the Pennsylvania Steel Company, advancing from draftsman-designer to Assistant to the Chief Engineer, Frederick C. Kunz. He worked on the Queensboro Bridge across the East River in New York, and in 1908 he was retained to aid in the investigation of the collapse of the cantilever bridge across the St. Lawrence River at Quebec. From 1909 to 1912, Mr. Ammann worked for Frederick C. Kunz and C. C. Schneider in Philadelphia and designed an arch bridge over the St. John River in New Brunswick, Canada, as well as a plan for the construction of the Quebec Bridge. From 1912 to 1923 he was with Gustav Lindenthal, a famed bridge engineer, working on the design and construction of the record-breaking Hell Gate Bridge, with its three miles of approach via ducts.

Continuing his earlier interest in a span over the lower Hudson River, Mr. Ammann submitted proposals for a structure farther north between Fort Lee, New Jersey, and upper Manhattan, New York. In 1923 he established his own practice and saw the authorization by the two states of the bridge that is now the George Washington Bridge. Mr. Ammann was then named as the first Chief Bridge Engineer, and later Chief Engineer and Director of Engineering for the Port of New York Authority, which was authorized to finance and execute the project. The bridge was opened in 1931, with a center span of 3,500 feet. In 1962, a second deck, provisions for which were included in the original plans, was completed, increasing the bridge capacity from eight to fourteen lanes. This bridge always ranked as Mr. Ammann's favorite, even though it was not the largest of his projects.

In 1934 the Triborough Bridge Authority was established, and Mr. Ammann was named its Chief Engineer. Thus, in his capacities with both the Port Authority and the Triborough Bridge Authority, Mr. Ammann was also in charge of planning and construction of such additional projects as the Outerbridge Crossing and the Goethals Bridge across Arthur Kill; the arch bridge across Kill Van Kull at Bayonne, New Jersey; the Lincoln Tunnel under the Hudson River; the Triborough Bridge; and the Bronx-Whitestone Bridge.

Mr. Ammann retired in 1939 to open his own consulting office, acting as bridge consultant on a number of large projects. He entered into partnership with Charles S. Whitney in 1946 to form the firm of Ammann & Whitney, which has attained a staff of about 500. The firm was retained by the Triborough Bridge and Tunnel Authority and the Port Authority on a large arterial program that included the building of the Throgs Neck Bridge, the double-decking of the George Washington Bridge, and, finally the construction of the Verrazano-Narrows Bridge between Brooklyn and Staten Island, the last marking the culmination of Mr. Ammann's brilliant career. It opened in 1964 and had a span 760 feet (or 22 percent) greater than the George Washington Bridge, and 60 feet longer than the Golden Gate Bridge.

Mr. Ammann received many professional honors, including the following honorary degrees: Doctor of Technical Sciences from the Swiss Federal Institute of Technology, Doctor of Engineering from New York University, Master of Science from Yale University, Doctor of Engineering from Pennsylvania Military Academy, Doctor of Science from Columbia University, Doctor of Science from Brooklyn Polytechnic Institute, and Doctor of Science from Fordham University.

In 1965 Mr. Ammann received the National Medal of Science from President Johnson in a ceremony at the White House "in recognition of outstanding contributions to the engineering sciences." He also received the Port Authority's Howard S. Cullman Distinguished Service Medal and the first Award of Merit from the Institute of Consulting Engineers. He was elected to Honorary Membership in the American Society of Civil Engineers in 1953.

Mr. Ammann is survived by his wife, the former Klary Noetzli, and his three children, Werner, George Andrew, and Margot. He will be remembered by all who knew him for his personal attributes of gentle modesty and inspiring humility, which were in marked contrast to the mighty structures he built. He displayed a deep affection for his associates and a marked seriousness and enthusiasm for his work. His many technical contributions are characterized by a progressive approach to engineering principles and are matched by his awesome contributions to the aesthetics and beauty of large bridge structures.

Robert Alexander Bowman

1907-1977

By John R. Kiely

Robert Alexander Bowman died November 29, 1977, at Fort Collins, Colorado. He had retired from Bechtel as Senior Vice-President and Director in 1973, after more than four decades of distinguished engineering accomplishments in the fields of heat transfer and power generation. In particular, he had a leading role in the peaceful development of nuclear power.

Bob Bowman was born in Huntington, Indiana, on December 29, 1907. He attended high school in Rogers, Arkansas, and the College of Engineering at the University of Arkansas, where he received his Bachelor of Science degree in mechanical engineering in 1929. In his senior year he was president of Tau Beta Pi and the General Engineering Society.

Upon graduation, he joined the Westinghouse Research Laboratories in East Pittsburgh, where he conducted performance tests on experimental blowers and pumps with special emphasis on ventilation of electrical machinery. In 1931 he transferred to the South Philadelphia Works of Westinghouse, where he continued work on flow and heat transfer problems. In 1933 he was transferred to the heat transfer section, where he remained for fifteen years, becoming Manager of the Condenser Engineering Division in 1940. Through his later years, Bob was remembered and admired by a large number of engineering and operating personnel in the electric generating utilities as a man who had an innate instinct for analyzing and solving operating problems in heat transfer equipment and rotating machinery.

In 1948 Bob Bowman was called on to serve as the first Manager of Engineering of the Westinghouse Atomic Power Division at Bettis Field and commenced building the organization that developed the light water reactor technology for the Naval Reactors Program. This technology ultimately became the basic technology for the U.S. power reactor program and eventually established the light water reactor as the world standard. By the time Bob left Westinghouse three years later to join Bechtel, the first land-based prototype light water reactor was nearing completion at Arco, Idaho; the first ship-based unit was committed and under construction; and the Engineering Department was well established. In later years there were scores of technical people who had served under Bob at Bettis and had spread out through the whole nuclear industry and who looked upon Bob as a fine leader, teacher, mentor, and, above all, a friend.

Bob Bowman joined Bechtel in 1951 as Chief Mechanical Engineer of the Power and Industrial Division, in charge of mechanical engineering and station layout. In 1953 he became Manager of Division Engineering with responsibility for a wide range of nuclear and fossil fueled generating stations, and industrial and metallurgical plants. It was also in 1953 that Bechtel became involved in nuclear power work through a cooperative study of nuclear power with the Pacific Gas and Electric Company. This study led to the association with several other utilities in the Nuclear Power Group and, in turn, to the Dresden Nuclear Power Plant committed in 1955 and completed four and one-half years later.

In 1958 he was elected a corporate Vice-President and became Division Manager in 1966. The following year he was elected a Director and in 1971 was appointed a Senior Vice-President. By the time of his retirement, in 1973, Bob had been involved in the engineering and/or construction of over sixty nuclear power units and was considered one of the foremost experts in this field.

Bob Bowman was much honored for his professional accomplishments. He was a Fellow in the American Society of Me chanical Engineers and a Member Emeritus and Fellow of the American Nuclear Society. He was elected a Member of the National Academy of Engineering in 1970. Among the honors he received were the American Society of Mechanical Engineers' George Westinghouse Gold Medal for "distinguished service in the power field" and "leadership in the development of economic power generation stations" in 1965. In 1966 he was installed in the Hall of Fame in Engineering at the University of Arkansas and in 1969 also received that institution's highest honor, the Distinguished Alumnus Award.

Bob Bowman held five patents in the field of heat transfer and was described by one of his colleagues as "one of the most knowledgeable men in the country in the whole area of thermodynamics and power cycles. If anyone came up with a new way of doing something, it went to Bob. With his vast knowledge he could sense immediately if we were on the right track. A lot of the techniques we use today wouldn't have been possible without Bob."

Roger Emile Marie Brard

1907-1977

By Phillip Eisenberg

Roger Emile Marie Brard, elected in 1976 as a Foreign Associate of the National Academy of Engineering, died in Paris, France, on July 14, 1977. He was born in Pontivy, Morbihan, Brittany (France), on June 17, 1907. He attended the Ecole Polytechnique, Ecole Nationale Supérieure du Génie Maritime, and the University of Paris, where he received the degree of Doctor of Science (mathematics). Roger Brard was a most unusual man of many accomplishments, combining a career as a professional naval officer, attaining the rank of Ingénieur Général de l'Armement (Vice-Admiral) in the French Navy, with simultaneous scientific and engineering contributions of the highest caliber and recognition. He had a remarkable ability for the most complex research in the hydrodynamics of ships and propulsion and the ability for practical design and utilization of research results in design. He also made important contributions in pure and applied mathematics. For his contributions to science and engineering, he was elected to the illustrious French Academy of Sciences (Institut de France), which is limited to 100 of France's most eminent scientists. He received the very high honor of being elected President of that institution for the year 1972.

He served as Director of the Bassin d'Essais des Carènes (the Paris Ship Model Research Laboratory) from 1941 to 1969, the date of his retirement from active duty but a date marking the continuation of a very active period of theoretical research in ship hydrodynamics. During his career, he served some six years in the naval shipyard in Brest in charge of the construction and repair of cruisers. His naval assignments included management of nuclear propulsion research as well. He held the post of Professor of Ship Dynamics at the Ecole du Génie Maritime and succeeded to the position of Director of that important institute from 1958 to 1962. He had also been Professor of Applied Mathematics at the Ecole Polytechnique, and, in the years since 1969, was Professor at the University of Nantes, where he established the first program in naval hydrodynamics. He was a Visiting Professor of Naval Architecture at the University of Michigan on several occasions and lectured extensively in American universities, where he was greatly in demand.

In the world of mathematics, his contributions to probability theory and random function theory are well known. Recognition of his reputation in mathematics is reflected in his election to the presidency of the Societé Mathématique de France in 1950.

His research in naval architecture and ship hydrodynamics dated back to 1930, when he published his first paper on the problem of determining the ship hull surface to assigned properties. His work on marine propeller theory forms the basis for the design of all French naval ship propellers. His methods were used in the design of the propellers for the ships *Dunkerque, Strasbourg, Richelieu,* and *Jean Bart*. He was responsible for the design of the propellers on the liners *Normandle, Flandre, Antilles,* and *France*. Dr. Brard was personally responsible for the design of a number of French combatant vessels, as well as liners. The best known of the latter was, of course, the *France*.

He made important contributions to ship wave theory; the physics of rolling of ships and ship motions in general; maneuverability; rudderhull interactions; and movement of ships in restricted waters-subjects that have very important bearing on modern problems of the control of ships. His work on stability of submarines is well known in the United States; he was responsible for the development of the theory and usage of the rotating arm as an important early facility for measurements of hydrodynamic coefficients of submarines and surface ship models. In recent years, he was concerned mostly with research on wave-making and viscous resistance and methods for better extrapolations of model results to full scale.

Roger Brard was an active member and contributor to the professional societies and journals of a number of the maritime nations and the recipient of many honors for his contributions. In the United States, among other honors, he was awarded the David Taylor Gold Medal of the Society of Naval Architects and Marine Engineers, the first foreign member to receive this high recognition.

When all of his activities are added together-his naval career in ship construction and repair, nuclear installations, weaponry, hull and propeller design, research and development; his career as an educator and mathematician; his innovations in ship and submarine design; his experimental contributions and development of ship research laboratory facilities such as the rotating arm; and his many scientific contributions in theoretical ship hydrodynamics-he came as close to being a Renaissance man as one can find in this day and age.

Roger Brard was very proud of his associations in this country. His many friends will miss his keen insight into technical questions and his good-natured discussions of philosophical and linguistic peculiarities. He took great delight in understanding and comparing the ethnic humor of his colleagues around the world and always brought warmth and importance to any gathering. He will be sorely missed.

Thomas Hamilton Chilton

1899-1972

By George E. Holbrook

Thomas Hamilton Chilton was born in Greensboro, Alabama, on August 14, 1899; he suffered a heart attack and died in Bonn, West Germany, on September 15, 1972. Tom Chilton grew up in Montgomery, Alabama, an area famous for Chilton County peaches. His grandfather, William Parish Chilton, was a member of the Congress of the Confederacy and Chief Justice of the Alabama Supreme Court. The Reverend Claudius L. Chilton, Tom's father, was a Methodist minister, as well as a writer and a poet. His mother, Mabel Pierce Chilton, conducted a school for young children, including her own.

Thomas Chilton, the next to the youngest of ten children, had six brothers and three sisters. His mother died when he was eleven years old, and his sisters then cared for the family. He was very close to his family and during his life maintained close touch with his brothers, sisters, nephews, nieces, and cousins. This led to his fond interest in genealogy. He even compiled a detailed record of the 400 direct descendants of his grandfather, William P. Chilton.

Tom's early education began in Montgomery at Starke's University School. During these early school days he worked in a printing shop-the Paragon Press in Montgomery-with his older brothers. Setting type by hand whetted his interest in printing and sharpened his eye for detail and accuracy. In later years his associates came to know and respect his penchant for exactness and detail, especially in written reports.

Tom Chilton's interest in chemical engineering began when, as a senior at Lanier High School in Montgomery, he heard an employee of Thomas Edison explain the process of making synthetic phonograph records. Chilton attended the University of Alabama, but after two semesters he suspended his education for a year to earn his tuition. When he returned to college, in 1917, he went to New York City and matriculated at Columbia University. He graduated from Columbia in 1922 with the degree of Chemical Engineer.

Tom Chilton often said he entered chemical engineering during a productive period when the field was first being recognized as a very important profession. From the start of his long and successful career, he was involved in research and development. His first employment was as a research chemist with F. J. Carman in New York, where he worked in process development research on the chemical utilization of natural gas. It was with Carman that he received his first patent-a method of producing acetylene from methane.

He came to Wilmington on May 26, 1925, as a chemist in the Du Pont Company's Chemical Department. Assigned to Du Pont's Experimental Station, the company's headquarters for research and development activities, he engaged in studies of ammonia oxidation and sulfuric acid process development until mid-1929, when he was appointed chemical engineer in charge of Chemical Engineering Research.

Tom Chilton's group spearheaded Du Pont's early fundamental research in chemical engineering. Areas of responsibility included fluid flow, heat transfer, distillation, adsorption, and absorption. Many far-reaching engineering correlations and formulas were developed under his guidance. Also, he won wide esteem for his original work and publications in chemical engineering unit operations.

In 1931 a Technical Division was formed in the Du Pont Engineering Department to incorporate work on metallurgy and corrosion and to undertake research programs in the more mechanical aspects of chemical engineering operations. These included filtration, grinding, and agitation and mixing. Chilton's group worked closely with this Division on many company projects.

By 1935 the closely related scope of work of the Chemical Engineering Group and the Technical Division afforded an opportunity to merge them into a single group-the Technical Division-in the Engineering Department. Henry B. du Pont, a great-grandson of the founder of the company, was named Division Head and Thomas Chilton was Assistant Division Head. In 1938 Chilton succeeded du Pont as Technical Division Head.

During the seven years that followed this promotion, Tom Chilton was responsible for many significant strides in the Du Pont Company's progress:

- Analysis of extensive large-scale laboratory tests of the dynamic flow on distillation column plates led to design of more effective distillation columns for acetic acid recovery.
- Important advances were made in the fields of spray-drying, filtration, and pneumatic conveying dryers.
- In the field of materials of construction, notable progress was made in understanding the behavior of stainless steels. The usefulness of then new varieties of stainless steels-the extra-low carbon grades-was demonstrated.
- Procedures for fabricating alloy tubing were established and techniques for welding it were developed.
- The corrosion behavior of titanium metal-especially its superior resistance to sea water and wet chlorine gas-was demonstrated through laboratory research. Also titanium was found to be resistant to nitric acid at elevated temperature and pressure, surpassing the resistance of stainless steels then available.
- In the field of applied physics, reliable methods were developed for on-plant continuous analysis of process streams by means of physical measurements.
- Concerning optics and the quantitative measurement of color, a differential colorimeter was developed for precise measurement of small differences between samples and standards. The device gained wide use in company plants and laboratories where exact color-matching was required.

From 1937 to 1941 Tom Chilton gained his first experience as a university lecturer. He made many visits to his alma mater, Columbia University, where he lectured to Chemical Engineering Department students and engineers from industry. In 1943 the University of Delaware conferred upon him the honorary degree of Doctor of Science in recognition of his achievement as a researcher and administrator.

During World War II Dr. Chilton was involved with the Manhattan District Project. He contributed personally to the solution of unusual and difficult technical problems of heat transfer and fluid flow for the original design of an atomic energy plant, the Hanford Engineer Works in Richland, Washington. For this work he received in 1948 the President's Certificate of Merit for service to the National Defense Research Committee. The certificate recognized Dr. Chilton's specific endeavors in the field of the production and use of oxygen.

Dr. Chilton was among a select group of scientists and engineers who witnessed the first self-sustaining nuclear reaction under the west grandstand of the University of Chicago's Stagg Field on December 2, 1942. Enrico Fermi, the great Italian physicist, headed this historic birth of the atomic age.

In 1945 Dr. Chilton was designated Manager and later Technical Director of Du Pont's Development Engineering Division (DED). This Division carried out all research and development for the Engineering Department. His work in the Technical Division and DED included the development of widely applicable design data for chemical processing and the development of equipment for mechanical processing of chemical products.

Dr. Chilton's eminence in the field of chemical engineering and his devotion to the profession were officially recognized when he was elected Vice-President of the American Institute of Chemical Engineers (AIChE) in 1950. He became President of AIChE in 1951.

By this time Dr. Chilton had become widely recognized outside the company for his achievements. In 1939 he received Columbia University's seventeenth Charles Frederick Chandler Medal for "his outstanding achievements in the discovery and formulation of principles underlying the unit operations of chemical engineering and in the application of these principles to process development, equipment design and chemical plant construction and operation." Four years later he was honored again by Columbia as a recipient of the Egleston Medal of the Columbia Engineering School's Alumni Association.

In 1950, Columbia University President Dwight D. Eisenhower presented Dr. Chilton the University Medal for Excellence. He was the fourth national figure to receive this honor. He was cited for "outstanding achievements in chemical engineering research." In the early fifties, Dr. Chilton became an important figure in the development of the Savannah River Plant project. The largest Atomic Energy Commission plant ever built, the project was designed and built by Du Pont between 1950 and 1955.

It was during the fifties that Dr. Chilton's wanderlust began to take hold. As president of AIChE and later the Engineers Joint Council, he made numerous talks to professional societies and student groups. His lecturing and public presentations became important facets in fulfilling his career.

Dr. Chilton's ability as a public speaker was commensurate with his technical competence. He could hold the attention of an audience wherever he went. He was the example of sincerity and devotion to the chemical engineering profession. He told hundreds of audiences: "Chemical engineering is only one 'unit' in the engineering profession which has as its unifying bond the application of principles of the physical sciences in construction and manufacturing enterprises.... We can work as individuals, and as members of progressively larger 'units' for that better day when not only communities and states but nations will be united effectively in combatting disease and infirmity, poverty, and ignorance, prejudice and intolerance and war."

Until his early voluntary retirement from Du Pont in 1959, he continued to be vitally involved in research and development work. Also his output of technical articles never faltered. His work included the development of widely applicable design data for chemical processing and development of equipment for mechanical processing of chemical products.

Following his retirement, in 1959, he moved to the University of California at Berkeley as a Regents' Professor. His pace on the university scene was perhaps the most ambitious of his entire career. But there could be no doubt that he had made the right decision. Academic work proved to be a continual source of fulfillment and satisfaction for him.

In 1960 he went to Japan and the University of Kyoto and Nagoya University where he was a Fulbright Lecturer. During the summer of 1961 he was Visiting Professor at the University of New South Wales, Kensington, Australia. The 1961-62 year found him in France as a Fulbright Lecturer. His fluent French impressed all who heard him at the universities of Nancy and Toulouse. He was Visiting Professor of Chemical Engineering at Georgia Tech in 1962 and came home to the University of Delaware in 1963-64.

The Chiltons often returned to "Mitylene," their Country home near Hockessin, Delaware. "Mitylene" was named for a small town in Alabama, where Dr. Chilton's wife, Cherridah McLemore, had been raised. The Chiltons enjoyed the company of their friends and hosted many social affairs at "Mitylene." Most popular were those parties having cultural themes.

A biographical account of Thomas Chilton would be incomplete if it did not mention the "Chilton comma." He was very particular about punctuation and couldn't resist inserting commas in a series when one was missing. At his retirement from Du Pont his fellow employees presented him a book containing no punctuation whatsoever. In the back of the book was a page of periods, commas, colons, semicolons, and other punctuation marks along with an invitation for Dr. Chilton to insert them at his discretion.

Chilton's hobbies included photography-he prized his collection of slides from many lands-and classical music. But his main hobby interest was his collection of auto license plates. He was a founder of the Auto License Plate Collectors of America and his famous collection contained license plates from all over the world. He was once introduced at a lecture as the only man in the world with 45 lines in *Who's Who* and 4,500 license plates in his garage.

After his assignment at the University of Delaware, Dr. Chilton went south to the University of Virginia, where he was Visiting Professor of Chemical Engineering during 1965-66. Subsequent tours were to the Birla Institute of Technology, Pilani, India, in 1967 and the University of Washington, Seattle, in 1968. He lectured at the University of Alabama in 1969, where more than a half-century before he had embarked on his chemical engineering career. The 1969-70 year was divided between the University of Massachusetts and the University of Puerto Rico.

He joined the Chemical Engineering Department at the University of Natal, Durban, Natal, South Africa, in 1970. He was Visiting Lecturer at the University of South Carolina in 1971.

While Dr. Chilton was in Tuscaloosa, Alabama, in 1969 his wife of forty-six years died suddenly of a heart attack. The loss of Cherridah greatly affected Dr. Chilton's adventuresome spirit, and he planned to end his academic travels after his stay at South Carolina.

On January 2, 1971, Dr. Chilton married Elizabeth C. Rinehart. She and her deceased husband, H. Wade Rinehart, had been close friends of the Chiltons for nearly forty-five years. After a successful visiting professorship at South Carolina, Dr. Chilton and Elizabeth retired to their home in Cragmere in Wilmington. However, "retirement" to Tom Chilton meant continued activity with AIChE, the Engineers Joint Council, and even professional and Governmental consulting work.

In September 1972 the Chiltons went to Paris, where Dr. Chilton spoke on "The Abatement of Pollution of the Atmosphere from Stationary Combustion Sources." He made the presentation on September 5 on the occasion of the 116th Event of the European Federation of Chemical Engineering, sponsored by the French Society of Chemical Industry. Its theme was Chemical Engineering in the Service of Mankind.

Two weeks later, on September 15, while visiting a stepdaughter in Bonn, West Germany, Dr. Chilton suffered his fatal heart attack.

During his seventy-three years Thomas Hamilton Chilton earned the respect and professional recognition that many men strive for but few achieve. He was an inspiration to his colleagues and the many young engineers he came in contact with during his extensive tours. He was a model of ethics to the profession. His dedication to chemical engineering is unparalleled. Above all, Thomas Hamilton Chilton was a gentleman, a scholar, and a humanist. For all these things he will long be remembered.

Edward Nicholas Cole

1909-1977

By Elliott M. Estes

Edward N. Cole, retired President of General Motors Corporation, died at the controls of his private plane in a crash near Kalamazoo, Michigan, on May 2, 1977. Flying alone in bad weather, he was enroute to Checker Motor Corporation, where he was redesigning the company's taxi cabs with the same enthusiasm and innovative spirit that marked his forty-four year career at GM.

At the time of his death at age sixty-seven, Ed Cole was Chairman and Chief Executive of Checker Motor Corporation and Chairman of International Husky, Inc., an air-freight venture he had headed since his retirement from GM in 1974.

To the end, Ed Cole never lost his insatiable appetite for anything mechanical, his enthusiasm for challenge, his constant search for new ideas-better ways of doing things, or his ability to "sell" a pet project with missionary persuasiveness.

Before his death, he was seeking to raise additional capital to launch at International Husky, Inc., an innovative air-freight system using seventy-five jumbo jets, a nationwide network of automated terminals, and computers to control flights and cargo loads.

Ed Cole was born September 17, 1909, at Marne, a small town in southwestern Michigan, about fifty miles north of the field where his twin-engine plane nosed in. A farm boy, he worked hard at chores. Milking cows and delivering fresh milk to community residents was a major job during high school days. During winters, with his growing interest in motors and electricity, he built and sold radios. In the summers, he sold Fordson tractors by giving farmers in-the-field demonstrations. He also rebuilt two old cars, becoming at age sixteen one of Marne's rare two-car owners.

Originally, Ed Cole wanted to be a lawyer and attended Grand Rapids Junior College. But one summer he took a job with an automobile supply company and got his first taste of what the industry was like. This led him to enroll in General Motors Institute (GMI) in 1930, a co-op school where he was sponsored by GM'S Cadillac Division.

Because of his talent, he was taken from GMI before graduation and assigned to a special Cadillac engineering project. He advanced through several jobs at Cadillac and in 1943 became Chief Design Engineer responsible for U.S. Army light tanks and combat vehicles. With the war over, Cadillac returned to civilian production, and Ed Cole was promoted to Chief Engineer in 1946 and Works Manager in 1950. With the outbreak of the Korean conflict, he was named manager of the Cleveland tank plant, and he got it into production three months ahead of schedule.

Throughout his life, associates marveled at how fast the energetic Ed Cole worked. "Whatever he's doing, he's a man in a hurry," said one. "Ed has just one speed," said another, "full throttle." His desire to speed up the action was clearly demonstrated when he visited the new Chevrolet Engineering Center in 1956. Noticing the new escalators in the building, he had their speed increased about thirty percent. "No sense in wasting people's time when they're riding," Cole said.

Promoted to Chief Engineer at Chevrolet in 1952, by the summer of 1956 Cole had been promoted again-to be Chevrolet General Manager and a Vice-President of GM. in 1961, he was elected to the GM Board of Directors and named a corporate Group Vice-President. In 1965 he became an Executive Vice-President, and by the time of his retirement, seven years later, he was Chairman of the Corporation's Administration and Executive Committees and served on a third policymaking body, the Finance Committee.

When he retired from GM, Ed Cole held eighteen separate patents and was widely recognized as one of the industry's most brilliant and innovative leaders. Even from the President's office on the Fourteenth floor of the GM Building, he took an active, personal role in GM'S products and its engineering. "I like to stay close to the hardware," he once explained. "That's where the action is."

Ed Cole was associated with many of the industry's most important projects while he was at GM. Not all of them were successful, but none lacked daring and imagination. Among his most important "credits" were:

- A major role in the development of the Cadillac short-stroke V8 engine.
- The moving force behind the innovative, rear-engined, air-cooled Corvair.
- A hand in the development of the Corvette sports car.
- A prime mover behind the Air Cushion Restraint System.
- A major proponent of the Rotary or Wankel engine.
- A major role in the development of the catalytic converter to control exhaust emissions.

It is this last development which automotive history will likely deem the most important. Trusting Ed Cole's vision and courage, GM took the lead in 1970 in lowering engine compression ratios and designing for unleaded gasoline to be ready for the day when catalytic converters would be used to control automotive pollution. Many in and outside the industry and more than a few within GM doubted that day would ever come. But it did when the 1975 models were introduced, enabling manufacturers to reduce emissions and improve gas mileage at the same time.

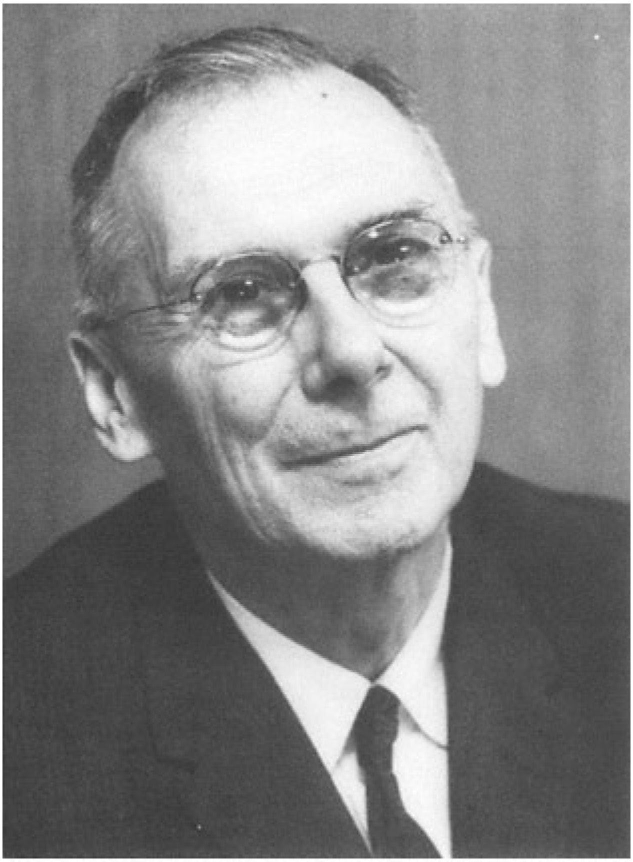
Today, more sophisticated catalytic systems are being developed to reduce emissions even further without serious losses in fuel economy. If Ed Cole needed a monument-which he doesn't-I couldn't think of a better one than this important new technology.

Ed Cole was a member of many professional, business, and charitable organizations. He was a Member of the Society of Automotive Engineers, Engineering Society of Detroit, the Detroit Board of Commerce, and the Economic Club of Detroit. He was active in the National Academy of Engineering, serving as a

Member and then Chairman of the NAE Finance Committee; on the National Research Council Assembly of Engineering Executive Committee in 1974-75; and as NAE Treasurer and a Member of both the NAE Council and Executive Committee from 1974 until his death.

Ed Cole did contribute a great deal to the auto industry and to the communities in which he lived. Among the things he left behind was a motto that summed up his attitude about innovation and the need to change. It will serve other unordinary, uniquely gifted people who follow him as well as it did Ed.

"If we find a better way," he said, "let's kick hell out of the status quo. The fact 'we have always done it this way' is the best reason I know to take a particularly close look at a system or procedure."




Hugh L Dryden

Hugh Latimer Dryden

1898-1965

By Jerome C. Hunsaker and Robert C. Seamans, Jr.

Hugh Latimer Dryden was born in Pocomoke City, Maryland, on July 2, 1898, and died on December 2, 1965, after a lengthy illness.

Hugh Dryden's father taught school and later kept a general store. This business failed in the panic of 1907 and the family moved to Baltimore, where the father became a street car conductor, following this occupation for the rest of his life. Young Hugh attended public schools and a high school, then called Baltimore College, graduating in 1913 just short of age fifteen.

Entering Johns Hopkins University with advanced standing, he completed a regular Bachelor of Arts curriculum in three years, receiving his degree with honors in 1916 and his Master of Arts degree in 1918.

It is of interest to observe that Dryden did not come from a scholarly family. But he was endowed with the highest order of intelligence; brought this gift to the realms of physics, engineering, and Government service; and developed a vigorous philosophy supported by strong Christian principles.

He married Mary Libbie Travers, on January 29, 1920, and their three children were highly educated. The son, Hugh, Jr., an organic chemist, graduated from Johns Hopkins and the Massachusetts Institute of Technology. The elder daughter, Mary Ruth Van Tuyl, graduated from Goucher College and is married to a mathematician at the Naval Ordnance Laboratory. Daughter

Nancy Travers graduated from American University and teaches school in Montgomery County, Maryland. There are five grandchildren.

In June 1918, Hugh Dryden joined the staff of the National Bureau of Standards as an inspector of munitions gauges, intending to return to graduate school on a fellowship in the fall. However, because of World War I and with the encouragement of Dr. Joseph S. Ames, Head of the Johns Hopkins Physics Department and Chairman of the National Advisory Committee for Aeronautics, his plans were changed. He obtained a transfer into the Bureau's newly formed Wind Tunnel Section. After Dr. Ames arranged to give courses to a number of Hopkins graduate students at the Bureau, Dryden was able to complete his thesis work on experiments carried on after hours in the wind tunnel. He was granted the Ph.D. in physics in 1919, when he was just under twenty-one, the youngest student ever to obtain a Ph.D. at Johns Hopkins. His thesis, entitled "Air Forces on Circular Cylinders," addressed itself to the fundamental problem of scale effects on the flow over circular cylinders normal to the wind. His results stimulated some of the more sophisticated inquiries into the same subject in the decade which followed.

In 1920, Dr. Dryden was placed in charge of the wind tunnels. Here his research on the problems of wind tunnel turbulence and boundary-layer flow brought him international recognition. He and his colleagues were first interested in accurately measuring turbulence in wind tunnels and in understanding its effects on force measurements. They devised an electrical network that restored the loss in amplitude and compensated for the lag. Extensive tests were made of the intensity and scale of turbulence produced by the wire screens at various distances from the working station. Having means for varying the intensity and scale of the turbulence, and for measuring these quantities with a compensated hot wire anemometer, Dr. Dryden built wind tunnels of very low turbulence and measured on models the effect of turbulence on aerodynamic forces. The theoretical equations of laminar flow within a boundary layer had been previously announced by Prandtl in 1907. Dr. Dryden and his collaborators were able experimentally to verify Prandtl's theories.

In collaboration with Dr. Lyman J. Briggs, Dr. Dryden made some of the earliest experimental measurements of the aerodynamic characteristics of airfoils at high speeds. The early motivation for this work had its origin in the effects of the high propeller tip velocities that were being encountered with high-powered engines. Dryden and Briggs carried out these investigations at a large compressor plant at the Edgewood Arsenal. Through this work, they furnished the propeller designer with airfoil data at high speeds and developed early insight into the effects of compressibility on lift coefficient and pressure distribution. They were among the first to observe experimentally the so-called transonic drag rise. Interest generated by this work led to the construction of many high-speed wind tunnels and was of pioneering significance when jet and rocket propulsion made supersonic and hypersonic flight feasible.

Although Dr. Dryden's career at the Bureau of Standards is characterized largely by his work in turbulence and boundary-layer research, his inquiring mind led him to grapple with other engineering problems with many different collaborators. His investigations of wind pressures on chimneys, mill buildings, and skyscrapers laid the basis for rational design of structures subjected to wind loads. His principal collaborator in this field was G. C. Hill. The motivation for this work was undoubtedly the strong concern during the early 1930's for the structural integrity of propeller blades under increasing speeds and disc loadings.

A summary of Dr. Dryden's scientific and engineering research would be incomplete without mention of his interest in the measurement of the acceleration due to gravity. This work took place during 1942 and 1943. This investigation, done in collaboration with E. A. Eckhardt, W. D. Lambert, and A. H. Miller, undertook to study the various determinations of the absolute value of the acceleration due to gravity and to recommend a "best value." The results indicated that only three determinations had been made with sufficient attention to the elimination of systematic error to merit consideration.

Dr. Dryden was responsible for extensive studies of the aerodynamics of aircraft bombs and for the development of a practical method of designing the tail fins to ensure aerodynamic stability. With E. J. Lorin, he standardized a form of bomb geometry that remained in use for many years. His less-known contributions ranged over aircraft noise, ventilating fans, aerodynamic design of aircraft control surfaces, automobile streamlining, and aerodynamic cooling.

As time passed, Hugh Dryden's management responsibilities at the Bureau of Standards grew, and he found less time for his own research. In 1934 he became Chief of the Mechanics and Sound Division. With the establishment of the National Defense Research Committee and later the Office of Scientific Research and Development in the early 1940's, he became Chief of a section developing a guided glide bomb. This section, located at the Bureau of Standards, was later expanded into the Navy Bureau of Ordnance Experimental Unit, with a staff of civilians from the Bureau of Standards and the Massachusetts Institute of Technology, as well as officers and men of the U.S. Navy. The radar homing missile, BAT, which saw service in combat in the Pacific, was designed by this team. The BAT missile destroyed many tons of Japanese shipping during the last year of the war. Fleet Air Wing One, under Rear Admiral John D. Price, used the BAT effectively against both ships and land targets. This was Dr. Dryden's first taste of the management of large projects with which he would have so much to do later.

Hugh Dryden once described his wartime service:

> I headed an unusual group at the Bureau of Ordinance Experimental Unit which developed the radar homing missile, BAT. I also served as Deputy Director of the Army Air Force's Scientific Advisory Group headed by von Karman. The group was appointed by General H. H. Arnold and many of us were in Europe on V-E day in uniform with simulated rank to study the use of science by the various European countries. *Towards New Horizons*, the series of reports by the von Karman group, proved invaluable in future years.

In September 1947, Dr. Dryden transferred from the National Bureau of Standards to become Director of Research of the National Advisory Committee for Aeronautics (NACA). In 1949, he became Director of NACA, its senior full-time officer. He directed from Washington the activities of the Langley, Lewis, and Ames laboratories and the flight research stations at Edwards Air Force Base, California, and Wallops Island, Virginia. The magnitude of this responsibility grew to embrace, during the last year of NACA'S existence, 8,000 employees and an annual budget of about $100 million. Under his leadership, NACA produced a vast body of new knowledge that made possible routine supersonic flight and laid much of the technological groundwork for space flight that was to come. We discern here, perhaps as much as in any other place, the impact of Dryden's leadership. The development of high-speed wind tunnels, flight testing, and a companion competence for theoretical research within the NACA contributed substantially to the leadership of the United States in supersonic flight.

In 1954, Dr. Dryden became the Chairman of the Air Force and Navy and NACA Research Airplane Committee formed to guide the development of an airplane to explore the problems of flight at the highest speeds and altitudes then feasible. The series of experimental aircraft, beginning with the X-1, X-2, X-3, D-558, and culminating with the X-15, are well known. Some of these aircraft were developed and tested prior to 1954; however, the hypersonic research airplane, the X-15, drawing on the previous flight experience, was from its conception the concern of this Committee. Before he died, Dr. Dryden saw the X-15 reach a maximum speed in excess of 4,000 miles per hour and an altitude of nearly seventy miles. It had been he who had carried the X-15 program through the political labyrinth of Washington, where funds for basic research and development were not plentiful. Much of this technology of manned flight came to bear in Project Mercury.

It was during this period that Dr. Dryden pressed for a solution to the critical reentry heating problem. This solution, based on knowledge accumulated in research, made it possible for the United States to proceed with assurance in the development of its ICBM program and manned satellites.

Hugh Dryden sustained a continuous interest in applied mechanics. He served as President of the International Union of Theoretical and Applied Mechanics and as a Member of the International Committee for the International Congress of Applied Mechanics. He took an active role in the organization of the Sixth International Congress for Applied Mechanics in Paris in 1946 and again at the Seventh International Congress in Istanbul in 1952. Together with von Karman, he was an editor of *Applied Mechanics Reviews*.

The final period in Hugh Dryden's life commenced dramatically in October 1957, with the launching of Sputnik I. The Executive Branch and the Congress prepared immediately to establish a civilian agency to conduct explorations of space for peaceful purposes. With Dr. Dryden's help at critical moments, the NACA was selected as the central building block of the new agency, and he participated in the drafting of the legislation and its defense before the Congress. On August 8, 1955, President Eisenhower appointed Dr. Dryden as Deputy Administrator of the new agency, a position he held under three Presidents until his death.

Project Mercury was conceived and organized with Hugh Dryden playing a major role. Later, he participated in the important planning for Gemini and Apollo. His hand was prominent in the studies and recommendations that led to the decision to mount a lunar exploration mission. He was clearly committed to the Apollo mission. This commitment was demonstrated in a notable letter dated June 22, 1961, to the late Senator Robert S. Kerr, then Chairman of the Senate Committee on Aeronautical and Space Sciences. Dr. Dryden said in part:

> The setting of the difficult goal of landing a man on the moon and return to Earth has the highly important role of accelerating the development of space science and technology, motivating the scientists and engineers who are engaged in this effort to move forward with urgency, and integrating their efforts in a way that cannot be accomplished by a disconnected series of research investigations in the several fields. It is important to realize, however, that the real value and purposes are not in the mere accomplishment of man setting foot on the moon, but rather in the great cooperative national effort in the development of science and technology which is stimulated by this goal....
>
> The national enterprise involved in the goal of manned lunar landing and return within the decade is an activity with critical impact on the future of this nation as an industrial and military power, and as a leader of a free world.

Had Senator Kerr heard the Wilbur Wright Lecture of 1949, he would have perceived a remarkable thread of uniformity in Dr. Dryden's approach to widely separated problems; a thread that dominated his thinking and will most certainly dominate national planning in science and technology for years to come.

As Director of the National Advisory Committee for Aeronautics for ten years, Dr. Dryden had great success in leading scientific and engineering research into important technical applications. When NACA was abolished in 1958 and the National Aeronautics and Space Administration (NASA) was set up by the Congress in response to Sputnik, Dr. Dryden was proposed by senior NACA members to be the Administrator of the new agency. This recommendation was seriously considered by the White House. However, his professional integrity may have antagonized members of the House Select Space Committee when he objected to an untested crash program to put a man on top of a missile in a sub-orbital space flight for propaganda purposes. He said this would have no more value "than shooting a woman out of a cannon at a circus."

The first NASA Administrator, President T. Keith Glennan of Case Institute, insisted that Dr. Dryden be Deputy Administrator and overseer of all scientific and technical aspects of space research.

Dr. Dryden felt a special responsibility for the 8,000 civil service people of NACA who were to be taken over by NASA. These people had been led, supported, chastised or promoted and, in many instances, recruited by Dr. Dryden. Also he carried over to NASA a most cordial and constructive relation with the military services, Government regulating bodies, the universities, the air transport and manufacturing industries, and professional societies and research establishments. These were to prove invaluable to the U.S. space program.

Dr. Dryden's public reputation permitted him to accept, in 1960, the difficult task of providing for the United States an interim "cover story" for the U-2 incident. The U-2 was a high-flying airplane used for photographic weather observations but that could be used for other reconnaissance. In providing the public explanation that the U-2 shot down over the Soviet Union had been involved in scientific exploration, Dr. Dryden placed the importance of affording to the United States a short respite in which to organize its policy response to this new development above the opinions of his personal integrity that might later result from the inevitable disclosure of the U-2's real mission.

Dr. Dryden's leadership capability itself was questioned in the report to President-Elect John F. Kennedy, dated January 12, 1961, by an ad hoc Advisory Committee on Space headed by Dr. Jerome Wiesner. This Committee found "a number of organizational and management deficiencies as well as problems of staffing and direction which should receive prompt attention. These include serious problems within NASA, within the military establishment, and at the executive and other policy-making levels of government."

The Wiesner Committee recommended for NASA several "requirements that must be met." These were, in fact, outstanding features of Dr. Dryden's leadership. As Home Secretary, Dr. Dryden had close relations with the National Academy of Sciences and in particular with the Space Science Board that was established within the Academy to advise and assist NASA. "Exert the greatest wisdom and foresight in the selection of scientific missions and of the scientists assigned." This was one of Hugh Dryden's main concerns within the policy and budget limitations of the President and Congress as the new NASA program gained direction and momentum.

The Wiesner Committee's report to President Kennedy, released to the press, did Dr. Dryden no harm. Probably it helped clear the air by requiring the new Administration to assess fully the space effort under way. When James E. Webb was asked by the White House to be the second NASA Administrator, he accepted upon the condition that Hugh Dryden remain as Deputy Administrator.

Dr. Dryden had a leading role in the sphere of international cooperation. In 1959, he was appointed to assist Ambassador Henry Cabot Lodge at the first meeting of the United Nations Committee on the Peaceful Uses of Outer Space. His activities were largely responsible for a proposal by NASA in December of that year, for joint research with other nations to promote international space cooperation.

Working toward international cooperation and peace fitted with Dr. Dryden's philosophy. A man of sincere religious faith, he was a licensed preacher for the Calvary Methodist Church in Washington during most of his adult life. He had found the bridge between science and religion.

Hugh Dryden lived under a sentence of death after October 1961, when exploratory surgery had disclosed a serious malignancy. Yet he continued on duty with frequent hospital treatments. He conceded little to the illness that marked the last years of his life.

In the last month of his life, he delivered the Thurston Lecture before the American Society of Mechanical Engineers. He pointed out that men were engineers for thousands of years before the basic concepts of science were known. Engineers now follow the scientists' step-by-step approach to develop the technology from which real benefits arise. But Dryden had a keen sense of social responsibility in planning engineering programs. He made the difficult choice among the many possibilities available to change the state of the art. In his Thurston Lecture he explained that the space program was already having an impact on engineering from new requirements in weight, size, performance, and reliability under extreme environmental conditions.

President Lyndon B. Johnson expressed the esteem of the Nation for Hugh Dryden when he said:

> No soldier ever performed his duty with more bravery and no statesman ever charted new courses with more dedication than Hugh Dryden. Whenever the first American space man sets foot on the moon or finds a new trail to a new star, he will know that Hugh Dryden was one of those who gave him knowledge and illumination.

After Dr. Dryden's transfer to the NACA in 1947, he assumed leadership in the fundamental research effort in the field in which he had made basic contributions twenty-five years before. It is fair to state that Dryden's 1920 work on supersonic aerodynamics led consistently to operational supersonic airplanes, the famous rocket-propelled X-15, and successful manned space flight. On February 10, 1966, the President of the United States presented to Mrs. Dryden the National Medal of Science awarded posthumously to Dr. Dryden: "For contributions, as an engineer, administrator, and civil servant for one-half century, to aeronautics and astronautics which have immeasurably supported the Nation's preeminence in space.

Man's steps in the advance of the art of flight are marked by the names of many researchers, designers, and flyers, but Hugh Dryden's name is rarely mentioned.

Hugh L. Dryden's life was given to helping good men get good results.

Gordon Maskew Fair

1894-1970

By Abel Wolman

Following a successful engineering career, Gordon Maskew Fair, who was born on July 27, 1894, in Burghersdorp, Union of South Africa, died on February 11, 1970, in Cambridge, Massachusetts.

Philosophers have frequently pointed out that ideas have a greater impact upon society than do material consequences of ideas. To engineers, the beautiful bridge, the soaring office building, or the graceful dam offer visible evidence of the translation of ideas into the service of man.

Professionals choose many routes to attain their major purposes in life. Whether consciously or not, Gordon Fair obviously chose to affect his fellow man through the route of ideas-as teacher, writer, investigator, and mentor. That he chose well, his long and preeminent career gives ample testimony.

Gordon Fair brought to his life's work an unusual intellectual capacity, deeply sharpened by extensive and broad education in the great institutions of learning of his day. He included in his armamentarium a competence in foreign languages, not usually the hallmark of many engineers. The statement that evidence of his accomplishments was not to be found in monumental structures, or that he did not work with steel or concrete, is only half true. Most of what he taught, wrote, and preached did in fact find its way into structures throughout the world, through the more subtle route of the minds of men.

One could quantify, at least, his direct impact on man via a count of his hundreds of students. More difficult is the estimate of his impact upon thousands of students and practitioners throughout the globe. His textbooks, perhaps the most valuable yet available, mirrored the intellect that he possessed to an extraordinary degree. As a matter of fact, few were as well endowed as he with such lucidity of reasoning, precision of language, and accuracy of recording. He demanded of his students an equally high level of performance-sometimes impatiently, perhaps even harshly. Such is the habit of those more broadly endowed than many of their fellows.

If one were patient, however, one could soon discover that, while his demands were high, a strong thread of humor, good sense, and even gentleness pervaded his life. Those of his friends who had the good fortune to sit and fish with him by the hour attest to these deep-seated softening qualities in an otherwise deceptively austere exterior. While he demanded high quality in the pursuits of his students, he asked no more than he persistently required of himself. The hallmarks of the man were orderliness of conception, honesty of diagnosis, sharpness of investigation, and clarity of exposition. And all his works stand as permanent monuments to these extraordinary virtues.

He was no "ivory tower" academe. He gave much of himself throughout his career to the needs of man throughout the world. He traveled widely to lend his competent aid in alleviating the lot of men, women, and children in almost every part of the disease-ridden and hungry universe.

One of his most fruitful contributions was to the Rockefeller Foundation, which he served as a Member of the Board of Scientific Directors-incidentally, the first engineer to be so honored. One of his colleagues in that activity describes him well in these terms: "Whether it be in the swamps of Sardinia, in the jungles of Brazil, in the lecture rooms of the Ecole Polytechnique in Paris or in the laboratories of the London School of Hygiene, the presence of Gordon Fair inspired all those with whom he came in contact."

He served long and contributed heavily to the peace-time and war-time activities of the United States and international agencies, notably, the League of Nations and the World Health Organization. His years of uninterrupted contributions to myriads of advi sory committees of the National Research Council, in the National Academy of Engineering, on the Army Epidemiological Board, and in the earliest efforts of the Agency for International Development in Central and South America are legion. The number and variety of these services are astonishing in the lifetime of one man, no matter how genetically well endowed he happened to be. It is compulsory that even his friends review anew the list of his commitments enumerated in this memoir.

Gordon Fair was no mere "sitting member" of these groups. As he participated in these sessions, he was simultaneously busily engaged in the laboratory and library, producing new materials, new interpretations, and new guides and criteria for engineering action for the betterment of that environment-recently discovered by more naive crusaders. Gordon Fair antedated them by a mere half a century.

The outcome of these wartime efforts, among many others, is that *vade mecum* of every global traveler, "globaline," still one of the excellent bactericides and amoebicides. It is well to remember this warborne asset to humanity that bears the hallmark of Gordon Fair's devotion to preventive action.

One of his perceptive admirers, Ed Cleary, properly noted, at the memorial exercises at Harvard University, that "he chose engineering as the fulcrum and teaching as the lever for moving the minds of men to cope with scientific and technologic change." He had an abiding faith in man's capacity to control his environmental fate with wisdom and logic. He needed no formal lesson in his own conception of engineering, that the engineer had a preeminent responsibility to society. He lived that way!

It may well be said of Gordon Fair what Nicholas Murray Butler said years ago of another great engineer, William Barclay Parsons, one-time distinguished member of the Army Corps of Engineers: "Parsons conceived of the engineer as an instrument of civilization." In any such Hall of Fame, Gordon Fair would qualify.

What of the man himself that private self so often concealed behind the public facade? Those friends, long close to him at Cambridge, had years to view him more intimately. They saw him raising his voice in song. They even claim he had a fine tenor voice!

Like all true Izaak Waltons he angled patiently and not too successfully. As Master of Dunster House, he presided for years over "the quick and the slow," fairly, judiciously, with reason and, most of the time, good temper. Good minds deserve *some* explosive moments.

Again, one of his close friends, Edward S. Mason, described him well as "preeminently a man of the age of reason, a classic rather than a romantic, a man with whom one could discuss any subject with the assurance he would come away with a balanced view."

The parading environmental activists of the coming decade will sorely miss the sense of equilibrium that Gordon Fair brought to the discussions of our ever-pressing ills. Although he recognized the ills, he also emphasized repeatedly the possibilities of solutions. These he did not feel would come from "the ravings of scaremongers or even by the practice of confrontation, as favored by the young, but through the careful scientific study that needs to precede action."

In his family life, as in his profession, Gordon Fair was fortunate. His wife, Esther, gentle and understanding, was devoted to him. He was proud of his sons, Gordon and Lansing, and they of him. The generation gap was not visible!

Merrell Robert Fenske

1904-1971

By Nunzio J. Palladino

The profession of engineering and the Pennsylvania State University lost a special friend and proponent with the death of Merrell Fenske, who was born on June 5, 1904, and who died on September 28, 1971.

Most of Merrell Fenske's friends and associates were familiar with his accomplishments. What his formal biography does not, and can not, speak of was Merrell Fenske's contributions to the lives of his students and associates, as well as his contributions to his profession, which extended far beyond the mere reciting of publications, patents, honorary society memberships, and technical society memberships with the rank of Fellow.

Professor Fenske was educated at DePauw University and the Massachusetts Institute of Technology. In 1928 he received the degree of Doctor of Philosophy from the latter, where he had worked with P. K. Frolich on catalysts for the formation of methanol from carbon monoxide. He went to the Pennsylvania State University shortly thereafter as an Assistant Professor and in due course became that rare combination of Professor of Chemistry and Professor of Chemical Engineering.

In 1929 he was made Director of the Petroleum Refining Laboratory, and his early work was devoted to research for the Pennsylvania Grade Crude Oil Association. From this, three major research interests developed-separations, hydrocarbon chemistry, and lubrication. It was while studying the compositions of Pennsylvania crudes that he built the first fractionating columns with 100 and more theoretical plates and also developed the classical equation that bears his name for columns operating under total reflux. His work on the composition of Pennsylvania gasoline constituted pioneering studies in which the individual compounds were identified and separated, and his equipment and techniques opened up the field for similar studies at other laboratories. The research aided materially in the design of commercial installations for the production of high performance aircraft fuels in World War II.

Distillation was a separation by molecular size, and Professor Fenske needed a more powerful means for separating the constituents of Pennsylvania crudes-the separation by molecular type. He and his associates turned to liquid extraction and elevated that process from an underdeveloped art to a useful unit operation by the development of techniques, equipment, calculation methods, and understanding. He was also responsible later for a similar development in the area of extractive distillation. His research in liquid extraction was applied by him in devising processes and apparatus for metal separations and purifications in the Manhattan Project (now Atomic Energy Commission).

Merrell Fenske's undergraduate training was in chemistry, and chemistry was most dear to him. His early work was on the catalytic formation of alcohols from carbon monoxide and hydrogen, later on the oxidation of Pennsylvania kerosenes, pure hydrocarbons, naphthas, and hydrocarbon gases. From these studies evolved many additional studies on the chemistry of oxidation and the chemistry of the oxidation products.

Work on Pennsylvania crudes could hardly have been conducted without touching on the preparation of lubricants. Fenske's early development, with Professor Cannon, of the viscometer that bears their names revolutionized viscosity measurement and specification in the petroleum industry. Later he was instrumental in the development of new hydraulic fluids, recoil oils, and lubricants for the Air Force, Navy, and Army. He standardized the specifications and helped in the initiation of the commercial production of these fluids in World War II. Today these materials are used by all services in aircraft, missiles, and in land and water ordnance. He also devised and obtained commercial production of jet engine lubricants for military aircraft and for the hydraulic systems of missiles and new supersonic aircraft.

During the forty years that Professor Fenske carried out and directed work on the science of petroleum refining and the application of fundamental knowledge to the practical problems of technology, he and his colleagues and students produced and published a truly remarkable volume of important work, both on theory and practice. Noted were distillation, viscosity and rheology, and oxidation, but the list extends far beyond this to thermodynamics, phase equilibria, hydrogenation, catalysis, refining processes, Raman spectra, heat pumps, fluidization of particulate solids, microorganisms and their behavior, fuels, analytical methods, and many more.

With a vigor and a breadth of interest that seem amazing, Professor Fenske's work touched an almost unbelievable spectrum of engineering problems. As a research director he was without peer. He was amazingly creative and could keep a wide variety of projects going. The key to the vast number of achievements was undoubtedly his capacity for continued hard work. And he expected a comparable diligence from his students and colleagues. He was never a forty-hour-a-week engineer, nor did he expect as little from his associates.

Those of us who worked with him will always remember his ability to get to the heart of a problem. If it involved research, he could identify the important factors. If it were a conference, he could sum up the important facts, bring the discussion back from irrelevances to the basic problem, and put it on a straight course again.

His lasting claim to public recognition undoubtedly lies in his research work, an area we can evaluate with statistics-numbers of publications, patents, and other tangible evidences of a productive professional life. But foremost, Merrell Fenske was a teacher. He taught in the classroom for only a little more than a dozen years, but in that time he developed a reputation for his clarity of presentation, his stress of fundamentals, and his emphasis on true understanding of the subject matter. His later students knew him only outside the classroom-as their research director or as a member of their thesis committee. But every contact they had with him was a real educational exercise. He professed in the very best tradition of the true professor.

Merrell Fenske's colleagues will long remember him as a strong stimulus. His comments were always direct, his evaluations reliable, and his advice dependable. The entire engineering community has lost a true friend and faithful worker in its behalf.

Antonio Ferri

1912-1975

By Adolf Busemann

Antonio Ferri, Vincent Astor Professor of Aerospace Sciences at New York University, President of General Applied Science Laboratories Inc., and Senior Vice-President of Marquardt Corporation, died on December 28, 1975, of a heart attack at his home on Long Island at the age of sixty-three. His death means a great loss to the National Academy of Engineering and to the national and international societies of aerospace engineering in which he was a very active and knowledgeable member throughout his forty years of professional life.

Dr. Ferri was born on April 5, 1912, in Norcia, Italy, and, during his youth, Italy was one of the most successful participants on the Schneider Cup Races for seaplanes, being the first country to win the cup a second and also a third time. Therefore, his choice to study electrical engineering (Ph.D., 1934) and also aeronautical engineering (Ph.D., 1936) at the University of Rome was quite appropriate for a student of his interests. But, when Great Britain became the first country to win the cup a fourth time in 1929 and Italy's new airplane for the last race in 1931 could not participate because of engine troubles, the Italian Air Ministry decided to build a new research center in Guidonia near Rome. Dr. Ferri received an appointment at the center when it was finished in 1935. For the center's opening event, the Royal Academy of Italy selected "High Speed Flight" as the subject of its Fifth Annual Volta Congress in Rome. Participants included famous scientists such as

L. Prandtl, Theodore von Karman, and G. I. Taylor, as well as two organizers of the Schneider Cup competition from England. The purpose of the Congress was to discuss the past experience of and future expectations for subsonic and supersonic flight.

Such an exposure to the latest ideas of the experts, as well as having the opportunity to test their reality and limitations on the most advanced wind tunnels, is certainly the fastest way to make a new engineer able to stand on his own feet in this new field of applications. In 1937 Dr. Ferri became the Head of the Supersonic Wind Tunnel of Guidonia. During World War II high-speed flight got even a greater priority, and he was charged with building new facilities for investigations. He had to destroy them when, in 1943, Italy wanted to surrender to the victorious Western Allies, but Germany tried to prevent it. However, with the fall of Rome in 1944 the Allies succeeded, and the Office of Strategic Services of the National Advisory Committee for Aeronautics (now a part of the National Aeronautics and Space Administration) offered him a chance to continue his research at the Langley Research Center, near Hampton, Virginia. His earlier and new experience was very much appreciated, and in 1949 he advanced to the Head of the Gasdynamics Branch. He was also allowed to bring his wife, the former Renata Mola, and his children to Hampton, and his admittance to U.S. citizenship was legally complete in June 1952.

In addition to his research publications for the National Advisory Committee for Aeronautics, Dr. Ferri wrote a well-known book, *Elements of Supersonic Aerodynamics,* which was published by the Macmillan Company, New York, in 1949. About that time the universities realized that they needed fresh blood in their aeronautics departments and new wind tunnels for the laboratories, and in 1951 Ferri joined the faculty of the Polytechnic Institute of Brooklyn as Professor for Aerodynamics. He became in 1954 the Director of their Aerospace Institute, and in 1957 he became Head of their Department of Aerospace Engineering and Applied Sciences. He was also President of the General Applied Sciences Laboratories, Inc., which was founded with Professor Theodore von Karman in 1956. In 1964 Dr. Ferri joined the Department of Aeronautics and Astronautics, School of Engineering Sciences, of the New York University.

The change from a government employee to a university professor in a city like New York gave Dr. Ferri plenty of opportunities to become a consultant for the private airplane industry and to realize their problems caused by the advancement of flight. Besides that, he was also a consultant for the Air Force and other government agencies.

The second half of Dr. Ferri's professional career became even more interesting and diversified by the addition of space flight and of hypersonic aerodynamics, overlapping at the reentry maneuvers of space vehicles into the atmosphere. A new element at such extremely high velocities is the surface heating of the vehicle by the air. At smaller hypersonic velocities an airbreathing jet propulsion is very advantageous if the combustion can be accomplished at supersonic speeds; but a normal shock ahead of the entrance of the duct can change the entrance speed from supersonic to subsonic. Dr. Ferri invented an air inlet to recover automatically from such shocks. He also helped solve the supersonic combustion problems for the jet. Even the surface heating by the air at speeds up to satellite speeds gave him plenty of ideas like separating the air from the surface by a jet or by a heat shield and how to minimize the cooling costs.

In his last years, Dr. Ferri was also working on the commercial supersonic airplanes and the changes they need in order to reduce the noise level and the air pollution in the upper atmosphere, and he was convinced that the second generation of the SST will be able to comply better with reasonable limits on these two ecological items.

Dr. Ferri, with his excellent combination of theoretical and experimental talents to solve the most difficult problems in engineering, was also an admirable teacher and a wonderful demonstrator of the facts in the laboratory, as well as an experienced leader of a research team on new problems. Though he earlier had been a committee member for the National Academy of Sciences, he was elected as a Member of the National Academy of Engineering in 1967 and became a great help in solving acute problems in several committees of purely technical or even sociotechnical character. He was also honored by many prizes and awards of national or international societies, beginning with the Premio dell'

Accademia d'Italia (for science) (1938); the Scientific Achievement Award (1954); the Italian Historical Society Award of America (1959); the Historical Society Award of America (1965); and the Akroyd Stuart Prize from the Royal Aeronautical Society (1965). He further received in 1966 the Department of the Air Force Commendation for Meritorious Civilian Service in recognition of his contributions to the U.S. Air Force as a member of the Scientific Advisory Board. In 1970 he received the Department of the Air Force Office of Aerospace Research Award for outstanding contributions to research. In 1975 he received the Sylvanus Albert Reed Award from the American Institute of Aeronautics and Astronautics.

Antonio Ferri will long be remembered by his friends, associates, and students as one who had what it takes to make a new branch of engineering blossom and grow.

Alfred Martin Freudenthal

1906-1977

By Harold Liebowitz

Alfred M. Freudenthal, Professor Emeritus of Civil Materials Engineering, died on September 27, 1977. His death takes from the George Washington University a man in whom extraordinary abilities in research, teaching, and engineering practice were richly complemented by those qualities of absolute integrity, unceasing interest in and intellectual curiosity about the world around him, and generosity of spirit.

Professor Freudenthal was one of the seminal engineers and scholars of his era. In 1975, to commemorate his exceptional contributions, the American Society of Civil Engineers established the Freudenthal Medal "in honor of his outstanding accomplishments in research, teaching, and engineering practice," to be awarded biannually to an individual in recognition of distinguished achievement in the area of safety and reliability applied to civil engineering.

Professor Freudenthal was born in Poland on February 12, 1906, and his education was the best that one could receive in Europe. He was awarded a degree in civil engineering in 1929 in Prague and in 1932 in Lwow. In 1930 he was awarded the degree of Doctor of Technical Sciences by the German Technical University in Prague on the basis on his dissertation on the theory of plasticity.

Professor Freudenthal started his professional career in 1930 as a structural designer. In 1935 he emigrated to Palestine (Israel) where he became the Chief Structural Engineer and subsequently the Resident Engineer in planning, construction, and technical administration of a new port in Tel Aviv between 1936 and 1946. In 1936 he accepted an appointment as Lecturer, later as Professor of Bridge Engineering at the Hebrew Institute of Technology in Haifa.

In 1947, on the basis of a paper on the statistical aspects of fatigue, he was invited to visit the United States and to lecture at several universities. In that year, he accepted an appointment with the University of Illinois as Visiting Professor of Theoretical and Applied Mechanics.

Between 1949 and 1969, he held an appointment as Professor of Civil Engineering at Columbia University. In 1969, he joined the faculty of the George Washington University as Professor of Civil and Materials Engineering and Director of the Institute for the Study of Fatigue and Structural Reliability. The Institute was transferred from Columbia University, where it had been in operation since 1962.

Under Professor Freudenthal's leadership, the Institute acquired a worldwide reputation in fatigue research, which included basic research both in the metal physics aspects of fatigue as well as in the development of a new methodology in the risk and reliability assessment of structures dominated by fatigue. It was for this pioneering work that the technical community awarded Professor Freudenthal the unique accolade by referring to him as the "father" of structural reliability.

Among his many honors and awards, he twice received the Norman Medal from the American Society of Civil Engineers; he also received the Swedish Aeronautical Society Medal and the von Karman Medal, to name a few. He was elected to the National Academy of Engineering in 1976. He was the author of seven books and about 150 papers, which were published in technical and scientific journals.

Professor Freudenthal was a truly educated person with a lifelong interest in science, technology, art, music, literature, philosophy, and world events. He could always be called on as a friend and counselor and his sage advice guided many of the faculty and students through both personal and professional difficulties. He gave of himself unstintingly when help was needed.

The legacy of Alfred M. Freudenthal lies in his outstanding research and original thinking, which will long endure. His lasting accomplishments are a satisfaction to those of us who were fortunate to know this good and gifted man.

Clifford Cook Furnas

1900-1969

By Lawrence R. Hafstad

Clifford Cook Furnas, President Emeritus of the University of Buffalo, died on April 27, 1969, in Amsterdam. It is significant that certain adjectives are invariably used when one refers to scientists and technical people. One reads often of the brilliant scientist and of the competent or successful engineer. One reads often of a shrewd lawyer, of a wily politician, and so on, but the adjective *wise* is reserved for the wise old doctor, or farmer, or even the wise old woman. There is a weakness in our educational process that makes the word combination *wise scientist* a jarring anachronism. The reason for this obviously is that scientists who can be described as wise are so few and far between.

However, among the host of scientists who richly deserve the adjective *brilliant,* there are a very few who do qualify as wise. Pegram of Columbia University, Tate of the University of Minnesota, and Lauritsen of the California Institute of Technology come to mind in this category. It is to this select group that we should add the name of Clifford C. Furnas.

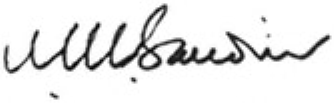
Cliff Furnas, as he was known to his associates, was truly a broad-gauge person. His extensive publications, many highly technical for the professional specialist and an equal number addressed to the lay reader, attest to this fact. His writings indicate that as long ago as the early 1930's, he was sensitive to the potential impact on society of the then embryonic developments in science. It was his remarkable combination of imagination and foresight, coupled with down to earth realism, that made his advice so valuable and so frequently sought.

Dr. Furnas was born October 24, 1900, at Sheridan, Indiana. He held the degree of Bachelor of Science, with honors, from Purdue University (1922), Doctor of Philosophy from the University of Michigan (1926), Honorary Doctor of Engineering from Purdue (1946) and the University of Michigan (1957), Honorary Doctor of Laws from Alfred University (1958), Honorary Doctor of Science from Thiel College (1960), Degree Honoris Causa from University Nacional de Asunción (Paraguay) (1963), and the Golden Cross of the Order of the Phoenix (Greece) (1963).

Dr. Furnas had always had a sustained interest in both research and education, and his working career reflected this quality. From 1926 to 1931 he conducted research work on metallurgical processes at the U.S. Bureau of Mines at Minneapolis, Minnesota. In the latter year he joined Yale University as Associate Professor in Chemical Engineering. In 1941 and 1942 he worked for the National Defense Research Committee, coordinating a large research and development program. He was appointed by CurtissWright as Director of its Aeronautical Research Laboratory in Buffalo in February 1943. This Laboratory was given to Cornell University on January 1, 1946, and he became Director and Executive Vice-President of Cornell Aeronautical Laboratory, Inc.

On September 1, 1954, Dr. Furnas assumed the post of Chancellor of the University of Buffalo. On December 1, 1955, he was granted a leave of absence by the University to serve as Assistant Secretary of Defense for Research and Development in Washington, D.C. He returned to his University of Buffalo post on February 15, 1957.

For a number of years Dr. Furnas was an active member of various technical boards and panels for the U.S. Government, particularly in the Department of Defense. He was Chairman of the Defense Science Board. He was also a Member of the Naval Research Advisory Committee, of the Army Scientific Advisory Panel, and of the Panel on Science and Technology of the House of Representatives Committee on Science and Astronautics, as well as many other advisory groups.



Antoine Marc Gaudin

1900-1974

By Reinhardt Schuhmann, Jr.

Antoine Marc Gaudin, eminent mineral engineer, died in Boston, Massachusetts, on August 23, 1974, after a long illness. He was Richards Professor of Mineral Engineering Emeritus at the Massachusetts Institute of Technology, where he had taught since 1939.

Professor Gaudin was a vigorously creative man and, throughout his productive career, an internationally respected leader of the profession of mineral engineering. Beyond his many significant technical and scientific contributions to such fields as froth flotation, comminution of ores, and uranium extraction, he manifested a strong sense of responsibility that engineering and engineers serve society. Thus, in 1964 he fittingly became one of the active founding members of the National Academy of Engineering. For his many students, as well as close colleagues, he was engineering teacher, wise and friendly counselor, and professional leader.

Antoine Gaudin was born August 8, 1900, in Smyrna, Turkey, where his father was general manager of a French-owned railroad. He grew up literally in the shadow of classic marbles from his father's archeological diggings. After early schooling in Haifa, Versailles, and Toulon, he received the degree of Bachelier-es-Sciences from Paris (1916) and Aix-en-Provence (1917). After his father came to the United States with the French War Mission, Antoine followed in 1917 and entered the Columbia School of

Mines. He completed the six-year program in four years and was awarded the Engineer of Mines degree in 1921.

After a few years of beginning engineering and industrial experience, Gaudin in 1924 returned to Columbia University as Lecturer in the School of Mines. From that time on, he was engaged continuously in teaching and research in mineral engineering and allied fields. During 1926, he became a U.S. citizen. From 1926 to 1929 he was Associate Professor of Metallurgical Research at the University of Utah and from 1929 to 1939 he was Research Professor of Mineral Dressing at the Montana School of Mines. His and his students' researches in Utah and Montana focussed on the then young science of froth flotation of minerals, and the flow of significant contributions and ensuing commercial applications brought national and international recognition. Professor Gaudin moved to the Massachusetts Institute of Technology (MIT) in 1939 as Richards Professor of Mineral Engineering and in this position, until reaching emeritus status in 1966, continued and broadened his pursuit of new mineral engineering knowledge and of solutions of important problems.

Although the campus was always Professor Gaudin's home base, he found great stimulation and challenge in putting his brain and hands to work on problems of the real world of the mineral industry-especially those others couldn't solve. His consulting practice was large, but he mastered the art of combining consulting, research, and teaching to the mutual benefit of each.

One of Dr. Gaudin's greatest accomplishments was his leadership of a team of engineers at MIT during World War II in developing processes for recovering uranium from low-grade raw materials. In the words of Lt. Gen. Leslie R. Groves, Manhattan District, U.S. Army Corps of Engineers, written in 1955:

> In March of 1946, he started work on the extremely low grade tailings from the South African gold mines. Many of our technical people and all those outside the project with whom we discussed the various problems were quite firm in the view that we were doomed to failure. Professor Gaudin justified our faith in his ability and judgment. A successful treatment process was developed and without undue delay. The proof of this has been given in the size of today's shipments of uranium from the Union of South Africa.

The uranium recovery project, with its urgency, major scientific and engineering challenges, and ultimate success, was a memorable educational and professional experience for all the young engineers and scientists whom Professor Gaudin brought together for the task.

As one of the twenty-five founding members of the National Academy of Engineering (NAE), Dr. Gaudin gave distinguished service to the Academy and to the U.S. Government. He was a Member of the NAE Council from 1964 to 1969 and active in several NAE operating committees. He brought his broad knowledge and perspective of mineral and metallurgical industries to the important work of NAE and NRC (National Research Council) panels and committees relating to materials resources and resource development.

Always active at the leading edge of mineral engineering research for a period of more than forty years, Professor Gaudin authored more than 150 journal publications. Many of these became part of the foundation of the science of froth flotation. Others constituted pioneering work in comminution, surface chemistry, applications of radiotracers, microscopy of minerals, and new process development. Dr. Gaudin also found time to organize and write important textbooks: two editions of *Flotation* (1932 and 1957) and *Principles of Mineral Dressing* (1939).

The American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) recognized the outstanding work of Antoine Gaudin by several of its highest awards: the Robert H. Richards Award (1957), the Mineral Industry Education Award (1969), and Honorary Member (1972). His honorary lectures were always stimulating events and included the Henry Krumb Lecture (AIME, 1967), the Extractive Metallurgy Lecture (AIME, 1961), and the Sir Julius Wernher Memorial Lecture (Institute of Mining and Metallurgy, London, 1952). The Montana School of Mines awarded him the degree of Doctor of Science Honoris Causa in 1941.

Many of Tony Gaudin's former students and colleagues came to know his charming and gracious wife, Nancy, and to enjoy the hospitality of the Gaudin home. He was himself justifiably proud of his sons, Paul and Robert, daughter, Elinor, and twelve grandchil dren. To his family, his daily living, and his many hobbies, Tony brought the same zest for living, curiosity about nature, and taste that characterized his professional activities. Thus, he was an avid fisherman, on occasion a gourmet cook, an artist, and a collector of paintings, as well as a patron of the Boston Symphony Orchestra and of the Boston Museum of Fine Arts.

The life and works of Antoine Marc Gaudin leave a clearly documented record of distinguished contributions to engineering knowledge and to the service of society. His influence will continue to grow into the future through the students and associates who benefited from his strong tutelage and example.

William Francis Gibbs

1886-1967

By Walter C. Bachman

William Francis Gibbs was born August 24, 1886, in Philadelphia, Pennsylvania, son of a successful financier, William Warren Gibbs, and of Frances Ayres (Johnson) Gibbs. Active, almost to the end, he died on September 6, 1967, at the age of eighty-one. An early interest in ships was undoubtedly stimulated when, as a boy, he had the opportunity to witness a ship launching at the Cramp shipyard in Philadelphia. This interest was confirmed and strengthened by a number of transatlantic crossings he made with his younger brother, Frederic, starting in 1901 with a trip on the White Star Liner *Oceanic,* the largest transatlantic passenger ship at that time. Later crossings were made on the *Celtic* and the *Lusitania,* outstanding ships of their day, and in 1907 on the maiden voyage of the *Mauretania,* which held the transatlantic speed record for over twenty years.

W. F. Gibbs received his primary and secondary education in the DeLancey School in Philadelphia, Pennsylvania, graduating in 1905. In 1906 he entered Harvard, where with characteristic individualism he did not pursue a formal curriculum leading to a degree, but selected a combination of courses, largely scientific, in his range of interest. His leisure was devoted to reading technical publications dealing with ship design and construction. During this period, he made an extensive study of all available information on the newest warships of the British Navy, which was prominent at that time.

His studies at Harvard were completed in 1910. Even though no degree was conferred, the Harvard Chapter of Phi Beta Kappa made him an Honorary Member in 1945.

On the advice of his father, who considered engineers poor businessmen, he entered the Columbia University Law School in 1911 and received a Bachelor of Law degree in 1913. At the same time, he did graduate work in economics, for which he received the degree of Master of Arts, also in 1913.

During this period, his father suffered financial reverses and William Francis took a position in the law office of William Osgood Morgan in New York. His vision of great ships remained, however. For the next two years, while working at law in New York during the week, he journeyed each weekend to the family home in Haverford, Pennsylvania. There, he spent all of his spare time together with his brother, Frederic Herbert Gibbs, investigating the possibility of designing a high-speed transatlantic passenger liner, 1,000 feet long. By May 1915, he was so encouraged by the results of this study that he gave up all other work so that he could devote full time to this project.

By January 1916, this design had progressed sufficiently so that the brothers presented it to Adm. David W. Taylor, then Chief Constructor of the U.S. Navy, and to the Honorable Josephus Daniels, Secretary of the Navy.

Encouraged by these men, they continued their efforts and, in June 1916, presented their design to Mr. P. A. S. Franklin, President of the International Mercantile Marine Company. Their proposal at this time included the development of a new port at Montauk, Long Island, with fast beat trains running to New York in order to reduce the total travel time to a minimum.

Mr. Franklin introduced the Gibbs brothers to Mr. J. P. Morgan, who was so impressed that he undertook the financing of further development of the design, including the necessary model testing.

Work on this project was interrupted by the entry of the United States into World War I in April 1917. W. F. Gibbs was appointed Assistant to the Chairman of the Shipping Control Committee of the General Staff of the U.S. Army and after the war was Assistant to the Chairman, U.S. Shipping Board on the American Commis sion to Negotiate Peace, in which capacity he attended the Peace Conference at Versailles.

In 1919, he was appointed Chief of Construction of the International Mercantile Marine Company, for whom he planned and supervised the conversion of the S. S. *Minnekahda* from a wartime transport to a third-class passenger and cargo ship for the New York to Hamburg service.

The great new German passenger liner *Vaterland,* which made her maiden voyage to New York in May 1914, was trapped there by the opening of World War I and seized by the United States Government for use as a troop ship in 1917, when it was renamed the *Leviathan*.

At the end of the war, the United States Shipping board decided to convert the *Leviathan* for passenger service, and the Gibbs brothers were asked to organize an independent firm to supervise this work. Accordingly, in February 1922, Gibbs Brothers, Inc., was organized, with William Francis Gibbs as President.

The *Leviathan* had been built by the German shipyard, Blohm & Voss, which held the detailed plans needed for the conversion and maintenance of the ship. The shipyard demanded $1 million for a set of these plans-an exhorbitant price at that time. Never one to submit to pressure, W. F. Gibbs immediately assembled a team of experienced men who completely measured the ship, including the internals of the main machinery, and drew their own plans at a considerable saving of money. The ship was converted for luxury passenger service by the Newport News Shipbuilding & Dry Dock Co., under W. F. Gibbs' supervision, with the care and attention to detail for which he soon became famous. The maiden voyage, on July 4, 1923, and several voyages thereafter were made under the supervision of Gibbs Brothers, Inc., acting as operating agents for the Shipping Board. With the successful completion of this great project, the reputation of the new firm was established.

Other commissions followed, and the firm supervised the conversion of a number of ships released from their wartime service to suit commercial requirements.

In 1929, the firm of Gibbs Brothers, Inc., was succeeded by Gibbs & Cox, Inc., a new firm organized to include Daniel H. Cox, an outstanding yacht designer of that period. This association permitted the Gibbs talent to be applied to several outstanding yachts, including the *Savarona,* the largest steam yacht ever built and the first to include the highest safety standards for merchant ships; and the great sailing yacht, *Sea Cloud,* 316 feet overall length, with the number and arrangement of sails of a full-rigged ship.

The Gibbs' outstanding knowledge of passenger ships was then devoted to the design and supervision of the construction of the S.S. *America*. This was the largest merchant ship built in this country up to that time and had safety features, including fire resistant construction, to a degree unequalled by any other passenger ship of the period. Completed in 1940 by the Newport News Shipbuilding & Dry Dock Co., she could not be used by the United States Lines in her intended service because of the war in Europe. After a luxury cruise to California, she returned to Newport News, where her luxurious furnishings were removed and she was re-outfitted as the troop transport U.S.S. *West Point*. Refurbished at the end of World War II, she became a popular ship in the transatlantic service for which she was designed.

In 1933, the U.S. Navy, which had built almost no new ships since World War I, started a new construction program. Three shipyards, United Dry Docks, Inc., Federal Shipbuilding & Dry Dock Co., and the Bath Iron Works Corporation undertook to build destroyers to a single design developed by W. F. Gibbs.

This program was particularly significant in two ways. It represented the first step in the development of modern, rugged, and more efficient steam propulsion machinery for naval ships. This type of machinery, further developed through a series of destroyer types, also of Gibbs design, was used to power practically all steam driven combatant ships in the U.S. Navy built during World War II, including destroyers, cruisers, battleships, and aircraft carriers.

In 1940, the British Government sent a purchasing mission to survey the busy American shipyards and order some cargo ships. The head of the mission approached W. F. Gibbs and said that his government wanted twenty ships. The reply was, "You don't need them." He then explained that if Britain was within twenty ships of winning the war she had won already. If not, she needed many more. The British then placed an order for sixty Ocean Class ships to be built in two new shipyards. From these ships was evolved the design of the great fleet of Liberty ships that carried so much of our military cargo during the war years.

As the United States mobilized for the war effort, the War Production Board was established and Charles E. Wilson, Vice-Chairman for Production, requested W. F. Gibbs to become Controller of Shipbuilding to coordinate the ship construction programs of the Navy, Army, and Maritime Commission. This appointment was made with an arrangement that permitted Gibbs to control U.S. shipbuilding policies, while at the same time he was freed of administrative detail so that he could continue to supervise the very important activities of his own company.

During this period, he served as Chairman of the Combined Shipbuilding Committee (Standardization of Design) of the Combined Chiefs of Staff. He was also Special Assistant to Director, Office of War Mobilization, and representative of the Office of War Mobilization on the Procurement Review Board of the Navy.

The key position occupied by the Gibbs organization in large government shipbuilding programs naturally invited several investigations by congressional committees. These committees, sometimes hostile at the outset, invariably ended with praise for the firm's contribution to the national effort. At the end of one such investigation, Gibbs remarked, "Nothing educates a man like being forced to look up the answer to every possible question that can be asked about his business." The care with which he replied to every question raised by the investigators undoubtedly was an important factor in the outcome of these hearings.

The dream of William Francis and Frederic H. Gibbs had been to see a great ocean liner built to their design. The *America,* which was completed just prior to our entry into World War II, was the largest passenger vessel built in the United States up to that time, and a fine and popular ship, but not a true competitor with the fast superliners, the *Queen Mary, Normandie,* and *Queen Elizabeth*.

At the end of World War II, preliminary studies for a new ocean liner were begun, and in 1946 the United States Lines Company commissioned Gibbs & Cox, Inc., to develop contract plans and specifications for the S.S. *United States*.

This superb ship resulted from the synthesis of all the experience gained from passenger ships such as the *Leviathan, Malolo, America,* as well as ships held by the Grace Company, combined with the technical advances made in machinery, structure, materials, and methods developed in work for the U.S. Navy.

That the combination of these many qualities in a single ship was actually accomplished has been amply demonstrated by the remarkable record of performance of the ship over the many years it has been in service.

When the Gibbs brothers were boys in Philadelphia, their father often permitted the family coachman, a former member of the city Fire Department, to drive the boys to fires, taking them from school, if necessary. This developed in W. F. Gibbs a fascination with fire fighting that lasted all of his life.

Because of his interest in the subject, the New York City Fire Department retained him as a consultant, and, in 1937, he designed and supervised the construction of the New York City fire boat *Fire Fighter*. Still the most powerful fire boat in the world, the *Fire Fighter* has demonstrated its great value many times at waterfront fires that were unapproachable by other means or even by ordinary fire boats.

The office of the President of Gibbs & Cox, Inc., was famed for its simplicity and austere appearance. For many years, W. F. Gibbs had no desk, but perched on a stool at a drawing board. These he retained even after he moved to a chair and a simple table. He worked surrounded by activity, and several secretaries were constantly kept busy supplying him with information and transmitting his numerous instructions and messages.

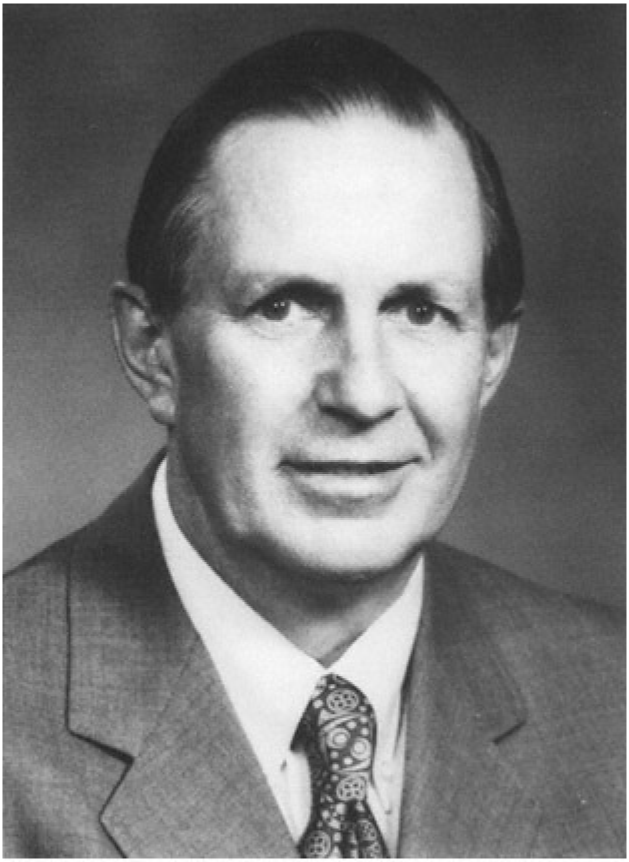
Devotion to ships, fire engines, and business appeared to many to be an all-consuming passion that took W. F. Gibbs to his office for long hours seven days a week. He was usually the first to arrive and often the last to leave.

Francis Gibbs, as he was widely known by family and friends, had many other interests as well. He frequently attended the theater, symphony, and opera and had many friends in the artistic world, for he appreciated quality and superb performance in any field of endeavor. He maintained a box at the Yankee Stadium for many years. He was a vestryman and active supporter of St. Thomas' Church on Fifth Avenue.

A keen sense of humor and a delight in surprising his listeners made him a most effective extemporaneous speaker before an audience of any size. He believed strongly that a sense of humor is vital in any field of endeavor.

Great engineering projects require the coordinated efforts of many people. William Francis Gibbs was a natural leader, who inspired great loyalty in his staff and confidence and cooperation in those with whom he did business. His extraordinary enthusiasm for his work set the example that drove all who worked with him to greater efforts to maintain the high standards of performance that he demanded. He took a close personal interest in his employees and quietly, often anonymously, assisted those in need.

Few men have so wholeheartedly dedicated a lifetime to a single objective as William Francis Gibbs or derived so much enjoyment from the great effort devoted to achieving his goals.



Richard Pitman Gifford

1922-1976

By William L. Everitt

Richard Pitman Gifford, Vice-President for Communications Projects of the General Electric Company at Lynchburg, Virginia, was born on February 9, 1922, and died on August 27, 1976, in Santa Maria, Switzerland, of a heart attack, while climbing on his vacation. An ardent outdoor enthusiast, he favored skiing and tennis and never slowed down at work or at play. An individual of broad interests, he served the National Academy of Engineering (NAE) as a valuable member of its Telecommunication Committee even before his election to NAE in 1973. For the NAE and NRC (National Research Council), he was also a member of the Panel on the Status of Telecommunication Research in the United States, 1972, was Chairman of the Urban Information Systems Inter-Agency Support Panel, 1974, and a member of the Metropolitan Communication Systems Study.

Always able to analyze any problem succinctly, Dick Gifford was turned to again and again by his colleagues to summarize the issues under discussion, guide them to significant conclusions, and organize important sections of reports. In 1968, as Chairman of the Joint Technical Advisory Council of the Institute of Electrical and Electronics Engineers (IEEE) and the Electronic Industries Association (EIA), he organized the study leading to the publication of *Spectrum Engineering-The Key to Progress*. His leadership recruited more than two hundred engineers from industry, government, and education who donated some forty man-years of work to the task.

Many consider this the most significant study ever completed in this area, and a unique marshalling of professional volunteer workers.

Graduating *cum laude* from Harvard University in 1943 with a Bachelor of Arts degree in mathematics, he entered the U.S. Navy, taught at Harvard, and, after further study at The Massachusetts Institute of Technology and Bell Laboratories, served as a radar officer in the evaluation of fire-control systems.

Upon release from the Navy, Dick Gifford joined General Electric in 1946. There he assisted in the establishment of the first microwave television relay from New York City to Schenectady. Later he was involved in development and design work for two-way mobile radio equipment at Electronics Park, Syracuse, and was rapidly recognized as a leading expert in that field.

He moved to Lynchburg, Virginia, in 1958 as Manager-Engineering of the Communications Products Department. In 1963 he became General Manager of that department. In 1969 he became General Manager of the entire division, which is composed of three departments-the Mobile Radio Products Department, in Lynchburg, the Telecommunications Products Department, also in Lynchburg, and the Data Communications Products Department, located in Waynesboro.

He was made a Fellow of the Institute of Electrical and Electronics Engineers in 1964 "for leadership in communication techniques and practice." He also served as a member of the Frequency Managerial Advisory Council of the Office of Telecommunications Policy.

Dick Gifford balanced his broad interest in business with concern and involvement in education and many other phases of community life. He was a "Christian Gentleman" in the very best sense of that concept, a man who demonstrated his deep religious convictions by a life of service to his fellow man. An elder in the Presbyterian Church, he was also a Sunday School Adult Class teacher, President of the Board of Lynchburg College, and from 1960 to 1972 served on the Lynchburg School Board. In 1971 he was awarded the Brotherhood Citation of the National Conference of Christians and Jews, and in 1973 he was appointed to the

Virginia State Board of Education. He was also Chairman of the Lynchburg Museum System Board.

To quote a local editor, "he was one of those rare men who give a large portion of their lives to serving their fellow man. In this, he measured up to the highest traditions of Virginia, traditionally established by those souls who eschewed their lives of ease to serve their community, state and nation because they considered it their highest duty. Richard Gifford was one of those men of whom it can truly be said that they improved the whole of human existence by the manner of their living."

Dick Gifford demonstrated that he believed engineering is a profession "for the benefit of mankind," and acted on that belief.

Lillian Moller Gilbreth

1878-1972

By James N. Landis

In 1966, well into her eighty-ninth year, Dr. Lillian Moller Gilbreth became the first woman to be elected to the National Academy of Engineering-for her the last, except for the Hoover Medal that same year, of a series of "first woman evers," which began in 1900 when she became the first woman ever to be a University of California commencement speaker. Number One on the membership roster of the Society of Women Engineers, she urged women to enter the engineering profession decades before engineering schools were working with any vigor toward this end. She was a strong advocate of removal of age barriers in the hiring of workers and considered compulsory retirement to be based upon an outgrown psychology that fails to put the health and happiness of workers above the adjustable mechanics of the system within which human beings work.

She was honored as few women have been, and through it all she retained an innate simplicity that is a distinguishing characteristic of a truly great human being. Asked late in life what in her career she considered her most important achievement, she replied without hesitation, "My work for the handicapped-that is the one that. has done the most good."

Dr. Gilbreth's achievements are even more remarkable in the light of her sheltered youth. Born in Oakland, California, on May 24, 1878, she was the oldest of six sisters and three brothers in the home of affluent parents where children arrived with proverbial silver spoons in their mouths. Children were taught the old-fashioned virtues in the Moller home, including obedience to parents, responsibilities for younger children, and that boys were not supposed to do girls' work and vice versa. Education was respected, but college was not for young women except those who would have to earn a living. It was taken for granted that no daughter would ever have to earn a living though no lady, of course, should ever be idle. However, Lillian keenly desired a college education. She was graduated from the University of California with a Bachelor of Literature degree and Phi Beta Kappa in 1900 and stayed on for two more years for her Master of Literature degree.

In 1904 she married a self-made construction engineer, Frank Bunker Gilbreth, the pioneer of motion study, with no idea that not only was she to become a leader in the engineering world, but was also to become mother of six sons and six daughters. One daughter died of diphtheria in 1912.

It was her specific talent for psychology that would enable her to contribute early in the field into which cooperation in her husband's work plunged her. Both Gilbreths recognized need for greater use of psychology in some of the work engineers performed. Her thesis on "The Psychology of Management" was submitted to her alma mater, but she was told that a Doctor of Philosophy degree could not be awarded without a year spent in residence as a doctoral candidate. This was impossible for a mother busily engaged raising a family at the same time. Through Frank's help, her thesis was published in installments between 1912 and 1913 in the magazine of the Society of Industrial Engineers and as a book soon thereafter, by Sturgis and Walton. Mr. Walton ruled there could be no word about the fact it was written by a woman, and it was published under the name of L. M. Gilbreth.

Frank Gilbreth next set out to help her get a doctoral degree. A contract awarded to Frank to install scientific management at a plant near Brown University brought them in contact with Dr. Faunce, President of Brown University, who was personally interested in psychology and its application to management. At Brown University in 1915, Lillian became a Ph.D. Although Frank, then enroute from Germany, was not there to see his wife receive this honor, the children were; and a few days later another daughter was born.

Interest in the psychology that underlies all industrial human relationships, plus interest in the motions involved in industrial practices, made work for the handicapped a natural outlet for the talents of both Gilbreths. Industrial accidents had long been inflicting physical disabilities on many human beings, but World War I increased the number and urgency of these problems. Thousands of service men in Europe and America were soon facing handicaps for the remainder of their lives with, in many cases, psychological blocks accompanying their physical disabilities. The Gilbreths faced the challenge of amputees and others. Often, with the help of motion studies, they were able to show how work formerly thought possible only for two-legged or two-handed men could be done by one-legged men, or by skilled one-handed men.

Dr. Gilbreth's first step alone toward the place she would win for herself in international management circles was taken five days after her husband's death, in 1924, when she sailed, as they had planned to sail together, for Prague, for history's First International Management Congress, which they had helped organize. Here she read the jointly prepared paper he was to have read, presided over the session where he was to have presided, and was made a member of the Masaryk Academy. Then she returned home to face the facts of life-the first of which was a home in which eleven children were growing up and would need forty-four years of college education and heavy financial necessities for a long time. She wrote down as the first item in her plan for the future, "Provide a home, a living, and love for the family," followed by, "Teach Frank's work," and a third item about finding and pushing projects that would affect the health and efficiency of human beings in industry.

Anyone who knew the Lillian Gilbreth of her later years knows how successful she was in fulfilling those three promises she made herself in 1924. Her first sixteen-week study course was under way the following January in the motion-study laboratory Frank and she had established in their Montclair home. During the next six years, it was followed by six other such courses in which representatives from Belgium, England, and Germany were trained in the laboratory side by side with representatives from American companies. By the time the seventh course was under way, she had been called upon as a consultant often enough to know that some American businessmen, at least, were ready and willing to use a woman's professional competence in management problems. She had been assured that the psychology she brought into the solution of management problems was resulting in changed attitudes, among both employees and employers, and had made her work profitable financially to business and industry. With motion-study laboratories now established at several colleges, she felt free to discontinue the courses in the home laboratory and devote more of her time to consultant work.

In 1935 she was appointed on a part-time schedule as Professor of Management at Purdue University, continuing there until 1948. She was able to become more selective in the jobs she accepted, preferring those in which psychological understanding was an asset and those in which upper management echelons were interested in achieving technical efficiencies without loss of the dignity, health, or happiness of workers. The interest in helping the disabled achieve satisfying work and the human dignity of supporting themselves would stay with Lillian Gilbreth as long as she lived. She helped enable industry to use the skills of highly gifted workers who, without the application of motion study and psychology to their problems, might have become a drain upon the nation's resources instead of being the national asset they actually became through utilization of their valuable resources. Moreover, individual homes as well as industries reaped happy results from her work when she found ways, which spread over America and Europe, to improve efficiency in the kitchens of both the able-bodied and the physically handicapped in wheelchairs.

The combining of psychological understanding and efficiency improvement was the specific realm to which Lillian Gilbreth brought superb qualifications. She became known and respected in domestic and international engineering and humanitarian groups-as well, probably, as any of her peers of either sex.

Between 1929 and 1966 she made literally hundreds of addresses, at their invitations, to technical organizations, civic groups, service clubs, hospital and rehabilitation teams, and universities, in the United States and abroad: Australia, Canada, England, Germany, Holland, India, Italy, Japan, Mexico, New Zealand, Philippines, South Africa, Sweden, Switzerland, Taiwan, and Turkey. To many of them she had become an American symbol of the art of human relationships. A woman of high gifts and remarkably without antagonisms, she was a bearer of international good will in scores of industrial centers.

Beginning in 1930 with Herbert Hoover's Emergency Committee for Employment, followed by later services on Hoover's Organization for Unemployment Relief, she served five Presidents on committees dealing with civil defense, war production, and rehabilitation of the physically handicapped. Over a decade of service was rendered to the Girl Scouts in national positions and service to numerous other humanitarian organizations. She authored or coauthored ten books. Several books and numerous articles were written about her. She received twenty-three doctorates, more than a dozen honorary memberships in professional societies, and some of the most distinguished medals and awards given by the engineering profession. Among the latter are the first (1931) award of the Gilbreth Medal created by the Society of Industrial Engineers, the Gantt Medal (with Frank B. Gilbreth, posthumously), the Wallace Clark Award, and the Washington Award of the Western Society of Engineers. In 1949 she received the Gold Medal of the National Institute for Social Sciences "for distinguished service to humanity" and, in 1961 (again with her husband posthumously), the Frank and Lillian Gilbreth Industrial Engineers Award of the American Institute of Industrial Engineers. This softspoken woman became accepted as American's First Lady of Engineering.

In 1966, soon after becoming a Member of the National Academy of Engineering, the Hoover Medal was bestowed on her by a Board of Award consisting of representatives of the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical En gineers, and the Institute of Electrical and Electronic Engineers. The citation accompanying the Hoover Medal constitutes a fine encapsulation of this notable lady's work and position in engineering:

> Renowned engineer, internationally respected for contributions to motion study and to recognition of the principle that management engineering and human relations are intertwined; courageous wife and mother; outstanding teacher, author, lecturer and member of professional committees under Herbert Hoover and four successors. Additionally, her unselfish application of energy and creative efforts in modifying industrial and home environments for the handicapped has resulted in full employment of their capabilities and elevation of their self-esteem.

Lillian Gilbreth's life, as lived joyously, fully, and generously, was one of activity for good. She died on January 2, 1972; until the day of her retirement, past ninety, in December 1968, she remained a doer and a worker wishing always to find the best way and to share her best.

Edwin Richard Gilliland

1909-1973

By P. L. Thibaut Brian

Edwin Richard Gilliland died suddenly on March 10, 1973, at his home in Belmont, Massachusetts. He was Institute Professor and Warren K. Lewis Professor of Chemical Engineering at the Massachusetts Institute of Technology (MIT), where he had shaped his career among the early builders of the chemical engineering profession. Dr. Gilliland's inspirational teaching, imaginative research, authoritative writing, and administrative leadership were acclaimed throughout MIT and throughout the chemical engineering world. He was also a highly sought-after and very successful industrial consultant and entrepreneur, and throughout his professional life he gave generously and very effectively of his talents in the service of his government. He was probably the most able and the most renowned chemical engineer of his generation.

Ed Gilliland was born in El Reno, Oklahoma, on July 10, 1909. When he was nine years old, his family moved to Little Rock, Arkansas, where he lived until he entered the University of Illinois to begin his career in chemical engineering. He graduated in 1930 with his Bachelor of Science degree and then went to Pennsylvania State College where he obtained a Master of Science degree in 1931. From there he went to MIT, where he was to spend his entire professional career except for a leave of absence to serve the U.S. Government during World War II. His doctoral research, under the direction of Professor Thomas K. Sherwood, was accomplished in approximately eighteen months, and it developed the wettedwall column technique that became widely used for studying mass transfer phenomena. He received the Doctor of Science degree in 1933.

After receiving his doctorate, Dr. Gilliland worked briefly as an assistant to Professor Sherwood, studying the drying of solids. He was planning to leave MIT to accept employment with a major industrial firm, but Professor Lewis was so impressed with him that he urged him to remain. He decided to stay as an assistant to Professor Lewis and began working on the mathematical analysis of fractional distillation columns. This initiated his long and continuing interest in the field of distillation, and his work in this field propelled him at a very early age to the pinnacle of his profession. Dr. Gilliland was appointed Instructor in 1934, Assistant Professor in 1936, Associate Professor in 1939, and Professor of Chemical Engineering in 1944. He was Head of the Department of Chemical Engineering from 1961 to 1969. He was named Warren K. Lewis Professor in 1969 and Institute Professor in 1971.

In 1934 Dr. Gilliland joined Professor Lewis as a consultant to the Standard Oil Development Company (later Esso, and now Exxon). That consulting relationship, which began when Dr. Gilliland was just twenty-five years old, grew and strengthened and continued throughout his life. Stimulated by their consulting work at Esso, Professors Lewis and Gilliland began experimenting at MIT with fluidized beds of solid particles, and they are given much of the credit for the development of the fluidized catalyst technique for catalytic cracking of petroleum fractions. The process was very important to the production of high-octane aviation gasoline during World War II, and it has remained at the heart of world petroleum technology and economics ever since.

In 1942 Dr. Gilliland went to Washington, D.C., where he was Assistant Rubber Director in charge of research and development for the War Production Board until 1944. Despite his administrative duties, he devoted much of his energy to the solution of the technical problems of producing synthetic rubber and made important contributions to the development of extractive distillation techniques for the recovery of butadiene. He then became a Member and Deputy Chief of Division 11, National Defense Re search Committee, Office of Scientific Research and Development. The following year he became Deputy Chairman of the Joint Chiefs of Staff, Guided Missiles Committee, and a Member of the Industrial Disarmament Committee. After the war and throughout his life, Ed Gilliland continued to serve his government in many important assignments, culminating in his appointment in 1961 to serve four years on the President's Science Advisory Committee under Presidents Kennedy and Johnson.

When Dr. Gilliland returned to MIT after the war, he resumed his academic career as a thirty-five-year-old full Professor of Chemical Engineering with a very bright future indeed. His research interests and professional publications, which had already ranged over heat transfer, mass transfer, distillation, fluidization of solids, polymerization kinetics, and high-pressure thermodynamics, continued to broaden. He had that very rare ability to penetrate deeply into a field, master it, make unique and lasting original contributions that would inspire many workers to follow him for years, and then to go to another field and repeat the process. He continued to develop an understanding of the mechanics of fluidized beds of solids, and he began research programs in electrochemistry, ion exchange, and electrodialysis. He initiated a series of fundamental investigations into adsorption phenomena, developing a unique understanding of the mobility of molecules in adsorbed layers. His publications also included fundamental advances in heterogeneous catalysis, properties of polymers, water desalination, and the rheology of human blood. He became a coauthor in 1937 of the third edition of the classic textbook *Principles of Chemical Engineering,* by Walker, Lewis, McAdams, and Gilliland. In 1939 he collaborated with C. S. Robinson on the third edition of *Elements of Fractional Distillation,* a fourth edition of which was published in 1950.

Edwin Gilliland's work was highly acclaimed in the chemical engineering profession. In 1944, at age thirty-five, he received the Bakeland Medal and Award for Achievement in Chemistry, presented by the American Chemical Society (ACS). The ACS also awarded him the Industrial and Engineering Chemistry Award in 1959. The American Institute of Chemical Engineers (AIChE) presented Dr. Gilliland the Professional Progress Award in Chemi cal Engineering in 1950, the William H. Walker Award for outstanding publications in 1954, the Warren K. Lewis Award in Chemical Engineering Education in 1965, and the Founders Award in 1971. He was elected a Fellow of AIChE in 1971. Northeastern University awarded him an honorary doctorate in 1948.

Dr. Gilliland was elected a Member of the National Academy of Sciences (NAS) in 1948, where he served as Chairman of both the Section of Engineering and of Class III from 1966 to 1969. He also served the NAS on the Nominating Committee (1965-66) and the Finance Committee (from 1966 until his death). He was elected a Member of the National Academy of Engineering in 1965 and was a Member of the Committee on the Patent System (1968-70) and the Projects Committee (1968-71). He was a Member of the Division of Engineering of the National Research Council and a Member of the Executive Committee (1969-73).

Ed Gilliland was a highly successful industrial consultant who derived great stimulation from the challenge of applying scientific and engineering principles to the solution of the real problems of the chemical industry. His consulting relationship with Exxon was noted earlier. In 1946 he became a Member of the Board of Advisors of the American Research and Development Company (AR&D) and as such he became intimately involved in the affairs of several high technology companies that were provided venture capital by AR&D. One of these was Ionics, Inc., where Dr. Gilliland served as President from its formation in 1946 until 1964 and then as Chairman of the Board from 1964 until he resigned, in 1971. This association with Ionics kindled Gilliland's interest in electrochemistry, ion exchange, and electrodialysis, and his teaching and research programs at MIT in these areas stimulated a generation of his students. This was typical of Ed Gilliland's total professional involvement in a field. His academic research and theoretical work contributed greatly to the solution of real industrial problems, and the stimulation and challenge of the real problems he encountered in his consulting work were carried back to the classroom and to the research lab at MIT to stimulate and challenge generations of his students.

Ed Gilliland developed a close association with Bradley Dewey when they worked together on the rubber program during the war, and that relationship lasted throughout their lives. He served as a consultant and a director of the Dewey and Almy Chemical Company, and, when Bradley Dewey later formed the Hampshire Chemical Company, Gilliland served as a director of that company too. Dr. Gilliland served as a consultant to Merck for more than twenty-five years and to Deering Milliken for fifteen years. As evidence of the strength of that latter consulting relationship, Deering Milliken named their production plant at Laurens, South Carolina, the Gilliland Plant. Gilliland developed a number of other consulting relationships, most of them continuing over many years, including Freeport Sulphur, Goodyear, General Electric Co., Halcon International, and Nestle.

In 1938 Ed Gilliland married Ann Frances Miller, and they had a daughter, Gail, who is now Mrs. Grafton J. Corbett III. They made their home for many years in Arlington, Massachusetts, and in later years in Belmont. They also had a summer home on Cape Cod, where Ed enjoyed sailing, motor-boating, and swimming. His other hobbies were electronics-his basement was filled with television sets he was building from war surplus spare parts-and making and repairing antique clocks. He seemed to get his greatest enjoyment in life from the challenges of the intellect. He was an avid reader on a wide variety of subjects, and he took great delight in a debate on any subject from science to politics.

Ed Gilliland will long be remembered and sorely missed by his many friends and colleagues and by four decades of students who came to the Massachusetts Institute of Technology to study chemical engineering, many of whom were attracted there by the promise of studying under Edwin Richard Gilliland.

Peter Carl Goldmark

1906-1977

By Benjamin B. Bauer

Peter C. Goldmark, a Member of the National Academy of Engineering, President and Director of Research of Goldmark Communications Corporation, and previously for many years Chief Research Executive of Columbia Broadcasting System (CBS), died on December 7, 1977. He was widely acknowledged as one of the world's leading electronic inventors and innovators. He was responsible for more than 160 inventions in such fields as acoustics, television, phonograph recording, and film reproduction, which have had an important effect on the development of electronics for entertainment and education.

Prior to founding Goldmark Communications, Dr. Goldmark had the principal responsibilities for research at CBS. Starting in 1936 with two technicians and one room, he built an industrial research laboratory rated as one of the leading electronics and communications research organizations in the world. He retired as President and Director of Research of CBS Laboratories and Vice-President of Columbia Broadcasting System, Inc., on December 31, 1971.

As the head of Goldmark Communications Corporation, which he founded in January 1972, Dr. Goldmark continued research and development efforts in such fields as cable television, electronic publishing, satellite communications, and many others destined to have a profound effect on society and the quality of life for mankind.

One such project, which he conceived and directed prior to his death, was a national pilot study known as "The New Rural Society" (NRS). Initiated in 1970 by a blue-ribbon panel of experts selected at the request of a Presidential Advisory Committee by the National Academy of Engineering, NRS was a national program dedicated to reduce substantially the critical problems of crime, pollution, narcotics, and overcrowding in large cities by reversing the outmigration trend of people from rural America. The purpose of NRS was to find ways to apply communications technology to correct urban-rural imbalance and to provide Americans for the first time with a choice, whether to live and work in a rural or urban community.

As an inventor, Dr. Goldmark had adhered to a strong personal philosophy-to invent only if society could benefit from the results of invention. Two of his major inventions have been enormously influential and exemplify this philosophy. The long-playing record initiated a worldwide industry, which is now in its thirtieth year. Another innovation-the first practical color television-has brought about the TV color revolution; while his original system, shrunk by modern technology to a fraction of its original size, was used by the Apollo astronauts to bring man's first moon landing into the homes of television viewers everywhere.

Another of Dr. Goldmark's innovations was Electronic Video Recording (EVR), which was instrumental in encouraging parallel efforts of others that have led to video disc technology, currently being vigorously pursued by several companies in the United States and abroad.

Among Peter Goldmark's other important inventions was the first "high-fidelity" packaged, integrated phonograph, which used the volume of air within its enclosures to enhance the quality of sound; a pioneering reverberation generating device for livening the quality of recorded and broadcast music, a "talking-book" phonograph the size of a cigar box capable of four hours of recorded sound on a single seven-inch disc; a "crispening system" for sharpening television images; a rapid transmission system for recording up to thirty educational TV programs on a one-hour reel of magnetic tape; a music teaching program; and numerous others. Dr. Goldmark was always applying communication science to the improvement of the quality of mankind.

Peter Carl Goldmark was born in Budapest, Hungary, on December 2, 1906. He studied engineering at the University of Berlin and received a doctorate in physics from the University of Vienna. From 1931 to 1933 he worked on television developments at Pye Radio, Ltd., in Cambridge, England. He joined the Columbia Broadcasting System in 1936 as Chief Engineer of the Television Department and astounded the technical world with his pioneering color TV broadcasts from atop the Chrysler building in 1940. After service with the Radiation Laboratory at Harvard during World War II, he returned to his peace-time pursuits, founding CBS Laboratories and becoming its President in 1954.

He was a scientific activist, a Fellow and Life Member of the Institute of Electrical and Electronic Engineers, a Fellow of the Society of Motion Picture and Television Engineers, a Fellow of the Audio Engineering Society, a Fellow of the British Television Society, a Fellow of the Franklin Institute, a Fellow of the American Academy of Arts and Sciences, and a member of numerous other scientific organizations. He was elected to the National Academy of Engineering in 1967, to the National Academy of Sciences in 1972, and to the Connecticut Academy of Sciences and Engineering in 1976. He was a Trustee of the Connecticut Educational Telecommunications Corporation and a Visiting Professor at the University of Pennsylvania Medical School in Medical Electronics and of Fairfield University in Communications Technology.

Dr. Goldmark always has been active in the cause of human rights and the betterment of mankind. He has served as a chairman of numerous civic programs, including the Urban Coalition and the antipoverty agency. Outstanding among his accomplishments for minority groups was the spearheading of a nationally recognized rehabilitation and training program for some 500 low- and middle-income families of Stamford's Southfield Village. As Chairman of the National Academy of Engineering Panel on Urban Problems he sparked the concept of the "New Rural Soci ety," which calls for the imaginative use of telecommunications to revitalize rural towns and stem the outmigration of people from rural to urban areas.

Peter C. Goldmark received wide recognition for his scientific and humanitarian efforts. Among the twenty-three awards he received are the Morris Liebmann Memorial Prize for Electronic Research (1946); the Vladimir K. Zworykin Prize for Television Technology (1961); the National Urban Service Award "for his efforts in the War on Poverty" (1968); the David Sarnoff Gold Medal Award "for outstanding scientific contribution to the Advancement of Television Technology" (1969); the Elliott Cresson Medal, Franklin Institute, "for his many outstanding contributions to the Field of Electronics, and particularly with respect to the development of the long-playing record, a practical color television system and the home video playback system" (1969); the Carnegie-Mellon Institute Medal "for continuing leadership and contribution to the Betterment of Science for Mankind" (1972); and the National Medal of Science, which was bestowed upon him in 1977 only a few days before his death. Among the honorary degrees awarded to him were the Doctorate of Humane Letters from Dartmouth College, Doctorate of Science from Fairfield University, and Doctorate of Engineering from Polytechnic Institute of New York.

Peter C. Goldmark was a man who always gave and demanded from his associates total dedication to science and society, who inspired enthusiasm in his colleagues, and confidence in his sponsors. And with all this he was a dedicated citizen, a talented musician, a fine family man, and a warm and sensitive human being. His death was a great loss to science and to society. His contributions will long be remembered.

Harold Benedict Gotaas

1906-1977

By Burgess H. Jennings and Donald S. Berry

His many friends, colleagues, and engineering associates were greatly saddened at the untimely passing of Harold Gotaas on August 24, 1977, in Evanston, Illinois. At the time of his death, he was active on many committees and projects of public interest, serving from the office he continued to maintain at Northwestern University. In 1969, he had retired as Dean of Engineering. This position he had held for the prior twelve years, where under his leadership the Technological Institute had developed an outstanding graduate and research program to complement the undergraduate program, which he also directed with diligence. He relinquished all his academic responsibilities in 1975 to assume emeritus status as Walter P. Murphy Professor of Civil Engineering and Dean of Engineering.

Harold Benedict Gotaas was born September 3, 1906, in Melette, South Dakota. He received his Bachelor of Science degree in civil engineering from the University of South Dakota in 1928 and his Master of Science degree in civil engineering from Iowa State College in 1930. After two years of service as a structural engineer he joined the faculty of the University of South Dakota. Having developed a strong interest in sanitary engineering, he resigned in 1936 to attend Harvard Graduate School, receiving his Master of Science degree in 1937. He then became Assistant Professor in the Graduate School of Public Health at the University of North

Carolina, becoming a full Professor in 1941, and receiving a Doctor of Science degree in engineering from Harvard in 1942.

Gotaas entered the army during World War 11, working in the Institute of Inter-American Affairs. He succeeded Nelson Rockefeller as President of that corporation until his resignation from active duty in 1946 after reaching the rank of colonel. He then joined the University of California (Berkeley) as Professor of Sanitary Engineering, in 1949 becoming Chairman of the Civil Engineering Division and Head of the Sanitary Research Laboratory. In 1957 he resigned to accept his final academic assignment as Dean of Engineering of the Technological Institute of Northwestern University.

He served on many committees, boards, and panels, notably membership on the Great Lakes Commission, Northeastern Illinois Planning Commission, U.S. Environmental Protection Agency, and Inter-American Association of Sanitary Engineering. Many significant activities were also carried on through the professional societies in which he took an active part.

Awards and decorations came to him in many areas, of which the following are most significant: Legion of Merit, United States; Order of Condor of the Andes, Bolivia; Order of Merit, Chile; Cross of Boyaca, Colombia; Order of Honor and Merit, Haiti; Harrison P. Eddy Medal, Water Pollution Control Federation; Kenneth Allen Award, Water Pollution Control Federation; Gordon Maskew Fair Medal, Water Pollution Control Federation; James R. Croes Medal, American Society of Civil Engineers; Rudolph Hering Medal, American Society of Civil Engineers; Marston Medal Award, Iowa State University; Chicago Civil Engineer of the Year, 1974, ASCE; Engineer of the Year, 1961, Illinois; Honorary Member, ASCE; Honorary Member, Western Society of Engineers; National Honorary Member, Triangle Fraternity; D.Sc. (Honorary), University of South Dakota; D.Eng. (Honorary), Rose-Hulman Polytechnic Institute; Distinguished Service Recognition, Great Lakes Commission; National Academy of Engineering, 1967.

Dr. Gotaas participated actively in committee work and on assignments for the National Academy of Engineering, serving with:

NAE Project Committee-1968-1974 (Member), Subcommittee on Human Welfare 1968-1970 (Chairman); NAE 1970 Annual Meeting-Panel on World Population (Member); NAE Committee on International Activities-1970-1973 (Member); NAE Project Committee, Panel on Environment-1970-1974 (Chairman); NAE Committee on Membership-Civil Engineering Peer Group-1974-1975 (Member); NAE Committee on Membership-Foreign Associates Search Task Group-1977 (Member).

He also served on a number of National Research Council committees and panels.

Although continuously busy, Harold B. Gotaas found time to write one book and more than one hundred research papers covering the environment, water, waste treatment and control, engineering education, and economic development problems. Best known as a sanitary engineer, his many-faceted career enabled him to contribute significantly in many other areas, in particular to engineering education. He is gone, but his work lives on and he will long be remembered by all who had the privilege of knowing him.

George Andrew Hawkins

1907-1978

By John C. Hancock

George Andrew Hawkins, former Dean of Engineering and former Vice-President for Academic Affairs at Purdue University, died in his sleep at his home in West Lafayette, Indiana, on April 6, 1978. He had retired in 1974, after forty-four years of service to the University. He was seventy years old at the time of his death.

Dr. Hawkins' lifelong career was largely in the field of engineering education as a student, researcher, teacher, and administrator. His early research on high-temperature, high-pressure steam was a noteworthy contribution to the technology of that field. This research prompted his advanced postdoctoral study of theoretical thermodynamics and heat transfer and led to his coauthoring a book in this field. He was cited at that time as the nation's outstanding young man in the field of heat transfer.

As a faculty member of Purdue University, he was an innovative teacher and administrator, having a significant impact on engineering education. He was Dean of Engineering during the years following World War II and was one of the first in the nation to lead his faculty in incorporating into their programs the new knowledge and techniques that evolved from research conducted during the war. He was cochairman of the 1968 "Goals Report" study, which did so much to establish national directions for engineering education at that time. All through his academic career, be he teacher or administrator, he remained actively involved in research and consulting in his area of thermodynamics and heat transfer. He, with his graduate students, made many contributions to the technology and the understanding of this area.

George Andrew Hawkins was born in Denver, Colorado, on December 11, 1907. He received his grade school education first in Denver and continued it in Long Beach, California. Following grade school, his family returned to Denver, where he attended Byers Junior High School. He then enrolled in and was graduated from East High School, Denver, Colorado, in 1926. He began his university work with two summer terms, and the full year between, at the Colorado School of Mines in Golden, Colorado. At that point, he transferred to Purdue University, where he completed his work and received his Bachelor of Science degree in mechanical engineering in June of 1930. After graduation, he joined the Purdue University staff as an Assistant in Applied Mechanics, while pursuing graduate study that earned him his Master's Degree in mechanical engineering in 1932 and his Doctor of Philosophy degree in 1935. During the summer of 1933, while still working on his doctorate at Purdue, he studied advanced mathematics at the University of Denver.

Joining the Purdue faculty as an Assistant Professor following the Ph.D. award, he taught in the School of Mechanical Engineering. In 1938-39, still intrigued by phenomena not completely understood, he took a year's part-time leave of absence to study theoretical thermodynamics and heat transfer under Dr. Max Jacob, who had just come to this country from Germany. This work led to the book, *Elements of Heat Transfer and Insulation,* jointly authored by Jacob and Hawkins (1942), and which led to Dr. Hawkins being cited as the nation's outstanding young man in the field of heat transfer. In 1940, at the annual meeting of the American Society of Mechanical Engineering, he was awarded the Pi Tau Sigma gold medal.

Dr. Hawkins advanced steadily through the professorial levels and was made a full Professor of Mechanical Engineering at Purdue University in 1942. One year later he was named Westinghouse Research Professor of Heat Transfer. For many years he was also on the staff of the Engineering Experiment Station and was named its Associate Director on July 1, 1950. In his research capacity, he performed a number of noteworthy investigations. He collaborated with Dean A. A. Potter and Dr. H. L. Solberg in studies of high-pressure and high-temperature steam. During World War II he was chosen to direct the U.S. Army Ordnance Research Project located at Purdue. The work carried out under his direction brought a special citation to Purdue University for developments leading to improved automatic weapons. For his own personal contributions, he received the War Department's Certificate of Appreciation.

At Purdue in 1947, he was made the Assistant Dean of the Graduate School and for fifteen months of that appointment, he served as Acting Dean. From July 1, 1949, to June 20, 1950, he was given leave from Purdue to be a Visiting Professor of Engineering at the University of California at Los Angeles. On July 1, 1953, he assumed the position of Dean of Engineering and Director of the Engineering Experiment Station, succeeding Purdue University's famous Dean of Engineering, Dr. A. A. Potter. For the period 1961-63, in addition to his responsibilities as Dean of Engineering, he was given the administrative responsibilities for the Department of Mathematical Sciences at Purdue University.

During the early years of his term as Dean of Engineering, educational programs were being impacted heavily by the information explosion that followed the release of information generated by research carried on during World War II. Assessing the importance of these developments, Dr. Hawkins was convinced that the next generation of engineers would have to be steeped in the physical and engineering sciences if they were to be able to design the complicated systems being envisioned by American industry. With imagination and courage, he took the steps required to sensitize the faculty to these developments and they, in turn, acted to achieve a major revision of the engineering curriculum at Purdue. Purdue's engineering curriculum was a model for other schools to follow-thus assisting the change to spread all across the nation.

Dr. Hawkins worked with faculty, using faculty seminars, personal contacts, and invited scholars to challenge them to familiarize themselves with the new concepts and the new technology that was emerging. He stressed the need to be prepared for change. He also believed that contemporary engineers should have a better understanding of the social sciences and the humanities if they were to respond to society's needs and demands. His ideas about a dynamic and changing curriculum were challenged and resisted by some; but with patience and sincerity, he pressed his points. Younger members of the faculty rallied to his cause, and he, in turn, encouraged them to absorb themselves in the work at the scientific frontier of engineering. This they did with a sense of pride and dedication; and curricula changed to reflect an emphasis on applied science rather than the "art" of engineering. Despite his administrative responsibilities, he, himself, devoted as much time as he possibly could to remain at the research forefront of his own specialty-heat and mass transfer.

On the national scene in the early 1960's, Dr. Hawkins was asked to be cochairman of the American Society of Engineering Education's goals study. This study was undertaken at the request of the Engineers Council for Professional Development and was financially underwritten by the National Science Foundation. Once more he made clear his beliefs in a scientifically oriented engineering curriculum, heavily bolstered by advanced graduate study. He was joined in this by many educators who contributed to this study; but again he ran into opposition from some educators across the country. However, as time went by, the view expressed in the Goals Report, was, by and large, accepted nationally.

On July 1, 1967, Dr. Hawkins was appointed Vice-President for Academic Affairs; and, at a meeting of the Board of Trustees in September 1971, he was designated Vice-President Emeritus for Academic Affairs. Following his retirement, he served the University in several postretirement positions, among which was one year as Acting Dean of Engineering, Acting Head of Aeronautical Engineering, Interim Provost, Special Assistant to the Provost, and others. He finally retired in July 1974, retaining the titles of Professor Emeritus of Thermodynamics, Westinghouse Research Professor Emeritus of Heat Transfer, and Vice-President Emeritus for Academic Affairs.

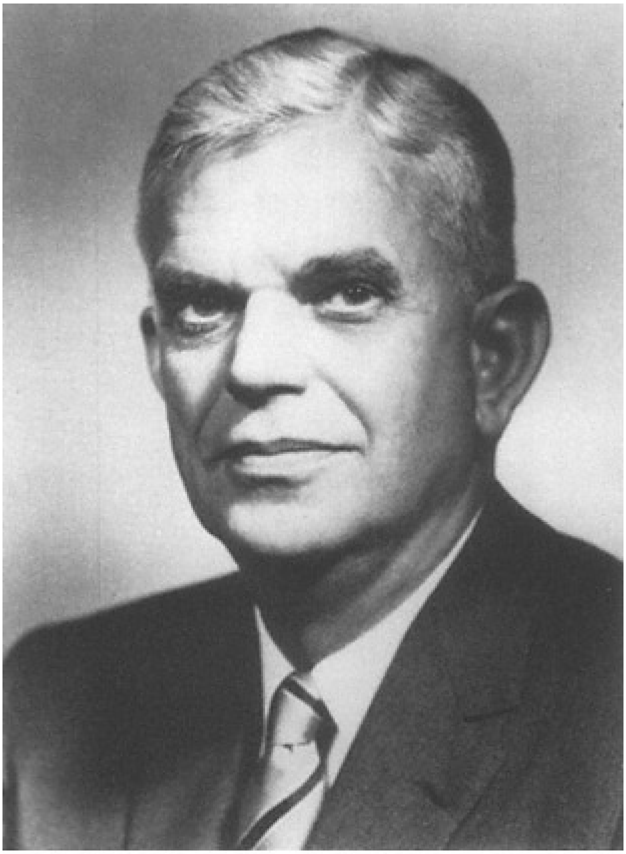
Dr. Hawkins was elected to membership in the National

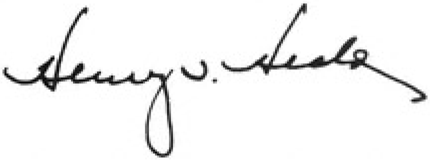
Academy of Engineering (April 1967). He was a Life Fellow and Honorary Member of the American Society of Mechanical Engineers, a Fellow of the American Institute of Chemical Engineers, and an Honorary Member of the American Society for Engineering Education (ASEE). In 1969-70 he was President-Elect and in June 1970 he became President of this latter organization. In June 1974, Dr. Hawkins was honored by being awarded the Lamme Gold Medal by ASEE. He also held memberships in the National Society of Professional Engineers, Scabbard and Blade, Sigma Xi, Tau Beta Pi, Pi Tau Sigma, Phi Kappa Phi, and Sigma Pi Sigma.

Dr. Hawkins is the author of five college textbooks and the author of approximately 240 articles and abstracts on engineering and related subjects, a number stemming from his own research work. He served as a consultant to a number of industries and to governmental and other organizations.

His hobbies included rifles and pistols, collection of selected categories of stamps, and wood carving (using both machine and hand tools-especially in the making of decorative water fowl and the Hopi Indian Kachina dolls). In this last category he was considered an expert, both as a craftsman with a knife and as a curator of the legends that surround each of the more than 280 varieties of these Kachina figures.

Until his death, George Hawkins was a scholar, artist, artisan, engineer, and friend. He leaves behind a rich heritage in the field of engineering education, both at Purdue University and throughout the nation.





Henry Townley Heald

1904-1975

By John A. Hrones

Henry Townley Heald, retired president of the Ford Foundation, died November 23, 1975, in Winter Park, Florida. For a decade, as President of the Ford Foundation, he played a key leadership role in the development of engineering and science in the United States. During this period (1956-66), university education and research in engineering and science experienced its greatest growth in scope and quality.

Dr. Heald was born in Lincoln, Nebraska, on November 8, 1904. His father, Frederick DeForest Heald, was a distinguished plant pathologist. Henry Heald received a Bachelor of Science degree in 1923 from Washington State College. Two years later he was awarded a Master's degree in civil engineering at the University of Illinois.

After two years practice as an engineer in Chicago, Dr. Heald began his distinguished career at the Illinois Institute of Technology, at that time the Armour Institute of Technology. He successively held the positions of Assistant Professor (1927-31), Associate Professor (1931-34), Dean of Freshman (1933-34), Professor of Civil Engineering and Dean of Engineering (1934-38), and President (1938-52).

The early years of Dr. Heald's presidency were critical ones. Without his perseverance in building a strong board of directors and his early success in fund-raising, the institution might well have closed. He led a successful effort to build the Armour Research

Foundation, which drew the interest of Midwest industry. A spectacular growth in research was paralleled by the development of a strong graduate program.

Dr. Heald was instrumental in bringing about the consolidation of Armour Institute of Technology and Lewis Institute to form the Illinois Institute of Technology in 1940. His presidency of the combined institutions was a successful struggle to achieve both quality and financial stability.

In 1952 Dr. Heald became Chancellor of New York University (NYU), one of the largest private universities in the United States. There, his administrative ability and the confidence that funding sources had in his leadership enabled him to strengthen NYU and to enable the University to cope effectively with its manifold problems derived from its urban location. In addition, he was Chairman of the New York State Commission on Educational Finances, which issued a comprehensive report, "Financing Public Education in New York State, 1956." He also chaired the Committee on Higher Education in the State of New York which issued a report, "Meeting the Increasing Demand for Higher Education in New York, 1960." Recommendations included in these reports were important building blocks in the reshaping of higher education in the State of New York. His tenure at NYU was constructive and successful, and he won the respect of all his contemporaries in urban higher education.

In 1956 Dr. Heald became President of the Ford Foundation, a position in which he served with vision and energy. During the period of his presidency (1956-66), the Ford Foundation committed approximately $1.75 billion for philanthropic purposes. Under his leadership, the Foundation established programs in the arts, the physical sciences and engineering, and in demographics; expanded overseas programs to Africa, Latin America, Japan, and Australia; inaugurated major school and community programs in low-income city neighborhoods; stimulated the growth of noncommercial television; created the Educational Facilities Laboratories; and initiated a special and extremely valuable program of unrestricted grants to support the long-range development of private universities and colleges. The Foundation, under his able leadership, demonstrated, often in a brilliant and imaginative way, how much a great philanthropic organization can do to develop and support the culture and welfare of an entire nation and of others beyond its borders.

Dr. Heald was a Charter Member of the Board of Trustees of the Asian Institute of Technology (Bangkok). He played a leading role in the founding of this private international graduate school of engineering, which attracts talented men and women from more than twenty countries.

In 1966 Dr. Heald founded the consulting firm of Heald, Hobson and Associates, which provided assistance to educational, research, and philanthropic organizations. He directed the study that recommended the federation of Case Institute of Technology and Western Reserve University. In 1967 those two institutions united to become Case Western Reserve University.

Dr. Heald was a member of numerous professional and honorary societies and served terms as President of the American Society of Engineering Education, President of the Western Society of Engineers, President of the Association of Urban Universities, and Chairman of the American Council on Education. He was the recipient of twenty-one honorary degrees. Other awards included the Navy Award for Distinguished Civilian Service, the Washington Award of the Western Society of Engineers, the Gold Medal of the National Institute of Social Sciences, and the Hoover Medal. He was elected a member of the National Academy of Engineering in 1965.

Dr. Heald's business affiliations included directorships of Equitable Life Assurance Society, American Telephone and Telegraph Company, United States Steel Corporation and Lever Brothers Company.

Henry Heald commanded the respect of all who worked with him. He was quiet yet determined in manner. He was a good listener. His thoughtful forward-looking leadership earned the respect of his colleagues, whose support of his programs made possible the enormous influence he had on higher education. This influence continues through the institutions his wise counsel helped shape. We who knew him are grateful to have had the opportunity to work with him.


Hubert Heffner

Hubert Heffner

1924-1975

By John R. Whinnery

Hubert Heffner, Professor of Applied Physics at Stanford University, died on April 1, 1975. He was a brilliant researcher, an inspiring teacher, and a tireless contributor to the Academy, to the U.S. Government, and to his profession.

Dr. Heffner was born in Lincolnton, North Carolina, on December 26, 1924. He received his Bachelor of Science degree in physics in 1947, his Master's degree in electrical engineering in 1949, and his Doctor of Philosophy degree in electrical engineering in 1952, all from Stanford University. Following two years of research at the Bell Telephone Laboratories, Murray Hill, New Jersey, he was appointed Assistant Professor of Electrical Engineering at Stanford in 1954, was advanced to Associate Professorship in 1957, and became Professor of Electrical Engineering and Applied Physics in 1960. He was Acting Chairman of the Applied Physics Division at Stanford in 1962, Associate Provost and Dean of Research for the period 1963-67, and was Chairman of the Applied Physics Department at the time of his death.

On a leave from Stanford in 1960-61, Dr. Heffner served as Scientific Liaison Officer for the London Office of the U.S. Office of Naval Research. His most important assignment with the Federal Government came on a second leave in 1969-71, when he served as Deputy Director of the Office of Science and Technology of the President. Lee DuBridge was Director at that time, and Much important policy was formulated on a variety of issues, including transportation, telecommunications, and early studies of the energy problem. Dr. Heffner was a member of many important advisory committees for the Government and for his professional societies. Among these were the "Tycho" Space Science Study Group for the National Aeronautics and Space Administration and the Advisory Group on Electron Devices of the Department of Defense. He was Chairman of the Working Group on Microwave Devices of this last organization for the period 1961-67. Other prestigious boards on which he served included the Defense Science Board, the General Advisory Committee of the Atomic Energy Commission, the President's Committee on the National Medal of Science, and the National Science Board.

Dr. Heffner was active on Academy assignments as well. He was a member of the National Academy of Engineering (NAE) Committee on Engineering Manpower Policy and Chairman of the Panel on Education of the NAE Project Committee from 1972 to 1975. In the National Research Council he served on the U.S. National Committee for the International Union of Radio Science (URSI) and was U.S. Chairman for Commission VII of that body. He served also on the Committee for AEC Postdoctoral Fellowships and the Evaluation Panel for the National Bureau of Standards' Institute of Applied Technology. In the Institute of Electrical and Electronics Engineers (IEEE), he was a Member of the Editorial Board for the Transactions of the Professional Group on Electron Devices (GED), Vice-Chairman of the GED, Chairman of the Inter-Society Joint Council on Quantum Electronics, and a member of the Board of Directors from 1968 to 1970. He was a Fellow of both the IEEE and the American Physical Society.

While at the Bell Laboratories, Heffner, working with Clogston, did some of the first fundamental work on periodic focusing for traveling wave tubes, resulting in a classic paper and several patents on that subject. Traveling wave tubes before that time were solenoid-focused, but now almost universally employ the lighter and less costly periodic focusing methods. His analysis of the backward-wave tube in 1954 was also the standard reference on that device during the important period of its development. At Stanford University he continued his definitive analyses of the newer microwave devices, including parametric amplifiers, E-type traveling-wave devices, and masers. The latter part of his work focused on quantum electronics with special analysis of quantum noise problems, nonlinear effects, and the quantum limits on measurement. He guided the work of many influential graduate students in both the microwave and quantum electronics fields and was known as a clear and incisive teacher. He was a much sought-after consultant both for industry and for policymaking organizations of the government.

At the time of Dr. Heffner's death, Norman Hackerman, Chairman of the National Science Board and President of Rice University said, "It is with deep regret that the Board learned of the death of Dr. Heffner. We knew him as an especially able scientist, and a thoughtful and dedicated administrator particularly interested in and knowledgeable in the area of science policy. Equally important, he was recognized by his students and his colleagues as a skillful teacher. His wisdom will be greatly missed." H. Guyford Stever, then Director of the National Science Foundation, stated, "Dr. Heffner made substantial contributions to the academic and scientific communities, industry, and international bodies through his scientific expertise and wise counsel. Significant among these were his efforts as a member of the Science Policy Working Group of the U.S.-U.S.S.R. Joint Commission on Scientific and Technical Cooperation. He will be missed by his colleagues and by the larger community he served so willingly and so well."

Hu Heffner is much missed by all who knew and worked with him, but he left a fine legacy of classic, fundamental papers and enduring contributions to sound policy for our country.

Arthur Thomas Ippen

1907-1974

By Hunter Rouse

Arthur T. Ippen, Massachusetts Institute of Technology (MIT) Professor Emeritus, died on April 5, 1974, of a heart attack at his home in Belmont, Massachusetts. An internationally known hydraulic engineer, his many professional contributions had been almost equally divided among the fields of education, research, and consulting, and his great personal warmth made him as widely loved as respected.

Born in London, England, of German parents on July 28, 1907, Dr. Ippen was educated in the schools of Lindau-am-Bodensee and Aachen, Germany, the Technische Hochschule of the latter city granting him the Diplom-Ingenieur degree in civil engineering in 1931. During his undergraduate years he served as draftsman with the municipal waterworks of Aachen, and the year thereafter as teaching and research assistant with the Hochschule. In September of 1932 he received an exchange fellowship from the Institute of International Education and journeyed to Iowa City for graduate study and research in hydraulics at the State University of Iowa. After the sudden death of his faculty advisor, Floyd Nagler, he transferred to the California Institute of Technology in December of 1933, where he was to remain the next five years as graduate student, research associate, and instructor.

Under California Institute of Technology professors Theodor von Kármán and Robert Knapp, Ippen conducted experimental and analytical investigations in the fields of sediment transport and high-velocity open-channel flow. His doctoral dissertation (1936) on the latter topic represented the first American development of the sonic-wave analogy to free-surface flow. Continued research and writing on this subject earned him an award from the American Society of Civil Engineers, and his experimental technique soon found application in the wave tanks supplementing supersonic wind tunnels.

Dr. Ippen received an appointment as Instructor in Civil Engineering at Lehigh University in August of 1938; there he assumed charge of instruction and research in hydraulics and was promoted to Assistant Professor in 1939. Principal among his projects was the determination of the influence of fluid viscosity on the performance of centrifugal pumps. In September 1945 Ippen accepted an appointment as Associate Professor of Hydraulics in the Civil Engineering Department at MIT. There he took over the operation of a small river hydraulics laboratory dating from before World War II and began the fourfold task of teaching, attracting a staff and graduate-student following, developing a research program, and designing a new laboratory.

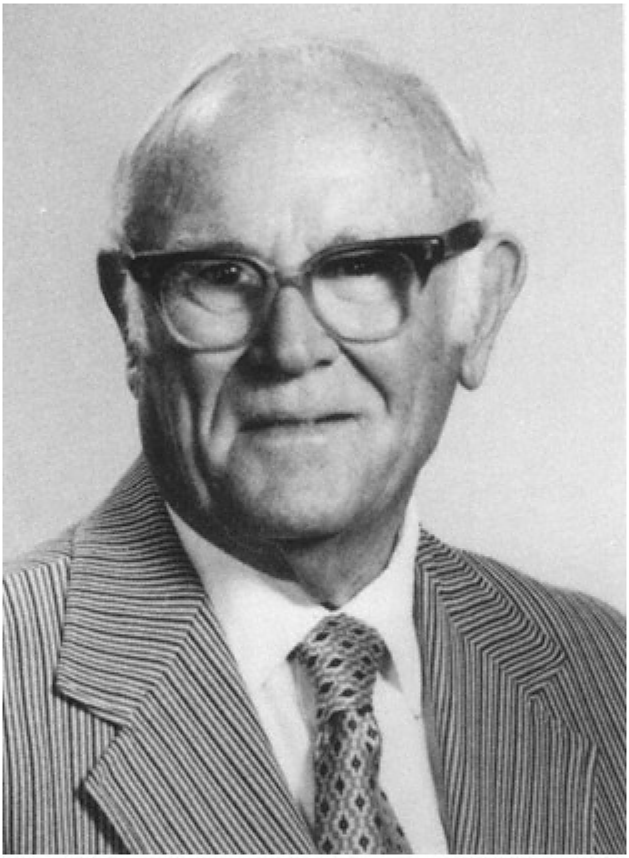
The resulting two-story structure was completed in 1951 and dedicated as the MIT Hydrodynamics Laboratory. By this time a senior staff of five and thirteen graduate assistants had been enlisted, and a dozen or more contract projects were under way. Initial fields of study included the sonic analogy, transient flows, instrumentation, turbulence, cavitation, shoaling waves, stratified flow, and sediment transport. With the passage of time, the staff and student body continued to increase in size and quality, and the additional fields of water resources and coastal engineering came to receive primary emphasis in the program. Eventually, in 1970, the laboratory structure was enlarged by two more stories and renamed the Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics, and three years later Dr. Ippen retired from its directorship.

During the course of his professional life, Dr. Ippen published some fifty-eight technical papers, edited one book, and was the author or coauthor of twenty-nine laboratory reports on contract research. He held more than thirty consulting appointments with industrial firms, governmental agencies, and foreign countries. He traveled extensively, both as a consultant and as a lecturer, and spent sabbatical leaves in Germany and in Japan. For several years he chaired the MIT Council on International Affairs, overseeing joint programs with institutions such as the Technical University of Berlin and the Birla Institute of Technology in India. A particular love was the International Association for Hydraulic Research (IAHR), which he served as President from 1959 to 1963; two noteworthy accomplishments during this period were the establishment of the association's *Journal of Hydraulic Research* and the encouragement of regional meeting, initially in Latin America and later in Asia. He was likewise active in the Hydraulics Division of the American Society of Civil Engineers (ASCE), serving in 1959-60 as Chairman of its Executive Committee; he also chaired three other committees and was involved in establishing the Engineering Mechanics Division.

Dr. Ippen was elected to the National Academy of Engineering in April 1967. He also held membership in the following organizations: Tau Beta Pi, Chi Epsilon, and Sigma Xi fraternities; the American Academy of Arts and Sciences; American Academy of Environmental Engineering; American Geophysical Union; American Society for Engineering Education; American Society of Mechanical Engineers; American Water Resources Association; and the Boston Society of Civil Engineers (President, 1960-61). Included among the many honors that he received were doctorates from the University of Toulouse, France, the University of Karlsruhe, Germany, and the University of Manchester, England; honorary membership in the Japan Society of Civil Engineers, the International Association for Hydraulic Research, and the Venezuelan Society of Hydraulic Engineers; the Vincent Bendix Award of the American Society for Engineering Education, the Prechtl Medal of the Technical University of Vienna, the Karl Emil Hilgard Prize of the ASCE, the Outstanding Civilian Service Medal of the Department of the Army, the Distinguished Alumnus Award of Caltech; a Ford Professorship at MIT; and finally the MIT Institute Professorship.

While still at Pasadena, Arthur Ippen married Elizabeth

Wagenplatz, whom he had known as a student at Aachen, and their two children-Erich Peter and Karen Ann-were born during their years in Bethlehem. His wife died in 1953. In 1955 Ippen married Ruth Calvert of Pasadena, who was to share the remaining two decades of his very productive life. His second heart attack, in 1974, proved fatal. In addition to his wife and two children, he left behind a step-daughter, a brother in Germany, and three grandchildren-not to mention the memories cherished by countless former students, colleagues, and friends throughout the world.



Lydik Siegumfeldt Jacobsen

1897-1976

By John A. Blume

Lydik Siegumfeldt Jacobsen, Stanford University Professor Emeritus, Member of the National Academy of Engineering, Past President and Honorary Member of the Seismological Society of America, and first President of the Earthquake Engineering Research Institute, died on December 22, 1976, following a stroke.

Dr. Jacobsen was internationally known for his pioneering work in determining the dynamic characteristics of buildings and other structures and their response to earthquake ground motion and other disturbances, as well as for his research and teaching in vibrations and dynamics. He directed the Vibration Laboratory at Stanford University from 1926 until his retirement, in 1962, and was Head of the Mechanical Engineering Department from 1949 to 1961. He coauthored, with Robert S. Ayre, a standard text, *Engineering Vibrations* (McGraw Hill, 1958), and he wrote many technical papers.

Lydik Jacobsen was born June 17, 1897, in Nyborg, Denmark, where his father owned a steam-powered flour mill. After completing the Danish equivalent of an American high school education, Lydik worked in various flour mills and at a fish hatchery, where he enjoyed manual labor. In 1917, his father, Hans Christian Jacobsen, sold his mill and took his wife and five children, including Lydik, to California. Lydik began work in the Sperry Flour Mill in Stockton, California, where he soon supervised all machinery on one floor. Because of his growing interest in the mechanical aspects of milling, he was encouraged to attend Stanford, where he obtained his Bachelor of Arts degree in mechanical engineering after three years of accelerated study. In 1921 he became a junior engineer with Westinghouse Electric Corporation in Pittsburgh, Pennsylvania, where he worked with S. Timoshenko. In 1924 Professor Durand, another engineer who later became famous, persuaded Lydik to return to Stanford for graduate study and provided him with an instructorship as a source of financial aid.

In 1927 Lydik obtained his Doctor of Philosophy degree in physics at Stanford and also became a U.S. citizen. That same year, with some financial aid obtained by Dr. Bailey Willis, he started a vibration laboratory at Stanford with a large shaking table. The combination of the 1925 Santa Barbara earthquake, Dr. Willis' aid and encouragement, and the opportunity to apply his knowledge of vibration from physics and mechanical engineering all contributed toward developing Dr. Jacobsen's interest in the problem of how buildings respond to earthquake-induced ground motion.

In 1931 Dr. Jacobsen was awarded a Guggenheim fellowship in applied mechanics that enabled him to visit universities and laboratories in five European countries. He became a Full Professor in Mechanical Engineering at Stanford in 1936. He was a Visiting Professor at the University of Michigan in 1938 and at the Illinois Institute of Technology in 1941. During a leave from Stanford in 1953 and 1954, he was a Fulbright Professor at Den Polytekniske Laeranstalt (the Danish Polytechnic Institute) in Copenhagen. After he retired from teaching, in 1962, he cofounded Agbabian-Jacobsen Associates, a consulting engineering firm, in which he was active until he retired in 1969. He continued his individual consulting practice until his death.

During World War II, he analyzed 271 U.S. Navy ships of all types and served aboard 130 of them to study ways to reduce sounds and vibrations and thus decrease detection by enemy submarines. He left the service in 1946 as a Commander in the Naval Reserve and with a U.S. Navy Commendation Medal.

Dr. Jacobsen published about forty scholarly, thorough, and precisely written papers involving a great deal of thought and effort on new subject matter in whose development he, personally, had played either a sole or a major role, including mechanics, stress analysis, vibrations, models, dynamic behavior of models, damping, shock, blast effects, ship vibrations, hydrodynamics, shaking table research, mathematics, and earthquake motion. In addition to his published works, he wrote many reports, both public and private, for clients during his decades of consulting work for industry and Government; such unpublished reports by a consultant of Dr. Jacobsen's caliber often involved more complexity, discovery, and innovation than was generally found in his published works.

Dr. Jacobsen received many honors and awards, but no doubt fewer than he deserved because of his frank honesty in all matters and also because his audience's understanding rarely matched his own. He was a pioneer in earthquake dynamics, but he was also a mechanical engineer, a mathematician, and a physicist who attempted to explain new and complex building dynamics to structural engineers, architects, and public officials. The work was made more difficult with warning public interest in such matters shortly after each damaging earthquake.

He was elected to the National Academy of Engineering in 1975; his citation was for "outstanding research, teaching, practice, and writing in mechanical and structural vibrations and shock." He served as President of the Seismological Society of America from 1953 to 1955 and was elected an Honorary Member in 1974. He was Chairman of the U.S. Coast and Geodetic Survey's Advisory Committee on Engineering Seismology from 1947 to 1949. He was one of the founders and the first President of the Earthquake Engineering Research Institute in 1949 and was elected an Honorary Member in 1969. He was a Fellow of the American Society of Engineering Education. His accomplishments are listed in *Who's Who in America, Who's Who in Engineering, American Men of Science, Blue Book of Denmark,* and *Danes in the World*.

Lydik Jacobsen was a dynamic person in every sense of the word-intelligent, vigorous, enthusiastic, energetic, friendly, fluent, greatly interested in people as well as in science and engineering, and a dedicated worker with much endurance. He enjoyed his work, especially research or a challenging, difficult problem. He was proud of the fact that, in 1975, eight of his former students were members of the National Academy of Engineering.

Lydik Jacobsen was respected by all his peers, even those who might not always agree with him. Some of Dr. Jacobsen's work-for example, his development of the phase-plane-delta method of treating inelastic, nonharmonic, vibrating systems-would have been much more widely applied had it not been for the computer, which later made such procedures unnecessary. The same is true of his dynamic (mechanical) models of buildings tested on the shaking table, which were replaced by electric analogs or by high-speed digital computers. Nevertheless, the pioneering innovation was there, and it helped to provide a solid base for later development with more exotic equipment. Lydik Jacobsen's pioneering work in vibrations and in approaching the earthquake problem as one of dynamics rather than statics was a great milestone that shall always be on record, remembered by all who knew him, and appreciated in the future by those who did not know him.

Dr. Jacobsen's survivors, besides his widow Mary Louise of Laguna Hills, California, include his first wife, Doris (Wetzel), of Menlo Park; two sons, Erland, of Fresno, and Ian, of Honolulu; and a daughter, Ellen Yazar, of Ankara, Turkey. His brother, Theodor, a retired professor of astronomy, lives in Seattle; a sister, Ingrid Wilson lives in Los Angeles; and two sisters, Kirsten Gregersen and Lisse Lindman, live in Santa Barbara.

Stephen Moore Jenks

1901-1974

By James B. Austin

Stephen M. Jenks, who retired in 1966 as Executive Vice-President-Engineering and Research for the United States Steel Corporation, died in Pittsburgh on April 12, 1974, at the age of seventy-three. During his forty years of service with U.S. Steel, he became one of the steel industry's best-known engineers and executives. Although he had been widely recognized within the company for his engineering skill, he first came into national prominence as General Superintendent of the great Gary Steel Works, at Gary, Indiana, during the years 1940 to 1949, when the production of that plant was critical for the war effort. In later years, as head of research, he exerted a prime influence on the development of the first large-scale continuous slab-casting facility at Gary, and he made significant contributions to the development and installation of automatic controls on rolling mills. Beyond these professional achievements, he was as much interested in men as he was in machinery and materials.

Stephen Jenks was born in Port Huron, Michigan, on February 18, 1901. Following early schooling there, he went to Cornell University, from which he received the degree of Mechanical Engineer in 1923. After graduation he worked for a brief period as a blast furnace blower at the Aliquippa Plant of Jones and Laughlin Steel Corporation. In 1925 he began his long association with U.S. Steel by joining the American Steel and Wire Company, then a subsidiary, as an engineer. Four years later he was transferred to

Gary, Indiana, as a fuel engineer, but he returned to Pittsburgh in 1933 as a power engineer. He was promoted to Assistant Chief Engineer in 1935, and a year later became Chief Engineer of the Construction Division of Carnegie-Illinois Steel Corporation, another subsidiary of U.S. Steel. In 1937 he returned to Gary as Chief Engineer of Gary. Steel Works and in that same year was named Assistant General Superintendent. In 1940 he was appointed General Superintendent.

Nine years later, he was made Manager of Operations for the Chicago District of Carnegie-Illinois Steel, but in 1950 he was named Vice-President-Operations with headquarters in Pittsburgh. When Carnegie-Illinois Steel Corporation was merged into U.S. Steel in 1951, he was appointed Vice-President of Manufacturing. In 1959 he became Executive Vice-President-Engineering and Research, a position he held until his retirement in 1966.

In recognition of his many outstanding accomplishments, in 1956 the American Institute of Mining, Metallurgical and Petroleum Engineers gave Stephen Jenks the Benjamin F. Fairless Award with the citation: "For distinguished achievements in iron and steel production and ferrous metallurgy." When the United States inaugurated a series of technical exchanges with the Soviet Union in 1958, the first delegation to visit Russia was a group representing the American steel industry. Stephen Jenks was a prominent and valuable member of this team. In 1966 he was made a Fellow of the American Society of Mechanical Engineers, and in 1968 he was elected to the National Academy of Engineering. From 1970 to 1972 he served on the Ad Hoc Panel on the Abatement of Sulfur Dioxide Emissions from Industrial Sources of the NAE-NRC Committee on Air Quality Management.

Among his special technical interests were the blast furnace and the open hearth processes that he was constantly trying to improve. He was a strong advocate of the use of sintered ore in the former and was much concerned about the development of better refractories for both of them. What he saw in the Soviet Union during his visit there led him to intensity his efforts to expand the use of sinter within U.S. Steel, and he became a leader in the design and construction of large ore-sintering plants. He also stressed the need for improved refractories and for better designs for open hearth furnaces.

One of Stephen Jenks' most notable engineering efforts, however, was the building of a defense armor plant within six months during World War II. Under a contract placed by the Defense Plant Corporation with U.S. Steel in April 1942, he directed the design and construction of a complete seventy-five-acre plant for rolling, flame cutting, heat treating and testing armor plate for tank tops. This involved moving a complete rolling mill and its motor drive from Gary Steel Works to a new location about a mile away. The plant went into production in October 1942.

In spite of his many professional responsibilities, he always found time to engage in civic affairs. While at Gary he was Director, and at one time First Vice-President, of the Indiana State Chamber of Commerce. He served for a time on the Indiana Governor's Tax Study Commission. He was Director of the Gary Industrial Foundation and of the Community Chest. Throughout World War II he was Chairman of the Gary Chapter of the American Red Cross. He was a Trustee of the Carnegie Institute of Technology and a member of the Cornell University Council.

He had a special interest in young people. He was for some time President of the Allegheny Council of the Boy Scouts of America and served on the Boy Scouts Executive Board. Jenks was also named Chairman of a Youth Service Committee, which made some specific recommendations aimed at curbing youth crime in Allegheny County.

But these bare bones of Stephen Jenks' career do not do him justice, because they only hint at one of his outstanding characteristics-his great friendliness and warmth, which contributed so much to his success as a leader of men and in his participation in public affairs. He obviously liked people, was considerate of them, and was always ready to help them. In matters of engineering he could be precise and demanding, but you always knew that you had his support at all times. So he has left behind him not only some technical monuments to progress in the steel industry, but also a fine example of leadership and the art of managing men.

Thomas Christian Kavanagh

1912-1978

By Anton Tedesko

Thomas C. Kavanagh was born August 17, 1912, in New York City and died May 23, 1978, in Florida. At the time of his death, he was a partner in the consulting firm of Iffland-Kavanagh-Waterbury, Engineers-Architects-Planners. He was a Founding Member of the National Academy of Engineering (NAE) and served as its Treasurer for ten years, from 1964 to 1974.

Tom considered himself a consulting engineer and an educator. He was a civil engineer, a renowned structural designer, and, long before the term was invented, a systems engineer. He was also a person of great vision, with superior technical ability, great optimism, energy and social consciousness, deeply involved in all phases of his discipline, committed to engineering work, dedicated to engineering causes, a leader in the technology of engineering, and a strong symbol of the best in the profession.

Tom had become fluent in German and maintained a familiarity with the contents of German technical publications. He never said "no" when asked to do something for the profession. When others failed to do what was required, Tom took over. When it was necessary to criticize, he did so in a pleasant way and with a smile. He started many young people on the route to professional work and encouraged their making contributions through committee work and publications.

He had a unique ability to bridge the gap between the academic and the practitioner's viewpoints and was held in high regard by both sides. He could translate issues and considerations peculiar to the building industry into terms understood by those on the outside. When Tom explained why something was impractical, people usually understood.

Tom understood the socioeconomic side of engineering-the positive and negative impacts of a proposed action-and was able to articulate it well. He was a patient listener, an effective adviser, and a good mediator. His approach was soft and diplomatic. He did not shirk difficult assignments and was equally at home among his peers as he was among junior groups.

Tom was conscious of an engineer's duties and service to mankind; he was conscientious, thorough, inventive, with a drive for improvements wherever he had any influence. He thought of civil engineering as the basic civilian discipline (in contrast to military engineering), the parent discipline from which spawned all the other branches of engineering. Specialties such as ocean engineering, in which he was interested, were part of Tom's civil engineer's world. This world Tom described as "encompassing that boundless activity directed toward fulfillment of human needs through adaptation and control of the land-water-air environment-a truly tremendous scope."

Tom, starting at an early age, was pretty much on his own. What he became was due to his drive, stamina, and intellect. A scholarship enabled him to begin his studies in engineering and allowed him to go to the Technological University of Berlin, Germany. He earned the Bachelor of Science and Master of Civil Engineering degrees from the City College of New York, a Master of Business Administration degree M.B.A. in finance, and a science doctorate from New York University (NYU). He became a structural designer, working for engineering firms in New York and Pennsylvania on railway and highway bridges, sanitary plants, industrial structures, transmission towers, power plants, waterfront structures, floating docks, and refineries. He was an aircraft engineer in World War II.

After several years as an Assistant Professor of Civil Engineering at New York University, Tom became a Professor at Pennsylvania State University and, in 1948, Head of its Structures Department.

In 1952 he moved back to New York University and became Chairman of the Department of Civil Engineering. In 1953 Tom started to spend one afternoon a week working with the consulting firm of Praeger & Maguire, which had not been strong in the structural field. It did not take too long until Tom joined this organization as a full partner, with the firm's name changed to Praeger-Kavanagh, and later to Praeger-Kavanagh-Waterbury. However, Tom kept up his teaching activities as an Adjunct Professor at NYU until 1956 and at Columbia University thereafter. During this period he was responsible for a number of outstanding engineering projects, including the Arecibo (Puerto Rico) radio telescope (the world's largest), the Hawkins Point Bridge, the planning for the Caracas (Venezuela) subway system, and the Long Island Sound bridge crossing. He also worked on the New York City Building Code and on design manuals for the U.S. Army.

Following a merger in 1969 involving Tom's company and another engineering firm, Tom joined Louis Berger International Incorporated in 1975 and became a Vice-President, managing large projects in Cyprus and Lagos. In 1976 he founded Iffland-Kavanagh-Waterbury, a consulting firm undertaking projects similar to those carried out by the Praeger-Kavanagh firm.

The variety of Tom Kavanagh's activities is hard to envision. Likely no other man involved in the work of dozens of committees, commissions, councils, or boards has made as many personal contributions on such a wide variety of subjects. He was a member of twenty professional societies. In the course of twelve years he served on twenty NAE committees. At one time or another he led twenty professional working groups; only ten of the twenty groups he headed as Chairman are listed here as examples: Committee on Ocean Engineering of NAE (this name later was changed to Marine Board), Finance Committee of NAE, Civil Engineering Peer Group of the Committee on Membership of NAE, Metropolitan Section of the American Society of Civil Engineers (ASCE), Research Committee of ASCE'S Structural Division, U.S. Council of the International Association for Bridge and Structural Engineering, Committee on Systems Engineering of the Consulting Engineers Council, Commission on International Relations of the Engineers Joint Council, Ethical Practice Committee of the Consulting Engineers Council, and Committee for Coordinated Construction Activity of the Building Research Advisory Board of the National Research Council (NRC).

Tom headed program committees, technical sessions, nominating boards, university advisory boards, and accreditation and educational committees. As ASCE Director, he represented those members who were not residents of the United States. He was a founding member of ASCE's Research Council for the Performance of Structures and for years was most active in the Column Research Council, later known as the Structural Stability Research Council. For six years he served on the NRC's Building Research Advisory Board (one year as Vice-Chairman). In the 1960's he served in the leadership of the Engineers Joint Council (as Senior Vice-President in 1971-72). A wide diversification of interests, a multidisciplinary approach to engineering projects, as well as a strong feeling for aesthetics, were his hallmark.

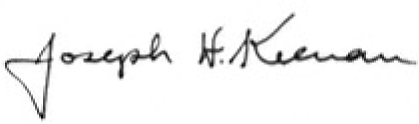
Tom Kavanagh was the author of over 100 technical publications. He received recognition and awards from numerous professional societies and agencies. These include: an Honorary Engineering Doctorate from Lehigh University; the Ernest E. Howard Award of ASCE for his Contributions to the Advancement of Structural Engineering; the David Steinman Medal for Structural Engineering from the City College of New York; the Gold Medal of the Architectural League; and an Honorary Life Membership in the New York Academy of Sciences.

During the 1970's he was most active in the Council on Tall Buildings and Urban Habitat. As a charter member of the Council's steering group, he touched everyone's thinking as he strongly urged the "systems approach" and the need to recognize the broader aspects of the impact of high-rise buildings. During one of his last series of trips to Egypt (1974-75) for Tall Building Conferences in Cairo, he was an important contributor and had meetings with the Minister of Reconstruction.

The engineering profession was Tom Kavanagh's whole life; he had no interest in "hobbies." It is only natural that he was a driving force among the twenty-five engineers, representing a broad spec trum of the profession, who in 1964 created what became known as the National Academy of Engineering. Tom was elected a Member of the Council of the new Academy. He was very much concerned that the quality of new members of the Academy be maintained at the highest level. His interest in improving the mechanism of the selection and election process continued when he himself served on the Committee on Membership.

When NAE President Robert C. Seamans, Jr., resigned that position in 1974 to accept an appointment by the President of the United States to an important Government position, Thomas Kavanagh headed the search committee for a new President of the Academy. When Courtland D. Perkins was named as a candidate, Tom's committee was instrumental in persuading Dr. Perkins to accept the nomination; his election to the presidency followed in 1975. Through this action Thomas C. Kavanagh left his final imprint on the Academy.

Dr. Kavanagh was married to Kerstin E. Berglund and had three children.



Joseph Henry Keenan

1900-1977

By Ascher H. Shapiro

Joseph Henry Keenan, Professor Emeritus of Mechanical Engineering at the Massachusetts Institute of Technology (MIT), former Head of the Department of Mechanical Engineering, and Member of the National Academy of Engineering, died on July 17, 1977, after a three-year illness, during which time he had steadfastly maintained an active personal and professional life.

Professor Keenan was born August 24, 1900, in Wilkes-Barre, Pennsylvania. In 1922 he received from MIT the degree of Bachelor of Science in naval architecture and marine engineering.

The course of his future professional career-centered on the deep structure of thermodynamics-was in a sense set by his first job, when, in 1922, he became a turbine design engineer with the General Electric Company in Schenectady, New York. Here he first became interested in the properties of steam, which necessitated thorough grounding in the fundamentals of thermodynamics.

In 1922, he entered the academic world, there to remain, as Assistant Professor of Mechanical Engineering at Stevens Institute of Technology in Hoboken, New Jersey. At the invitation of Karl Taylor Compton he came to MIT in 1934 as Associate Professor of Mechanical Engineering and was promoted to Professor in 1939.

During the more than forty years he was associated with MIT, Professor Keenan made a host of friends among his colleagues and students. He is remembered by all for his personal qualities and for his dedication to the Department of Mechanical Engineering and to the Institute. He consciously strived throughout his career to ensure continued excellence of the Department, the preeminence of which was a constant source of pride for him. His concern for students was deep and genuine, not only for their professional development, but for their growth as educated persons in the broadest sense. Truly a master teacher with a highly individual style, he patiently led students, by means of leading questions, to individual discovery and insight. No less was he concerned with the discovery and nurturing of the promising young faculty members, by this means imprinting the Department with his lasting influence.

Professor Keenan's works on thermodynamics are world-renowned and have directly and indirectly changed the face of thermodynamics teaching in engineering. His contributions to thermodynamics derived from an uncompromising search for understanding and elimination of ambiguities overlooked or accepted by others. He developed a coherent and logical exposition of the fundamentals of thermodynamics so that the widest possible range of problems could be considered in a uniform and consistent manner. To the very end he strove to improve the exposition and to make it more useful for practicing engineers. His famous textbook, *Thermodynamics,* published in 1941, remains a classic. It represents the distilled essence of thinking up to that time, and it is characterized by simplicity of approach, rigor in logical development, and economy of effort. This book has had an authoritative and continuous influence on teachers of thermodynamics, in all branches of engineering, and throughout the world.

James B. Killian, Jr., then Chairman of the MIT Corporation, said of Professor Keenan in 1966:

> To my mind he is one of the finest examples I know of a scholar of the first order who is also unremittingly interested in and concerned with the art of teaching. Not only has he made important contributions to the body of knowledge and understanding in the field of thermodynamics, but he has been able with great success to transmit his understanding to his students and associates.

Through his writing and teaching, Professor Keenan brought to the engineering profession the fundamental work of J. Willard

Gibbs in thermodynamics, which, for the most part, had been overlooked by engineers and scientists for five decades. In the 1930's he adapted Gibbs' concept of thermodynamic availability to the steady-flow processes of engineering. The initial motivation for this development was the allocation of fuel costs in a process with many outputs. The concepts of availability soon became widely used in chemical engineering and power-plant engineering, particularly abroad. In the United States, it has in a sense been tardily rediscovered and has recently become an important tool in the shaping of a national energy policy.

In the late 1950's and 1960's, Professor Keenan contributed to a new interpretation of thermodynamics that is applicable to a much wider range of systems and physical phenomena than any other interpretation presented in the past. This new interpretation applies to quantum systems and classical systems, relativistic mechanics and Newtonian mechanics, nuclear reactions and chemical reactions, fluids and solids, and to single molecules. It is presented in a book he coauthored, *Principles of General Thermodynamics,* published in 1965. In this book, the conflict between the postulates of thermodynamics, including irreversibility, and those of quantum mechanics are resolved, and many aspects of these two sciences are unified into a single conceptual entity.

The development of accurate tables of the properties of steam, so vital to the electric power industry, was a continuing preoccupation during Professor Keenan's career, the initial milestone being his appointment in 1929 as the U.S. delegate to the First International Conference on the Properties of Steam; he served as delegate in all successive conferences on this subject until the eighth in 1974. His name is synonymous with the Steam Tables, familiar to generations of students and practicing engineers; he was author or coauthor of successively improved tables of steam properties published in 1930, 1936, 1939, and 1969, all of them authoritative. The Air Tables, and then the Gas Tables, which he also coauthored, provided for the emerging gas-turbine industry what the Steam Tables had done for the steam-power industry.

During his professional career, Professor Keenan conducted significant experimental research, most of which represented pioneering efforts. Among his works were the determination of steam-turbine nozzle performance, experiments on friction coefficients of air at supersonic speeds, experiments on injectors and on heat transfer at high speeds, the development of the free-piston compressor for gas-turbine applications, the development of equipment for processing coffee and cocoa, and the development of dust-separation equipment.

Professor Keenan headed the Department of Mechanical Engineering at MIT from 1958 to 1961, leading the Department through the post-Sputnik years, one of the most difficult periods of its recent history. The introspective studies under his leadership were important factors in the changes that kept the Department in a preeminent position.

Among the many honors awarded to Professor Keenan are Honorary Membership in the American Society of Mechanical Engineers (1966), the Worcester Reed Warner Medal of the American Society of Mechanical Engineers (1954) for permanent contributions to the literature of engineering, a Fulbright Lectureship at Cambridge University and at the Imperial College of Science and Technology in London (1951), an Honorary Doctor of Laws degree from the University of Glasgow (1966), and Membership in the American Academy of Arts and Sciences (1937) and the National Academy of Engineering (1976).

Professor Keenan is survived by his wife, the former Isabel Morrison, and two children, Mrs. John W. Carr III of Bryn Mawr, Pennsylvania, a Research Associate at the Philadelphia Child Guidance Clinic, and Matthew A. Keenan of 4 Dana Road, Belmont, an investment counselor.

Professor and Mrs. Keenan were summer residents of Nantucket for forty-five years. For the last ten years they lived in the Shimmo section of the island.

An avid sailor and tennis player, Joseph Henry Keenan was a Member of the Siasconset Casino, the Belmont Hill Club, the Harvard Musical Association, and the Nantucket Yacht Club.

Clarence Francis Kelly

1906-1976

By Roy Bainer

The death of Clarence Francis Kelly, on May 5, 1976, following a prolonged illness, terminated a highly productive career in agricultural engineering of more than four decades. At the time of his passing, he was Professor Emeritus of Agricultural Engineering and Agricultural Engineer Emeritus in the Agricultural Experiment Station, University of California, Davis. During the final ten years of his career, he served as Director of the California Agricultural Experiment Station, Statewide.

"Kelly," as he was known to everyone (he disliked his given name), was born in Lawton, North Dakota, on October 18, 1906. He received the degrees of Bachelor of Science and Master of Science from North Dakota State College in 1931 and 1933, respectively. In 1964, his alma mater awarded him the honorary degree of Doctor of Science.

During the first three years, following graduation, he served his Alma Mater as Agricultural Engineer and Project Manager with the North Dakota Rural Rehabilitation Corporation, Bismarck.

In 1936 he joined the U.S. Department of Agriculture (USDA) to work on grain conditioning and storage problems in Washington, D.C. This work was transferred to Iowa State College, Ames, in 1941. The results of this investigation received international recognition. The work was suspended, however, for the duration of World War II, when Kelly served the U.S. Navy in antisubmarine warfare. Following the war he returned to Ames to continue the studies on grain conditioning.

A major change in his career occurred in 1946, when the USDA transferred him to the Davis campus of the University of California. His new responsibility was to initiate research, in cooperation with the Animal Science Department, on the effects of environment on the production of swine and beef cattle. He soon demonstrated the ability of working harmoniously with scientists in other disciplines.

Dr. Kelly and animal scientist Herbert Heitman, working on a study of swine conducted in the psychrometric chambers at Davis, obtained basic data on the metabolism of animals held under controlled environmental conditions. Differences of 300 percent were shown in food consumption for swine of the same weight, with temperature changes of only 30 percent (70°F versus 100°F). These results were crucial to the development of swine housing environment throughout the United States.

A field laboratory for studying the effect of heat stress on beef cattle was established at the Imperial Valley Experiment Station, where summer temperatures often reach 110°F to 120°F. Animal scientist Nicholas Ittner and USDA Agriculture Engineer T. E. Bond cooperated in these studies. Through modification of the environment in the feeding yards, they were able to show gains in weight exceeding two-and-one-half pounds per day (comparable with gains obtained in the Corn Belt). As a result, thousands of cattle are now fed under controlled environmental conditions in hot regions.

During the late 1950's, Dr. Kelly cooperated with Dr. Milton Smith of the Animal Physiology Department in the study of the behavior of chickens held in an environment where accelerating forces exceeded one G. This work was supported by grants from the Office of Naval Research, the National Aeronautics and Space Administration, and the National Science Foundation. Kelly designed and supervised the construction of huge centrifuges in which the chickens were studied. This study covered several generations of chickens. Whereas there were no final results, there were physiological changes in the birds. For example, a sixfold resistance to chronic acceleration (one- to three-G range) was obtained by several generation selections.

Dr. Kelly left the USDA and joined the agricultural engineering faculty of the University of California in 1950. In addition to continuing his research on animal environmental problems, he taught a senior-level course in farm structures and a freshman orientation course. He also directed graduate student thesis research. He became chairman of the department in 1961. In 1963, he was transferred to Berkeley to serve as Associate Director of the California Agricultural Experiment Station. He was made Director in 1965, a position that he held until retirement. In this position, he was responsible for coordinating agricultural research on four campuses of the university and at ten agricultural field stations. Dr. Kelly retired from the University in 1973 and devoted a year to administration service with the USDA in Washington, D.C.

In 1958 Kelly was elected a Fellow in the American Society of Agricultural Engineers (ASAE). He was chosen the first correspondent representative of ASAE in the International Society of Agricultural Engineers in 1959. He served as Vice-President and on the Board of Directors of ASAE. in 1960-63 and President in 1972-73. During the annual meeting of the Society in Lexington, the Governor made him a Kentucky colonel.

In recognition of his exceptional and meritorious achievement in agricultural engineering, Dr. Kelly was awarded the Cyrus Hall McCormick Gold Medal by ASAE in 1963. In 1968 he was the second agricultural engineer elected to the National Academy of Engineering. His contribution to the Academy included serving on the Committee on Agricultural Production Efficiency and the Committee on Membership-General Engineering Peer Group.

Dr. Kelly's bibliography lists some 140 papers. He received national recognition for four of them. He was a recognized pioneer for his contributions related to livestock production with emphasis on thermal stress and environmental modification for improved efficiency in production. He had a pleasing personality and was a close friend to all that knew him. He had a subtle sense of humor that was enjoyed by all.

Clarence Kelly is survived by his wife, Elizabeth, a son, Robert, and a brother, Laddie, in all of whom he took a great pride.

Rudolf Kompfner

1909-1977

By John R. Pierce

Rudolf Kompfner, known universally as Rudi, Professor Emeritus at Stanford University, Quondam Fellow of All Souls College, Oxford, was born in Vienna, Austria, on May 16, 1909; he died suddenly of a heart attack at the Stanford University Medical Center on December 3, 1977.

Rudi Kompfner is known especially for his invention of the traveling-wave tube and the backward-wave oscillator; for his work on satellite communication, in which the traveling-wave tube has played an important part; for work on light-wave communication and optical fibers; and for contributions to acoustic microscopy. He was a scientist, engineer, and inventor with a great enthusiasm in his life and work and a great talent for friendship and the inspiration of others.

The seemingly diverse elements in Dr. Kompfner's life were welded into an unforgettable personality through a constancy of interest expressed during a diversity of circumstances. The constancy of interest included his technical work; his family life; and his love of music, skiing, swimming, good company, and good food.

The diversity of circumstance was great. Immediately after World War I, when the Allies still blockaded Austria, Dr. Kompfner was sent to stay with a Swedish family in order to escape starvation, for which we should all be eternally grateful. With an enthusiasm for physics inspired partly by reading the works of Arago as a young man, he was not permitted to pursue this career.

Rather, he studied architecture at the Technische Hochschule in Vienna, becoming a Diplom-Ingenier in 1933. He then emigrated to the United Kingdom, where he was an architectural apprentice with P. D. Hepworth in London from 1934 to 1936. He was Director, Almond Franey and Sons, Ltd., Builders, London, in 1936-1941. During this period, he not only designed buildings that still stand, but he also studied electron tubes in the Library of the Patent Office in Chancery Lane. This led to the publication of several papers and to his patenting a novel television pickup tube.

Early in World War II, Dr. Kompfner was interned briefly on the Isle of Man as an enemy alien. This gave him an opportunity to think about physics and to study with interned German physicists. In the summer of 1941, he was given a job with the Admiralty, to work on microwave tubes at the Physics Department of Birmingham University under Professor M. L. Oliphant. The work there on high-power magnetrons for radar was a revelation to him. But the fruitful outcome was the invention of the traveling-wave tube, while trying to make a better klystrom amplifier for radar receivers. His fundamental idea-the continuous interaction of an electron stream and an electromagnetic wave of the same velocity traveling along a helix-was ingenious, and the realization worked!

In 1944 Dr. Kompfner was transferred, still as an employee of the Admiralty, to the Clarendon Laboratory at Oxford. There he was haunted with the idea of a voltage-tunable traveling-wave oscillator. His interest persisted through the period during which he studied for his Doctor of Philosophy degree in physics, which he obtained in 1951. He made some theoretical and experimental progress toward his end, partly in collaboration with F. N. H. Robinson of SERL (Services Electronics Research Laboratory) at Baldock.

In 1950 Dr. Kompfner left the Admiralty and became associated with the Atomic Energy Research Establishment, but he continued to work at the Clarendon Laboratory on microwave tubes. In 1951 he accepted employment at Bell Laboratories and arrived at Murray Hill, New Jersey, on December 27, 1951. There he found the facilities necessary to continue his work on tunable traveling-wave oscillators, and in a short time he had demonstrated electronic tuning over an unprecedented range of 10,000 megahertz-a wave-length range from 6.00 to 7.50 millimeters.

His interest in microwave tubes extended over many years, and his contributions were various, including the use of coupled helices, novel means of focusing (slalum focusing), understanding of noise, and the effects of nonreciprocal loss. Eventually, he assumed greater responsibilities, becoming Director of Electronics Research in 1955, Director of Electronics and Radio Research in 1957 and Associate Executive Director, Research, Communication Sciences Division, in 1962.

In 1958, together with J. R. Pierce, Dr. Kompfner became interested in communication satellites. In 1959 they published a paper outlining the potentialities of such satellites. The Bell Laboratories work on the Echo satellite, which was launched on August 12, 1960, was carried out in Dr. Kompfner's department and under his direction. He was also deeply involved in the Telstar experiment-the launching by AT&T in 1962 of a satellite that carried live television across the Atlantic for the first time.

In the late fifties, Dr. Kompfner became enthusiastic about communication using light waves. His leadership played a large part in the exploration of various possibilities, which led ultimately to the first use of light-wave communication to carry commercial telephone traffic in Chicago in 1977.

In June 1973, Dr. Kompfner retired from Bell Laboratories. Thereafter he divided his time between Stanford University, where he became Professor of Applied Physics and, almost immediately, Emeritus Professor, in 1974, and Oxford, where he was Fellow of All Souls-the first engineer and architect since Christopher Wren, among classicists and humanists-and Professor of Engineering Science.

In this later period, Dr. Kompfner's chief interests were divided among work at Oxford on ingenious ideas concerning the use and interconnection of optical fibers and work at Stanford, chiefly in C. F. Quate's program on an acoustical microscope. He had had an enthusiasm for this field as early as 1966, when he talked of a program with Quate, Joseph Pick, and Marvin Chodorow. He contributed a number of ideas in this area, including observation by means of harmonics and means for improving depth of focus.

Dr. Kompfner's work received widespread recognition. In 1955 the (British) Physical Society awarded him the Duddell Medal. Happily, this led to his delivering and writing a lecture, "Some Recollections of the Early History of the Traveling-Wave Tube." He later wrote a short book, *The Invention of the Traveling Wave Tube* (San Francisco Press, 1964).

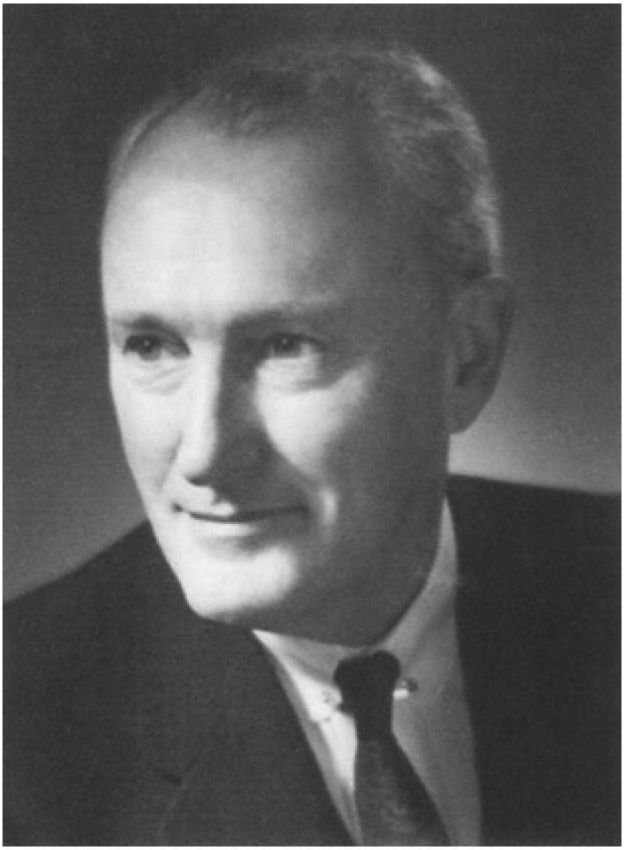
Dr. Kompfner was awarded the National Medal of Science (1975), the David Sarnoff Award (1960), the Medal of Honor of the IEEE (1973), the Stuart Ballantine Medal of the Franklin Institute (1960), the John Scott Award (1974), and the Sylvanus Thompson Medal from the Routgen Society, Incorporated, with the British Institute of Radiology (1974). He was awarded an Honorary Doctorate of Science by Oxford University in 1969 and an Honorary Doctorate of Technical Science from the Technische Hochschule in Vienna in 1964 not as a former student of architecture, which would have been inadmissible, but allowable because he had never been a student of physics in that institution.

Dr. Kompfner was a member of a number of societies and institutions: The National Academy of Engineering, the National Academy of Sciences, the Physical Society (British), and a Fellow of the IEEE. He served these organizations and his country in a number of ways. In the National Academy of Engineering he served as a Member and Chairman of the Awards Committee, as a Member and a Vice-Chairman of the Aeronautics and Space Engineering Board (ASEB), and as a Member of the Selection Committee for the Zworykin Award. He also served the NAE Committee on Science and Public Policy, the Space Science Board, and the Academy Forum General Science Advisory Committee. He was a Member of the Trustees of the Associated Universities, Inc. He was made a Fellow of the American Association for the Advancement of Science (AAAS) in 1974.

His countries and many individuals owe Rudi Kompfner a great debt of friendship and inspiration. A good part of this writer's career was built on Rudi's invention of the traveling-wave tube.

Rudi's career exemplifies the benefits that this calling can bring to society. He, himself, summarized the personal rewards:

> The feeling one experiences when he obtains a new and important insight, when a crucial experiment *works,* when an idea begins to grow and bear fruit, these mental states are indescribably beautiful and exciting. No material rewards can produce effects even distantly approaching them. Yet another benefit is that an inventor can never be bored. There is no time when I cannot think of a variety of problems, all waiting to be speculated about, perhaps tackled, perhaps solved. All one has to do is to ask questions, why? how? and not be content with the easy, the superficial answer.



John Montgomery Kyle, Jr.

1904-1970

By Thomas C. Kavanagh

John M. Kyle, Jr., Chief Engineer of the Port of New York Authority (PONYA), died on September 30, 1970. He served that agency for almost a quarter of a century and was the latest in a line of distinguished engineers-Gen. George Goethals, Othmar Ammann, and John C. Evans-in the Authority's highest engineering post.

As Port Authority Chief Engineer, Mr. Kyle established his own unique and worldwide reputation. He participated during his years of service in the design and construction of every major project that was initiated and carried forth in those years by this large-scale public corporate agency, which was created by the states of New York and New Jersey to purchase, construct, lease, operate, and otherwise administer terminal and transportation facilities and to promote commerce in the Port District. Among the more recent projects of PONYA, for which Mr. Kyle had direct responsibility, was the design and construction of the Third Tube of the Lincoln Tunnel, the new LaGuardia Airport terminal complex and its runway extensions over water, the second deck of the George Washington Bridge Bus Terminal, and the foundations for the World Trade Center.

As Chief Engineer of PONYA since 1947, Mr. Kyle was responsible for the design and construction of all new facilities, as well as all major improvements to existing facilities. These included the New York International Airport, Newark; LaGuardia and Teterboro airports; the Midtown Port Authority Bus Terminal; the New York and New Jersey Union Motor Truck terminals; Port Newark; Port Elizabeth; Hoboken piers; Brooklyn Port Authority piers; the land tunnel spanning Manhattan at 179th Street; and the rehabilitation and partial reconstruction of the Hudson & Manhattan Railroad (now known as PATH) connecting New York and New Jersey. The broad scope of Mr. Kyle's activities encompassed more than 1,500 square miles of the teeming New York City metropolitan area, with some 13 million inhabitants.

It is difficult to grasp the enormous breadth of activity and scope of responsibility carried by John M. Kyle during his service with the Port Authority, as it covered close to $2 billion worth of public facilities: four major airports; two underwater highway tunnels and one of the world's great suspension bridges; piers, docks, and marine terminals in the country's biggest seaport; bus and truck terminals; the world's tallest buildings; a rail rapid transit line; and a host of smaller structures, with new construction contracts exceeding $100 million each year.

Austin J. Tobin, Executive Director of PONYA, most concisely described the overall functions and responsibilities of John M. Kyle as follows:

> Engineering (in the Port Authority) is a staff department that carries forward the functional plans of the line departments (Aviation, Marine Terminals, Inland Terminals, Rail Transportation, Tunnels & Bridges, and World Trade), converts their dreams into reality, and transforms paper plans and cardboard models to structures of steel and concrete.
>
> Its general objective is to construct a facility that will meet the needs and requirements of the people who are going to operate it, and of* the public who are going to use it, and to do so at the lowest feasible cost. The chief' engineer is responsible for the integrity of all Port Authority construction.

John M. Kyle has been aptly described as one of a new breed of civil engineers in public service, because of his ability to organize his engineering staff into an efficient team to meet the diverse demands of such a multidisciplined agency. He organized the department into five major divisions: Design, Construction, Materials, Solis & Foundations, and Research & Development. He encouraged imagination and innovation among his staff and brought in eminent consultants to advise and assist on projects of a monumental character. Thus, on the George Washington Bridge double decking, Mr. Othmar Ammann was a consultant; on the commuter bus terminal at the New York end of the George Washington Bridge, the eminent Italian engineer Pier Luigi Nervi was called in as a consultant; and on the World Trade Center buildings many noted architects and engineers were consulted. On the foundations of the last named project, Mr. Kyle played a major role in the adoption of the new slurry-trench method of placing concrete perimeter walls with prestressed tie backs under difficult soil conditions.

John M. Kyle's technical contributions constitute a variety of diverse developments in construction and design technology:

1. The development of the sand drain and surcharge methods for consolidation of marsh land to provide foundations for buildings and roads at Port Newark and Port Elizabeth.
2. The advancement of the development of prestressed concrete in this country, where the Port Authority was one of the first to recognize the economic advantages of prestressed concrete and has used this method of construction at a number of its facilities, including the highway bridges at Kennedy International Airport, the approach viaduct construction and the avenue bridges of the New York approach of the George Washington Bridge, and, most recently, the prestressed concrete runway extensions at LaGuardia Airport.
3. The conceptual development of use of air rights above the George Washington Bridge Expressway.
4. Construction methods and procedures for subaqueous tunnels for the Lincoln Tunnel Third Tube. Mr. Kyle was an internationally recognized authority on subaqueous tunnel design and construction.
5. Conceptual and technical development of the high-temperature hot water distribution system at Kennedy International Airport combined with circulating chilled water for refriger

ation. This combined boiler plant serves the entire Central Area (Terminal City) of Kennedy International Airport.

Mr. Kyle's pioneering interest in research in engineering is also typified by his authorization, as part of the design of the World Trade Center buildings, of extensive wind tunnel tests on models, which in turn have helped move forward the boundaries of the engineering profession's knowledge of wind effects on buildings.

John M. Kyle was born on December 3, 1904, in New York City. In 1925 he graduated from Stevens Institute of Technology with a Mechanical Engineering degree; he also did graduate study in architecture at Columbia University and in airport engineering at New York University.

From 1932 to 1943, Mr. Kyle was with the George J. Atwell Foundation Corporation, as Chief Engineer. His project operations with that firm included the approaches to the Lincoln Tunnel and to the Queens Midtown Tunnel, portions of the New York Central West Side Improvement, the Hendrick Hudson Parkway, and the foundations for Radio City.

During the war period, from 1943 to 1946, Mr. Kyle served as a major in the Corps of Engineers. In this service he participated in the training of Airborne Aviation Engineer units and, as Staff Officer in Headquarters AAF, in the survey and field evaluation of major Air Force facilities in Europe, Africa, Asia, and the Pacific Islands. He was awarded an Army Commendation for his service.

Following the war, Mr. Kyle joined the Port of New York Authority, where he served as Assistant to the Chief Engineer from 1946 to 1947, following which he was appointed to the post of Chief Engineer.

John M. Kyle was an active participant in professional society activities and in furthering technical education. He was a Member of the National Academy of Engineering and an Honorary Member of the American Society of Civil Engineers. Other memberships included the International Society of Soil Mechanics & Foundation Engineering, Association Internationale Permanente Des Congres De La Route, National Society of Professional Engineers, American Society for Testing and Materials, and the

American Association of Port Authorities. He was also a Civil Engineering Member of the Inspection Committee of Engineers' Council for Professional Development and a Director of the Society of American Military Engineers, and a Member of the Board of Governors of the New York Building Congress. At Princeton University he served as a Member of the Advisory Council of the Department of Civil Engineering. He was also a member of the Moles.

As a member of the National Academy of Engineering, Mr. Kyle served on the Aeronautics and Space Engineering Board, the Ad Hoc Committee on Airport and Support Facilities, and the Ad Hoc Study Advisory Committee on Aeronautics.

Mr. Kyle received many awards in his professional career, among which were the following:

1. James Laurie Prize-American Society of Civil Engineers, 1952.
2. Metropolitan Civil Engineer of the Year-American Society of Civil Engineers, 1960.
3. Distinguished Engineer in Public Service-New York State Society of Professional Engineers, 1960.
4. Man-of-the-Year-American Public Works Association, 1963.
5. Honor Member of Chi Epsilon-National Civil Engineering Fraternity.
6. Distinguished Service Medal-The Port of New York Authority, 1957.
7. Honorary Member-Brooklyn Engineers Club.
8. Honorary Member-American Society of Civil Engineers.
9. Included in *Engineering News Record* list of Men Who Made Marks in 1967.
10. Howard S. Cullman Distinguished Service Medal (awarded posthumously by the Port of New York Authority, 1970).

In his personal life, Mr. Kyle served as an Elder of the Marble Collegiate Church and as a Director of the American Foundation of Religion and Psychiatry. He was survived by his widow, the former Virginia Tuxill (who passed away a few days after his death); two sons, John III and Charles T.; and a daughter, Sarah Jane.

John M. Kyle was an engineer of outstanding ability. He will long be remembered by his fellow engineers and many friends for his brilliant engineering and administrative skills, for his dedication and integrity in his professional ideals, and for his warm personal interest in his associates and in young engineers.

Leon Lapidus

1924-1977

By Neal R. Amundson

Leon Lapidus, Chairman of the Department of Chemical Engineering, Princeton University, died suddenly in his office on Thursday, May 5, 1977. He was fifty-two years old. His death came as a great surprise and shock to his many friends and colleagues, both in the chemical and computer industry, as well as in the academic world, where he was widely known for his research, extensive writings over a wide area, and as an excellent teacher and superb mentor of a series of excellent students. He had joined Princeton University first in 1951 as a Research Associate and became Head of the Chemical Engineering Department in 1968, succeeding the late Richard H. Wilhelm.

Leon Lapidus was born in Syracuse, New York, on September 26, 1924, and received the bachelor's and master's degrees from Syracuse University, the latter in 1947. He attended the University of Minnesota and received his doctorate in chemical engineering in 1950, being one of the rarities of modern times, a three-year Ph.D. degree recipient. Leon was a graduate student who worked consistently and constantly, but whose outward appearance was not one of compulsion. He coauthored three papers before he received the doctorate. He was a postdoctoral fellow at the Massachusetts Institute of Technology for one year, following which he went to the Forrestal Laboratory at Princeton, where he worked under Professor Richard H. Wilhelm on the chemical kinetics of the water-gas shift reaction, a reaction which at the present time is again receiv ing a great deal of attention. He became an Assistant Professor in 1953 and a full Professor in 1962 and was elected to the National Academy of Engineering in 1976. He was recognized in 1970 by Princeton University, when it appointed him Class of 1943 University Professor of Chemical Engineering.

Dr. Lapidus early in his career became interested in the more theoretical aspects of chemical engineering and was one of the early workers who used the modern digital computer in his research. His main thrust in research, after an early foray into transient phenomena, liquid-liquid fluidized systems, and theoretical analysis of various unit operations, was in the field of control and optimization applied to chemical reactions coupled with heat and mass transport in chemical reactors. He was one of the first to apply Lyapunov functionals to distributed parameter systems, particularly tubular and stirred pot reactors, and his interest and work in nonlinear control initiated much of the work of others. He worked on process identification, adaptive control, time-optimal control, filtering, and, in general, applied all of the techniques now commonly used before they were so.

In the recent past, probably because of his close association with IBM for a number of years, he became interested in efficient and accurate methods of computation for a variety of problems in chemical engineering. He developed means for handling stiff systems and applied these to a wide variety of chemical reactor problems. In fact, from 1965 to 1977 he published over 100 papers and at the time of his death had ten major works in press, two of these being books, one of which was published the day after his death. Prior to his death he had developed some new numerical techniques about which he was very excited. He had presented these in January 1977 at a seminar at the University of Minnesota and appeared to be in robust good health. These techniques were remarkably simple and accurate, and hopefully they will appear posthumously. In 1962 he authored "Digital Computation for Chemical Engineers," followed by "Optimal Control of Chemical Processes" in 1967, "Numerical Solution of Ordinary Differential Equations" in 1971, and "Mathematical Methods in Chemical Engineering-Volume III: Process Modeling, Estimation, and

Identification" in 1974. He coedited a memorial volume for Richard H. Wilhelm on *Chemical Reactor Theory* in 1977 and had just finished "Numerical Solution of Partial Differential Equations."

Dr. Lapidus had been honored by the American Institute of Chemical Engineers with the William H. Walker Award for research and with its Professional Progress Award. He had been Chemical Engineering Lecturer for the American Society of Engineering Education and had been a Member of the American Chemical Society and the American Institute of Chemical Engineers. He was widely sought after as a consultant and did so for Shell, Exxon, IBM, Cities Service, Humble, and others. He had always been in great demand as a seminar lecturer and as a symposium leader.

Leon Lapidus was married to Elizabeth Kalmes, of Rolling Stone, Minnesota, and had a son, Jon Jay, and a daughter, Mary Kalmes. He is survived by his sister Mrs. Florence Goldman of New York City. In addition to his many professional activities, he was an active and excellent lawn tennis player and at his death was President of the New Jersey Tennis Association.


Warren K. Lewis

Warren Kendall Lewis

1882-1975

By Hoyt C. Hottel

Warren K. Lewis, who died on March 9, 1975, has been called the father of chemical engineering, America's number-one chemical engineer. Though his contributions both to education and to the chemical industry during a life of ninety-three years were many and solid, his hallmark was stimulation of hard thinking in others. Attack-from the head and not the heart-was Lewis' characteristic most remembered by his associates of two generations. "Doc" could bring to the solution of a problem, whether industrial or educational, a sound knowledge of physics and physical chemistry. That knowledge was well organized, his capacity for expression was superb, and his dedication to the objective of finding the answer was obvious and intense. In any discussion he loved to lecture-to students, to researchers, to industrial planners, to anyone.

Born on a farm in Laurel, Delaware, on August 21, 1882, Lewis transferred in his high school days to Newton, Massachusetts, for better schooling, and in 1901 he entered the Massachusetts Institute of Technology (MIT) and began his association with Dr. William H. Walker, Head of Chemical Engineering. On graduation he was awarded a fellowship for study in physical chemistry in Breslau, and, after receiving his Doctor of Philosophy degree in 1908, he returned to MIT as a Research Associate in Applied Chemistry. For one year he was a chemist for a tannery in New Hampshire, then returned to MIT as Assistant Professor in 1910. Having become a full Professor under Dr. Walker in 1914, Lewis was made head of

MIT's Department of Chemical Engineering in 1920 when, after thirty-two years, it was finally separated from the Chemistry Department.

Dr. Lewis early recognized the need for a more unifying philosophy of education in chemical engineering and, stimulated by Arthur D. Little, worked with Walker and McAdams in identifying and quantifying what were called the unit operations of chemical industry-distillation, heat transfer, fluid flow, absorption, and so forth. In 1923 this effort produced the classic *Principles of Chemical Engineering*.

Dr. Lewis' other two books reflected his interest in chemical engineering education, and on applications to industrial problems. He considered combustion one of the unit operations, especially valuable in showing the student how much insight on industrial problems can be contributed by energy balances and by material balances on single chemical species. This led to publication in 1926 of a book with Radasch, *Industrial Stoichiometry*.

From concern with unit operations, Dr. Lewis turned to an emphasis on industrial chemical processes involving macromolecules, particularly in the areas of leather, paper, rubber, clay, textiles, and plastics. The result was a book with Squires and Broughton, *The Industrial Chemistry of Colloidal and Amorphous Materials*.

Dr. Lewis never failed to emphasize to his students the importance of their being able to recognize the implications to chemical industry of what they knew, and his best instruction was by example. His contributions to industry were many. A few of them follow:

Recognition of some of the implications of the alcohol industry's know-how to the oil industry, including an early improvement in vacuum distillation of lubricating oils; responsibility for the first large-scale application of continuous rectification in the petroleum industry; the upgrading of shell stills by superimposing rectifying columns; contributions to improved quantification of multicomponent distillation.

In the rubber industry, contributions to the structure of macromolecules and to improved understanding of the kinetics of vulcanization; a course of instruction to a rubber research group on applied physical chemistry.

Major aid in bringing coke deposition in thermal cracking of petroleum under control, through identification of the kinetics of thermal cracking. He recognized the importance of eliminating hold-up in processing equipment, of allowing for the contribution, to the deposition of coke, of higher-than-first-order polymerization processes occurring in two-phase flow.

In oil-field recovery problems, work on two-phase flow through porous media, on high-pressure p-v-T relations for hydrocarbons, on interphase equilibrium constants.

Fluidized-bed catalytic cracking. Dr. Lewis was a pioneer in the study of fluidization of comminuted solids, in the application of fluidization to catalytic cracking, a process replacing fixed-bed operation in which loss of catalyst activity through carbon deposition and difficulty in temperature control during regeneration by carbon burn-off had been major problems. The present capital investment in fluidized-bed processes is in billions of dollars.

Space has not permitted adequate elaboration of these few of many contributions made by Dr. Lewis to chemical industry. His performance both as an educator and as a practicing engineer was recognized by many honors and awards, listed here:

Honorary Doctorate Degrees-University of Delaware, Princeton University, Harvard University, Bowdoin College

President's Medal of Merit

President's Medal of Science

Perkins Medal of the Society of Chemical Industry

Lamme Medal of ASEE

Establishment of AICHE'S Warren K. Lewis Award

Priestly Medal of the American Chemical Society

Gold Medal of the American Institute of Chemists

New England Award of the Engineering Societies of New England

Industrial and Engineering Chemistry Award of the ACS

American Petroleum Institute Gold Medal for Distinguished Achievement

Founder's Award of the American Institute of Chemical Engineers

John Fritz Medal of five national engineering societies

Establishment at MIT of the Warren K. Lewis Professorship in Chemical Engineering

Warren Kendal Lewis would have been proud to know that by now twenty-seven of his former students have become members of the National Academy of Engineering. Perhaps the best closing tribute to him is a quote from an article written, when he was still vigorous at eighty-eight, by his former student he admired most, Edwin R. Gilliland:

> The characteristics that made Dr. Lewis outstanding as a teacher and builder of men were a tireless devotion to his work and to his ideals, a rare form of modesty in giving credit to others, sympathy for the man who made an effort (excellence preferred, but the effort was paramount), a wonderful enthusiasm for his profession and for tackling the tough problems, for making chemical engineering practice a vivid and colorful experience, and a knack for teaching and for inspiring the best in his students and associates.


Percy H. McGauhey

Percy Harold McGauhey

1904-1975

By Vinton W. Bacon

P. H. (Mack) McGauhey, who died on October 8, 1975, was intimately known and deeply respected by professional engineers, educators, and governmental officials in the State of California and throughout the nation and world. His name was synonymous with sanitary engineering and water resources. There were few people facing perplexing, practical engineering problems who did not seek his help.

Professor McGauhey was born on a homestead ranch on January 20, 1904, in Ritter, Oregon. The harshness of the eastern Oregon lands is reflected in his philosophy of life and in his verses, many of which appear in *Rimrock Ranch and Other Verses* and in *Oral History of the Sanitary Engineering Research Laboratory,* published by the Bancroft Library of the University of California, Berkeley.

Before getting to the real man and human being, let us look at his outstanding professional record, which was recognized by election to the National Academy of Engineering in 1973. In 1927 he received a Bachelor of Science degree in civil engineering from Oregon State University; a Civil Engineering degree in 1929 from Virginia Polytechnic Institute; and a Master of Science degree in hydraulic and sanitary engineering from the University of Wisconsin, Madison, in 1941. Utah State University honored him with a Doctor of Science honorary degree in 1971.

He served in faculty posts at Virginia Polytechnic Institute, at the University of Southern California and at the University of California, Berkeley, the last beginning in 1952. In 1957 he was appointed Director of the Sanitary Engineering Research Labora tory, Professor of Civil Engineering, and Professor of Public Health. In addition, he was appointed to the chairmanship of the Department of Civil Engineering.

It was in the latter capacity that he molded and led what has become one of the most respected sanitary engineering laboratories in the world. Professor McGauhey conducted pioneering investigations on a wide variety of subjects that included the composting and management of solid wastes, the economic evaluation of water, the treatment of waste by septic tanks and percolation fields, the eutrophication of natural waters, the fate of detergents in sewage treatment, and the use of the soil mantle as a waste management and water reclamation system. In each of these areas, Professor McGauhey became a world expert. What was so amazing, besides the diversity and excellence of his research, was his ability to bring his spirit of eternal optimism and his manner of meaningful compromise into the organization of his research, into the organization of the Sanitary Engineering Research Laboratory, and into the academic programs in civil engineering and public health. These qualities are reflected in the type of research that he undertook-he had the ability to hold together interdisciplinary research groups with the knack of allowing each investigator to contribute both toward the mutual objective of the group and toward fulfilling his own individual satisfactions.

He retired as Director of the Laboratory in 1969, but he was soon recalled by the Chancellor of the Berkeley campus to conduct a study of the role of the University in environmental studies.

In addition to the honors mentioned above, he received the Fuller Award of the American Water Works Association (1950), the Harrison Prescott Eddy Medal of the Water Pollution Control Federation (1960), the Distinguished Service Award of the National Clay Pipe Institute (1964), the Service Award of the California Water Pollution Control Board (1964), and the Gordon M. Fair Medal of the Water Pollution Control Federation (1969).

He served as a consultant for the State of California on the Lake Tahoe water management problems, HEW, AID, Israel, the Ford Foundation, and many others. One of his last significant contributions was as chairman of a three-person board of consultants that developed a Wisconsin Statewide Solid Waste Recycling Program, which resulted in the legislature creating an authority empowered to design and operate recycling systems-the first of its type in the nation.

But such creative achievements are expected of someone elected to NAE. Virginians, Californians, and admirers around the world will always remember the warm, humble, helpful, philosophical, and poetic man.

First and last, he was an educator. He had unique and old-fashioned views as to what an educator should be. Undoubtedly, these were formed by his early bleak schooldays in a one-room schoolhouse in eastern Oregon and by the fact he had to work his way through grade school, high school, and college. Such experiences would harden in philosophy even the softest of dispositions. His verse "Schoolhouse" expresses his ideas on the real purpose and meaning of education:

Schoolhouse
Its blackboard showed the sentence parsed-
Though feebly understood
And random truths there shone a while,
Then disappeared for good.
Yet stubborn minds perforce must yield
Beyond its battered door.
We went in poor and ignorant-
And came out only poor.

Adversity being the creator of character, Professor McGauhey had more than his share. Just when he was about to complete his doctorate, he contracted tuberculosis. He spent two years in a sanatorium and another year recuperating from surgery. From his verse "Sanatorium," a glimpse of this time emerges:

Sanatorium
Infirmary
Like patient oxen in their stalls
We lie benumbed of flesh and brain;
Each crack, each smear upon the walls,
Becomes the pattern of our pain.

Horizons

Slowly the restful are where earth
Meets patterned skies we knew so well;
The far horizons of the mind
Are squared and shrunk to fit this cell.

Evening In Summer

There is a hungriness that grips the heart
When the last oblique rays of the dying sun
Shatter like hopes against these ageless hills
That wall us off from life.
I see you there alone-yet cannot come
To share your solitude
When lengthening shadows of the evening grow-
Suddenly-to a blackness that is night;
Bearing on its restless wings
The hot damp cloak of loneliness.

Education to him was the task of instilling useful and well-structured knowledge into recipients who were expected to work hard and doing this without unnecessary interference or ballyhoo from administrators. He had little time for professors who taught at 8:10 a.m. what came into their heads at 7:55 a.m.; nor did he have much sympathy for the professional student who spent too many years getting too few degrees. In his unpublished novel, aptly entitled "Phooey on Your Alma Mater," you can find these attitudes precisely stated:

> Sound advice and high purpose have not always been the considerations by which our institutions of higher learning are populated. A good long loaf at the old man's expense has always stood high among the reasons for congregating within ivy-covered walls. Nor, has improvement in headwork always been the end result of the learning process in such an environment. A couple of generations ago, some colleges were so successful in converting their loafers into sots that many parents were thankful that poverty protected their sons from the moral strain of a college education.

On the "free-thinker" professor he states:

> Much of a University catalog is given over to a list of subjects along with descriptions indicating that the whole field of human knowledge is to be covered by Professor Van Beer in three hours per week for one semester.

> By this subterfuge the grouchy old professor can teach anything he pleases without fear that the accrediting committee will compare his course unfavorably with the same course at Harvard.

He gave equally short shrift to the elitist academician who felt that the dispensation of knowledge and the conduct of esoteric scholarly research had to be divorced from any semblance of everyday hard work. In his *Oral History of the Sanitary Engineering Research Laboratory,* he notes that the Richmond Field Station is some seven miles northwest of the Berkeley campus and remarks:

> Reluctance of some faculty members to undertake such a long journey (from campus) was one of the problems of utilizing the (Field Station). I once explained this phenomenon on the rationale that the (Field Station) was located on the wrong side of the Campus. Thus it was not on the way to Europe and hence (was) geographically inconvenient.

His feelings on the unreasonable world of academe were summed up, during the so-called Free Speech Movement at Berkeley, on a scrap of paper found in his desk drawer:

> There is nothing so crude, lewd, or treasonable that the sub-species of apes, it tolerates as students, will not attempt to force upon the community. There is nothing so preposterous, unbecoming an academic community or even common civilization, that its faculty will not, in its childlike naivete, espouse in the name of Academic Freedom. There is nothing so craven or absurd that its administration will not embrace when the enemies of society and America have at the gates of Sproul Hall. There is no demand so preposterous, that it will not be tolerated while faculty and students ponder how to remove the cause of this blatant attack on society.

Mack said he was one person who "gave up church for Lent and never went back"; and when he became Emeritus he would let you know that he had just been "retarded from the University." His poetry conveys his wit and "pure fun" humor:

Advice Is Worth Its Salt
I sought a friend (advice to borrow).
He said, "Go home and drown your sorrow!"
I felt so bad I shed a tear-
And found the salt improved my beer.

La Cucuracha
I picked up my glass and went for a drink,
There was something in it, and he jumped in the sink.
He got clean away-cause he saw me first.
Strange how a cockroach can quench one's thirst!

Professor McGauhey's poetry showed all his moods. There are things in these lines that you rarely heard him say. The barely endurable pain that he must have suffered almost constantly throughout his life only seeps through to the outside world in his verses.

Dichotomy
Though 'gulfed in weariness by day
That makes him long for bed,
A man may come to dread the night-
When night holds things to dread.

Mack was a true example of the type of individual here now being paid homage: a descendent of pioneer Americans who took the promise of the American dream literally and who achieved it through the application of strenuous physical labor to a lifelong quest for education and excellence. In Rimrock he wrote his epitaph:

He did not lose his zest for life
Nor judge the race not worth the run.
But he would have judged his duty shirked
If he failed to do-what must be done.

Throughout his life, Percy Harold McGauhey was sustained by a loving and loveable wife called Margo.

John E. McKeen

1903-1978

By Ernst Weber

John E. Mckeen, innovative chemical engineer whose great achievements for the benefit of mankind are known world wide, but who remained unassuming and warm-hearted, died in West Palm Beach, on February 25, 1978. His name has become inseparable from mass production of antibiotics, the "miracle" healer of infectious disease.

Born in New York City on June 4, 1903, Dr. McKeen was educated at the St. John's Preparatory School in Brooklyn and received his degree of Chemical Engineer in 1926 from Polytechnic Institute of Brooklyn. Upon graduation, he joined Charles Pfizer and Company, Inc., in Brooklyn, as a "painter," became successively Control Chemist, Process Development Engineer, Assistant Department Head, and in 1935 Head of one of the manufacturing departments in the Brooklyn plant. He spent 1936-37 in England to assist in the design and construction of a fermentation plant in London utilizing a new citric acid process (Kemball, Bishop Company). Returning to New York, in 1938 he became Assistant Superintendent of Pfizer's Brooklyn plant and took charge of the development of a process for the manufacture of riboflavin; he also supervised the design and construction of the plant.

During the early World War II days, an urgent need developed for mass production of penicillin, and in 1941 Dr. McKeen set up a pilot plant for laboratory production of penicillin. Because of his success, in 1942 he was made its Superintendent of the Brooklyn plant and put in charge of the scale-up of the pilot process for large-scale production of penicillin. This he achieved in record time, supplying a large percentage of this needed "miracle antibiotic" to the armed forces. In recognition of his contributions to the growth and success of the Pfizer Company, in 1944 he was elected to the Board of Directors and in 1945 became Vice-President and Member of the Executive Committee.

After the end of World War II, in addition to his continuing activities in fermentation, he took charge of manufacture of citric acid and in 1947 directed the construction of a large production unit at the new Pfizer plant in Groton, Connecticut. He guided also the expansion of this Groton plant and participated in the planning and design of new facilities for the production of penicillin, terramycin, streptomycin, and other antibiotics, as well as a number of vitamin products. In 1948 he was assigned to convert a Government-built chemical warfare plant at Terre Haute, Indiana, into a plant for production of streptomycin; in fact, this plant furnishes today a large portion of all the streptomycin used throughout the world. In December 1948 he was made Executive Vice-President and on September 27, 1949, he was elected President of Charles Pfizer and Company. On December 14, 1950, he also became Chairman of the Board. He held the two posts until May 3, 1965, but continued as Chairman of the Board until April 29, 1968, when the Board made him Honorary Chairman, a newly created position in Dr. McKeen's honor.

Between 1950 and his retirement, the company expanded worldwide, with subsidiaries in many countries, which required worldwide travel almost annually. Dr. McKeen's marvelous personality gained him friends everywhere, and he was honored by many nations:

Order of Vasco Nunez de Balboa, Panama (July 1, 1953)

Annual Good Will Award, Filipino Youth Organization of New York (November 21, 1953)

Grand Cross and Ribbon of the Order of Honor and Merit, Cuban Red Cross, Havana, Cuba (March 4, 1954)

Order of Merit of Bernardo O'Higgins, Santiago, Chile (October, 1954)

Citizen of Quito, Ecuador, by Society of Quitenos (November, 1954)

French Legion of Honor, "Chevalier," Paris, France (June 9, 1955)

Silver Medal, Hellenic Red Cross, Athens, Greece (July 8, 1955)

Knight of St. Gregory, Rome, Italy (November, 1955)

Medaille d'Or de Leopold Ier, Royal Academy of Medicine, Brussels, Belgium (June 15, 1956)

Dr. McKeen also was a member of many professional and honorary organizations, such as the American Chemical Society since 1926, the American Institute of Chemists since 1937, the American Institute of Chemical Engineers since 1940, Sigma Xi since 1943, the New York Academy of Sciences since 1950, and others.

He presented many papers before these professional societies, in particular "The Production of Penicillin" in 1944 before the American Institute of Chemical Engineers in St. Louis, Missouri; "Contributions of the Pharmaceutical Industry to Medical Science" in 1959 before the P.M.A. Research and Development Section at White Sulphur Springs, and "The Search for New Antibiotic Substances," in 1962, published in the *Journal of the Indiana State Medical Association,* Vol. 55, No. 3, pp. 348-356.

As a result of the research and development activities during World War II, Polytechnic Institute of Brooklyn had founded the Polytechnic Research and Development Company, Inc., in February 1944, which it continued to own and operate until it was purchased by the Harris-Intertype Company in Cleveland, Ohio, in December, 1959. Dr. McKeen served as Member of a small Board of Directors from June 16, 1947, until its sale and gave freely advice and counsel on the basis of his own invaluable experience.

Dr. McKeen was elected to the National Academy of Engineering at the first membership election in 1965 and has served as Member of the Audit Committee, 1966-67; of the Committee on Gifts and Endowments, 1966-69; and of the Ad Hoc Committee to Determine the Feasibility of Providing Advisory Services in the Field of

Engineering in Medicine and Biology, 1966-67. He also served as representative of the National Academy of Engineering on the Division of Engineering, 1965-67, and on the Subpanel on Chemical Resources of the Committee on Ocean Engineering, 1966-69, both in the National Research Council.

His alma mater, the Polytechnic Institute of Brooklyn, awarded him the honorary degree Doctor of Engineering in June 1951. Because of his heavy commitments to the company, he could not accept serving on the Institute's Board of Trustees until October 1956. When he accepted, however, he was meticulous in attending Board meetings whenever in town and in participating on committees, such as the Patents, the Funds and Investments, the Development, and the Executive committees. He served as Vice-Chairman of the Board of Trustees from 1966 to 1969, when he found it necessary to relinquish further obligations, having moved to Palm Beach for the greater part of the academic year.

Dr. McKeen was also actively engaged on the Board of Directors of many civic organizations, in particular the American Foundation for Pharmaceutical Education, 1959-70; Health Information Foundation, 1950-60; World Medical Association, 1951-57; and World Rehabilitation Fund, Inc., 1958-63. Everywhere he left an indelible impression of friendly assistance when necessary, of counsel, where advisable, and of active participation when time permitted.

In all his activities and many of his travels, John E. McKeen had a valued, trusting, and dedicated companion in his wife, Noreen F. Condon; they were married on July 3, 1927, and thus shared the full and rich rewards, as well as burdens, of a most successful life.

William Burdette McLean

1914-1976

By David S. Potter

William B. Mclean, a pioneer in the development of air-launched guided missiles and advanced torpedoes, died in San Diego, California, on August 25, 1976, after a long illness.

A talented engineer, inventor, and research physicist, Dr. McLean probably is best known for his original concept of the successful SIDEWINDER air-to-air missile, which, at the time of its development, represented an unsurpassed level of reliability, simplicity and low cost, and which provided his guidelines for future missile systems engineering.

Dr. McLean was born on May 21, 1914, in Portland, Oregon. He received a Bachelor of Science degree from the California Institute of Technology in 1935. He then served as a physics instructor at that institution, while pursuing graduate studies in nuclear physics in the Kellogg Radiation Laboratory under Charles Lauritsen and William Fowler. Dr. McLean received a Master of Science degree (1937) and a Doctor of Philosophy degree (1939) in physics from California Institute of Technology before accepting a postdoctoral fellowship in nuclear physics at the University of Iowa from 1939 to 1941.

As a young graduate student, Dr. McLean displayed the inventive design and engineering abilities that would characterize his career. He designed and built a half-million volt Van de Graff generator as a pilot project for a larger, one-Mev generator later built at Kellogg. He then used the generator, coupled with a cloud chamber built by his fellow student and lifelong friend and colleague, Robert A. Becker, to complete his doctoral studies of short-range alpha particles.

During his fellowship at the University of Iowa, Dr. McLean continued his research into the physics of subatomic particles, concentrating on the angular distribution of protons from the D-D reaction as a Research Associate under Alexander Ellett.

Dr. McLean entered Government service in 1941 as a Research Physicist designing weapons fuses for the National Bureau of Standards. In 1945 he moved to the Naval Ordnance Test Station (now the Naval Weapons Center) at China Lake, California. During his twenty-two years at China Lake, he rose to national prominence in the development of air-launched guided missiles and advanced torpedoes. He was Technical Director at China Lake for thirteen years. He then became Technical Director of the Naval Undersea Center when it was established in 1967, for seven years before his retirement in 1974.

Dr. McLean was a staunch supporter of a strong Government program in oceanography. He predicted that significant advances in underwater detection and surveillance would be made in the areas of improved acoustical signal processing and display. He also made notable contributions to the advancement of science and national defense and to the field of public service in his thirty-three years of Federal service.

McLean was a superb engineer. His personal hallmark was artistic engineering design, wherein the parts fit and work together in a most natural and economical manner. He possessed a facile and profound synthetic and spatial imagination. As a result, he customarily invented and perfected complex electronic circuits and electro-pneumo-mechanical devices on the bench and in the shop without using diagrams or drawings of any kind. His only use of such aids, typically, was in trying to communicate his ideas to machinists, technicians, patent attorneys, or other people.

Since Dr. McLean was educated as a physicist and was by nature a systems thinker, he paid little attention to the traditional boundaries between such disciplines as mechanical, electrical, and fluidic engineering. And even though he had an excellent ability to use the mathematics of all those fields, he put little trust in the analyses or deductions of such mathematics. His preferred working mode was to place himself mentally in the position of each element of the device under consideration in order to "feel" whatever forces or current flows the element would be required to generate or respond to. Then he would quickly build an example of what he was thinking about and observe its behavior under various conditions. Next, he would upgrade his thoughts and the device he was working with, and then he would test it again-it was a highly dynamic and fluid process.

In addition to his achievements in developing the SIDEWINDER guided missile, Dr. McLean was busy inventing and developing hundreds of other systems and devices both great and small. At the time of his death, he was actively pursuing, as best as he could under the conditions of his illness, the development of a wave-powered upwelling pump for application to the vast oceanic seaweed production farms that many believe will be a striking feature of the world of the next century.

In recognition of his outstanding achievement, special awards included the maximum Federal Government Award of $25,000 for the development of the SIDEWINDER missile (1956), Naval Ordnance Test Station's L. T. E. Thompson Award (1956), Resolution of Commendation by the California State Legislature for SIDEWINDER development (1957), the President's Award for Distinguished Federal Civilian Service (1958), the American Ordnance Association's Blandy Gold Medal (1960), the Rockefeller Public Service Award for Science, Technology, and Engineering (1965), the Secretary of the Navy Certificate of Commendation (1966), California Institute of Technology Alumni Distinguished Service Award (1969), and the IEEE Harry Diamond Award for outstanding leadership of development in guided missiles and undersea exploration and transport (1972).

Dr. McLean served on various committees and boards of national prominence, including the National Inventors Council, American Physical Society, and American Association for Advancement of Science. He was a member of Tau Beta Pi and Sigma Xi and served as a Fellow of the New York Academy of Sciences and of the

Institute of Electrical and Electronics Engineers. He was elected to the National Academy of Engineering in 1965 and to the National Academy of Sciences in 1973 and served on various Academy committees, panels, and boards. He authored numerous publications, and there are more than thirty-five patents to his credit.

William McLean is survived by his wife, Laverne (née Jones); his three sons, William Robert, Daniel Malcolm, and Mark Alan; and two grandchildren.

William Cyrus Mentzer

1907-1971

By Robert W. Rummel

William Cyrus Mentzer died on December 23, 1971, at the Stanford Medical Center in Palo Alto, California. With his passing, the aviation industry lost one of its most distinguished members-a pioneer in the area of high-speed aircraft and in techniques in airline engineering maintenance and overhauling of aircraft. He was highly respected as a leader and innovator by his peers throughout the field of aviation.

Mr. Mentzer's career spanned the entire period of the development of modern transport aviation-from the time of the Ford trimotor to the introduction into service of the giant Boeing 747 aircraft. His personal efforts were recognized as having contributed to the development of no less than fifty aircraft. It was during this period that the air transport industry replaced its fledgling wings and grew to the maturity typified by widespread reliable and safe air transportation systems. "Bill" Mentzer, as he was known to all of his friends, personally impacted developments of this period and left lasting marks of achievement.

William Cyrus Mentzer was born May 27, 1907, at Knoxville, Iowa. He graduated from the University of Nebraska during the spring of 1929 with a Bachelor of Science degree in journalism and from the Massachusetts Institute of Technology (MIT) during 1931 with a Bachelor of Science degree in aeronautical engineering. His early aspiration was to be a journalist. While waiting for a promising opportunity during the summer of 1929, he took a job as a mechanic's helper in the Cheyenne, Wyoming, shops of Boeing Air Transport, one of the early air carriers that would later become part of United Air Lines. It was this early exposure to aviation that shaped the course of "Bill" Mentzer's life. After graduating from MIT in 1934, he chose to throw his lot with the air transport division of United Aircraft and Transport, a holding company, from which United Air Lines emerged.

Mr. Mentzer's progress through United Air Lines was measured and wholly predictable. He rose from Engineer in 1934 to Senior Vice-President-Engineering and Maintenance during March 1962. During 1938 he became Chief Engineer, in 1945 Director of Engineering, in 1946 Vice-President-Operations, in 1947 General Manager of Engineering, in 1958 Vice-President-Engineering, then Senior Vice-President-Engineering and Maintenance. At the peak of his career, Mr. Mentzer headed an organization consisting of some 6,000 United Air Lines maintenance and engineering personnel.

In 1935 Mr. Mentzer was assigned by United Air Lines' young President, W. A. Patterson, the task of writing specifications for an aircraft that would be larger and faster than any then-existing transport. This led to the development of the triple-tailed Douglas DC-4E, a program participated in by five of the leading airlines of that era. Notwithstanding the intervention of World War II, a somewhat smaller derivative design, the Douglas DC-4, which directly reflected earlier Mentzer efforts, emerged and found widespread use throughout the world.

Mr. Mentzer was one of the first aeronautical engineers to apply scientific methods to the solution of problems encountered in airline engineering and maintenance operations. This general methodology is now recognized as a separate discipline and is generally referred to as operations research or management science.

In 1940 Mr. Mentzer and H. E. Nourse of United Air Lines, Inc., jointly published a paper entitled "Some Economic Aspects of Transport Aircraft Performance." This paper was a mathematical model that related airline operating costs to airplane design parameters. The "Mentzer-Nourse" equations first described in this paper have been continuously refined and updated, and today are in worldwide use as the "ATA Operating Costs" formulas. All this played an important role in the development of transport aircraft, which have brought the airline industry to its current level of efficiency.

Mr. Mentzer's in-depth studies of the basic character of airline maintenance requirements led to the development of new concepts of airframe and engine maintenance, overhaul, and inspection. Implementation of these concepts produced important operating economics with no degradation in reliability.

During 1957 he received the President's Award, United Air Lines' highest tribute to an employee, for his outstanding work as chairman of a committee responsible for integrating the activities of the entire airline in preparing for operations of the first United Air Lines jets, the Douglas DC-8's, and Boeing 707's. Transition from the "piston" era to the jet era involved detailed evaluations and changes to nearly every facet of every support function of the airline. It was virtually tantamount to remaking the airline to efficiently accommodate jet-type aircraft.

Beginning in 1965, Mr. Mentzer chaired the newly formed U.S. airline Supersonic Aircraft Committee, a committee consisting of the top-ranking engineering airline officials. This Committee was requested to assist the Federal Aviation Administration and the manufacturers in the development of the U.S. supersonic transport aircraft. It participated in the detailed evaluation of manufacturer proposed designs and systems in coordination with the Federal Aviation Administration on the basis of the organized direct participation of appropriate airline technical staffs. Mr. Mentzer also participated in the affairs of the airline "Concorde SST Committee."

Mr. Mentzer, in recognition of his outstanding engineering accomplishments, was elected a Member of the National Academy of Engineering in 1968. Before this, during 1967-68, he served as a Member of the Ad Hoc Committee on Aircraft Operations. He also accepted membership on the Ad Hoc Study Advisory Committee on Aeronautics in 1969 and served as a Member of the Aeronautics and Space Engineering Board of the National Academy of Engineering from May 1, 1969, to his passing.

He also was a Member of the Society of Automotive Engineers, a Fellow in the American Institute of Aeronautics and Astronautics, and a Member of the Corporation Development Committee of the Massachusetts Institute of Technology. He served on the Visiting Committee of the Stanford University School of Medicine and on the Advisory Committee of the Institute of Transportation and Traffic Engineering of the University of California.

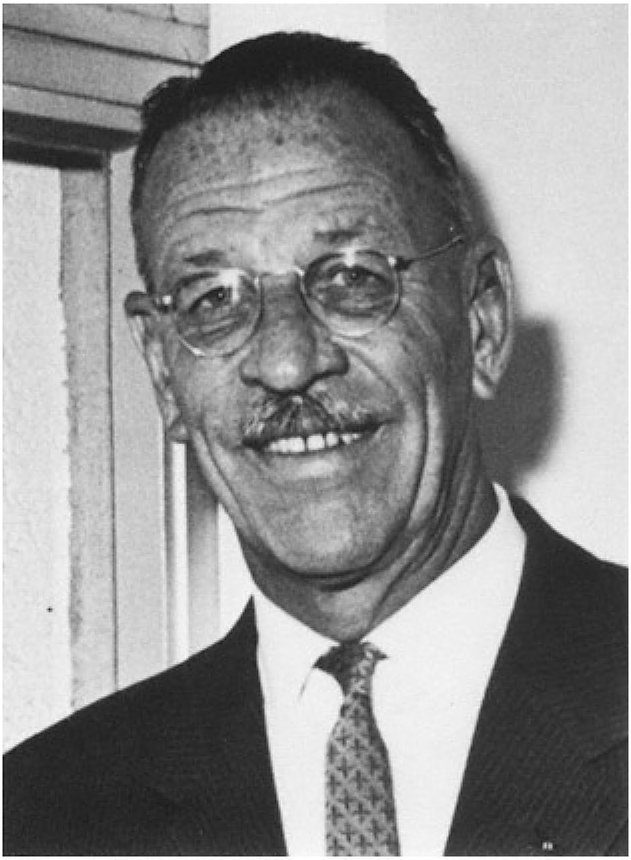
The Federal Aviation Administration/Department of Transportation's "Award for Distinguished Service" was presented to Mr. Mentzer on May 27, 1969, for "effective leadership and counsel" in support of two areas of aviation activity. One area was his service as Chairman of the Airline Supersonic Transport Committee and the other was his leadership in the "development of innovative techniques and maintenance procedures which contribute to air safety." This award is reserved for those outside of the Federal Aviation Administration who have made aviation safer, more economical, or more efficient.

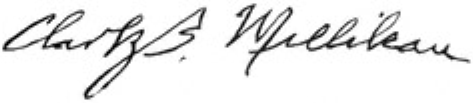
During 1969, Mr. Mentzer was also presented by his colleagues in the Air Transport Association of America with their "Nuts and Bolts Award," the highest award that can be granted by that organization.

In 1972 the Guggenheim Medal was awarded posthumously in recognition of Mr. Mentzer's "manifold accomplishments in airline engineering, maintenance, and economic disciplines."

In his private life, he enjoyed a long and happy marriage and a family of three children-William, Jr., Molly, and Sally. He and his wife traveled widely, which, as a history buff, he especially enjoyed.

William Cyrus Mentzer combined a penetrating and analytical mind with personal modesty and skill in facilitating cooperation. The foundations he provided contributed significantly to the evolutionary development of the fine air transportation system enjoyed today.





Clark Blanchard Millikan

1903-1966

By Ernest E. Sechler

Clark Blanchard Millikan was born in Chicago on August 23, 1903, and died on January 2, 1966. His birth occurred almost simultaneously with the decision of the Wright brothers that their airplane was ready to fly under its own power. These brothers shipped their frail craft from Dayton to Kitty Hawk in September of that year. Whether or not this coincidence was important can never be known, but it is a fact that, in his early impressionable years, Clark was surrounded by the publicity attendant on the rapid development of this new means of transportation.

Being the son of Robert Andrews Millikan, at that time Professor of Physics at the University of Chicago, any latent interest in new advances in science and technology was sure to develop. According to his own memory, Clark was only eight or nine years old when he first decided to make his life's career in some area associated with aeronautics. During this eight- or nine-year period, many startling firsts in aviation were accomplished, beginning with the Wright brothers' first flight in December 1903. All of these events would surely have been discussed at the home of a university professor, and it is little wonder that one of his sons saw glamorous possibilities in aeronautics as a future career.

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

After spending a year divided between the University of California (Berkeley) and Throop Institute of Technology (now the California Institute of Technology), he entered Yale as a freshman in the fall of 1920. Although Clark specialized in physics and mathematics at Yale, it is obvious that the impact of the airplane on the world conflict between 1917 and 1919 must have left a strong impression on his mind. At that time very few schools had courses in aeronautics, although Jerome Hunsaker was detailed (from the Navy) to the Massachusetts Institute of Technology in 1913 to develop courses in aerodynamics.

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

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

Throughout the 1920's there was an ever-growing aviation activity in Southern California. Small firms were springing up from Burbank to San Diego, and, since Caltech was one of the leading engineering schools in Southern California, it was natural that there should be an early and continuous contact between this new and exciting industry and the staff and students of Caltech. Donald Douglas, Sr., and his chief engineer Arthur Raymond; "Dutch" Kindleberger, who went from Douglas to North American; "Kelly" Johnson from Lockheed; and Jack Northrop were all friends of Caltech and soon became close personal friends of Clark Millikan. Through them he saw how aircraft were built and flown so as to round out his theoretical knowledge of the subject.

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

This wind tunnel, which had for that time the very high velocity of 200 miles per hour was operated, calibrated, and turned into a highly efficient research tool largely by the efforts of Clark Millikan, "Maj." Klein, and a handful of graduate students in this embryo Aeronautics Department at Caltech. It was during this period that the acronym GALCIT (standing for the Guggenheim Aeronautical Laboratory of the California Institute of Technology) was coined, and ever since the words GALCIT and Clark Millikan have been synonymous.

GALCIT was under the directorship of von Kármán from 1930 until 1949, and during that time Clark was in charge of the applied aerodynamics phases of the Laboratory's activities and supervised all of the testing and research carried out in the wind tunnel. Since this was the only available large wind tunnel in Southern California, the local, and sometimes some distant, aircraft companies found it an ideal piece of test equipment for developing new aircraft designs.

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

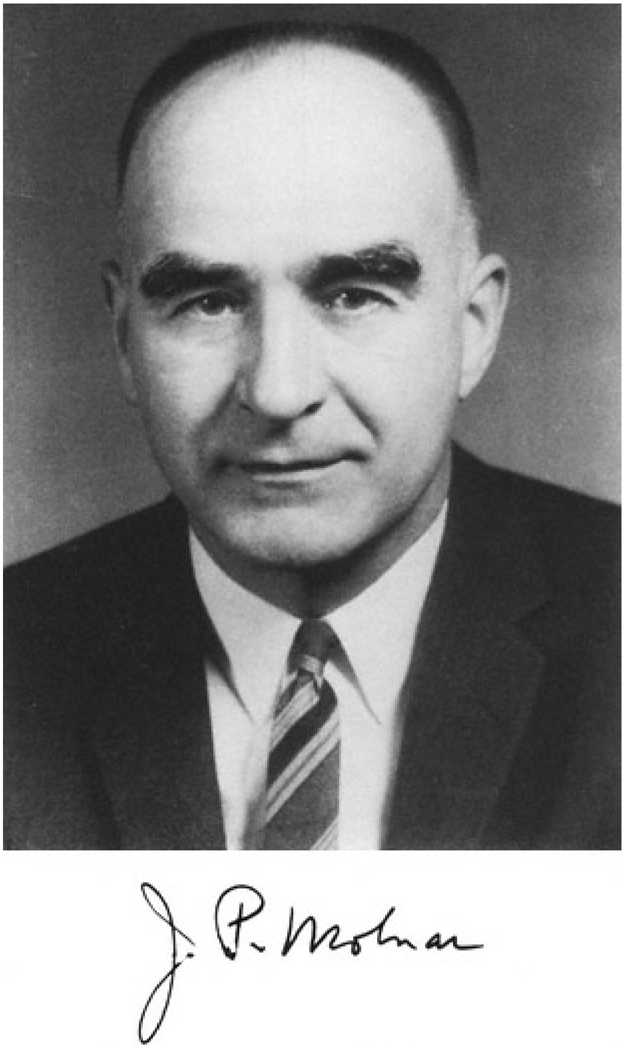
Unlike many people in the engineering and scientific world who join societies but take no part in them, Clark Millikan was not only a member of many scientific and technical organizations but was usually an "active" member in the truest sense of the word. He served as an officer, on executive councils and advisory boards, and his advice and participation were not only solicited but were given generously. In this manner, his influence extended far beyond the confines of his already broad academic activity at Caltech.

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

He was Director of the Southern California Cooperative Wind Tunnel during its first fifteen years of existence (1945-60) and contributed greatly to its success. This was a joint venture financed by five Southern California aircraft companies and managed and operated by Caltech. It was one of the first large supersonic wind tunnels and was known throughout the world for its efficiency, flexibility, and accuracy. It contributed greatly to the development of postwar commercial and military aircraft, and a large part of this contribution came about because of the intense interest of its Director in every phase of the operation and in the aerodynamic phenomena being studied.

His contributions to the military strength of the United States were great. With his wide knowledge of the entire aeronautics field and his personal friendship with so many of its leaders, his services and advice were constantly being sought-and, what is more, were generously given-by the armed services. Although his later activity in the field of missiles and spacecraft were largely connected with the Air Force through his activity as a member of its Scientific Advisory Board (from 1952 until his death), he also had contact with other services. He was a lieutenant commander (USNR) in 1942-46; served on the Naval Research Advisory Committee in 1947-50; was a member of the Defense Science Board of the Department of Defense in 1957-62; and was Chairman of the Guided Missile Committee of the Research and Development. Board of the Pentagon. He was influential in Army circles through his membership on the Army Ballistic Research Laboratory's Scientific Advisory Committee.

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


J. P. Molnar

Julius Paul Molnar

1916-1973

By Emanuel R. Piore

At the time of his death, on January 11, 1973, Julius P. Molnar was Executive Vice-President and a Member of the Board of Directors of Bell Laboratories, the research and development unit of the Bell System, headquartered at Murray Hill, New Jersey.

During his Bell System career, spanning twenty-seven years, he also served as President of Sandia Corporation, a Sandia Director and concurrently a Vice-President of Western Electric Company. He was a resident of Summit, New Jersey.

Dr. Molnar was born in Detroit, Michigan, on February 23, 1916, and attended public schools in Toledo, Ohio. He received a Bachelor of Arts degree in physics from Oberlin College in 1937 and a Doctor of Philosophy degree in physics from Massachusetts Institute of Technology in 1940. He then worked for the National Defense Research Committee in Cambridge, Massachusetts, and the Gulf Research and Development Company in Pittsburgh, Pennsylvania, before joining Bell Labs in 1945.

During his early Bell Labs career, he worked in physical electronics and the development of microwave tubes. Of this work, John A. Hornbeck, Bell Labs Vice-President for computer technology, design engineering, and information systems, said, "Two physical effects are associated in the literature of physics with his name. One is the M-band, an optical absorption band in salt crystals, named in recognition of Molnar's discovery of the band and his contributions to the study of its properties. The second one, the Hornbeck-Molnar effect, is an ionization process by which molecular ions are formed in the noble gases (helium, neon, argon, etc.). While a research physicist in physical electronics early in his career at Bell Labs, he was an influential and helpful consultant to his fellow scientists. Later, as a device engineer, he was closely associated with bringing the traveling wave tube from the research laboratory to practical utilization by the Bell System on its long distance communications routes."

Dr. Molnar was appointed Director of Electron Tube Development at Bell Labs in 1955, where he continued his work on traveling wave tubes, and in 1957 he became Director of Military Systems. He was named President of Sandia Corporation, Albuquerque, New Mexico, and a Vice-President of Western Electric in 1958. Lt. Gen. Alfred D. Starbird, who was Deputy Director of Defense Research and Engineering, U.S. Department of Defense, noted that "as president of Sandia Corp., Dr. Molnar strengthened its technical and operational functions in a critical period. He made significant contributions to Bell Labs design and development of the defense Automatic Voice Network (AUTOVON) and guided development of the Safeguard system. His contributions to the defense and security of our country were most impressive."

In 1960 Dr. Molnar returned to Bell Labs as Executive Vice-President. He was described by former Bell Labs Board Chairman James B. Fisk as "A man of great talent, of unmatched energy and drive, a perfectionist. He was totally dedicated to Bell Labs." For the numerous accomplishments in development that can be attributed to Bell Labs in this past decade, a large share of the credit belongs directly to Julius Molnar. "Under his firm hand," said Kenneth G. McKay, Bell Labs Executive Vice-President, "an unprecedented development program evolved during the past decade at Bell Labs. This program attacks virtually every phase of communications with advanced electronics and modern techniques; its results will be felt for decades."

In 1967, Dr. Molnar was named to the Committee of Science and Technology of the U.S. Chamber of Commerce. A Fellow of the Institute of Electrical and Electronics Engineers and the American Physical Society, he was elected to the National Academy of En gineering in 1969 for his leadership in the development of radio guidance systems. He also served as a trustee of the American Optical Company, Southbridge, Massachusetts. In 1971, he received the distinguished George Washington Award, presented annually by the American Hungarian Studies Foundation in recognition of his contributions "to research, human knowledge, the arts, and understanding among men and nations."

"Although he was devoted to the values of organization," said W. O. Baker, President of Bell Laboratories, "he never forgot that it depended on people whose personalities and individualities had always to be recognized and rewarded. Thus, he himself matched and enhanced the principles of community of the Bell System, and especially Bell Laboratories. Although firmly committed to what seemed to him to be best for the whole institution, he never forgot that this could conflict with the feelings of any particular person and always tried to heed both factors in advancing our cause. Indeed, Julius sought ever to understand what made things work in people and in nature, and pursued argument eagerly and vividly in a ceaseless effort to be informed, so as to serve more fully the large and challenging endeavors which he undertook."

Ben Moreell

1892-1978

By Richard H. Tatlow III

Ben Moreell, Admiral of the Navy and Chairman of the Board, President, Chief Executive Officer, and Director of Jones & Laughlin Steel Corporation, died in Pittsburgh at the age of eighty-five, on July 30, 1978, after a brief illness.

"The Chief," as he was respectfully and fondly known, retired in 1958, but he remained a Director until 1964 and through retirement was active in political and professional affairs.

Admiral Moreell was a distinguished engineering leader and organizer, master of innovative design and construction, creator of the SeaBees, proven industrialist, and a great citizen.

Born on September 14, 1892, in Salt Lake City, Admiral Moreell received in 1913 his Bachelor of Science degree in civil engineering and in 1943 his first honorary degree, Doctor of Engineering, from the Washington University in St. Louis. He was later awarded nine other honorary degrees-four in engineering, three in science, and two in law.

Admiral Moreell had an excellent theoretical foundation as a civil engineer and subsequently acquired great practical knowledge and experience as a constructor and an administrator of engineering and construction projects. While a lieutenant commander, he was responsible for writing what turned out to be the U.S. Navy's excellent concrete manual. He was most conscious of the quality of design and detail, was progressive and innovative, and, as Chief of the U.S. Navy's Bureau of Yards and Docks and as Head of its Civil Engineering Corps, he gave the fullest support to those who came up with new ideas. He took pride in elegant engineering solutions executed under his command, sometimes overruling the more conventional and conservative engineers on his staff. It was exciting to work for him. Admiral Moreell was a man who got things done and done well.

The SeaBees, organized by Moreell, grew from an initial authorization of 3,300 officers and men on December 28, 1941, to an organization of more than 10,000 officers and 240,000 men. More than three-fourths of these were active on overseas duty at the end of World War II. These were construction men who were trained in combat. They replaced the pre-Pearl Harbor civilian construction workers formerly employed by the Navy. The fate of the latter-at Wake, Guam, and Cavite-strengthened Admiral Moreell's conviction that the Navy needed men who could both build and fight. By the war's end, Admiral Moreell had directed a $10 billion construction program in building up the shore establishment needed to support the fleet. During the war the SeaBees and civilian construction forces worked at more than 900 naval bases and stations, including 300 new advance bases, some of which were as large as Peoria, Illinois, or Columbia, South Carolina.

The total worth of these bases was fifteen times the value of all naval shore establishments existing before the war. Moreell was the American engineer who probably made the greatest number of engineering contributions toward winning World War II.

In October 1945, President Truman placed Admiral Moreell in charge of the major portion of the nation's petroleum industry, which had been seized by the Government as the result of a nationwide strike.

In May 1946, the strike-bound nation's bituminous coal industry was seized by the Government, and President Truman designated Admiral Moreell to be Coal Mines Administrator.

Admiral Moreell became Chairman and Chief Executive Officer of the Jones & Laughlin Steel Corporation in early 1947. During the ensuing years, until he retired, Jones & Laughlin embarked on a prodigious expansion program conceived and directed by Ben Moreell, during which time it established clear leadership among the largest steel companies in this country as the first such company to pioneer basic oxygen steelmaking on a large scale. This decision on the part of Ben Moreell called for a combination of engineering judgment, business intuition, and industrial fortitude. In any group of engineers turned senior executive of a large American corporation, Ben Moreell's career would stand out for his technical and administrative leadership. At the same time, anyone who knows him would identify him as a great natural leader of men.

Under his leadership, the Jones & Laughlin Steel Corporation launched a $500 million expansion program that added impetus to plans for the redevelopment of Pittsburgh, Pennsylvania. When the decision was made to build a new $70 million open hearth shop in a blighted area on Pittsburgh's South Side, Ben Moreell saw to it that the company, working with the union and with the city government, found homes for the 296 families that had to be moved from the area.

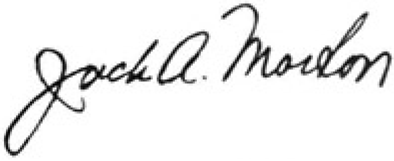
In addition to his official duties, he established himself as one of the nation's authorities on concrete and reinforced concrete. In 1929, he wrote "Standard of Design for Concrete," which received much favorable notice from the engineering world. He also has published other papers on the design and construction of concrete structures and on cements.

Admiral Moreell served as Chairman of the Task Force on Water Resources and Power of the Second Hoover Commission, directing a twenty-six-man committee from November 1953 through June 1955. Former President Herbert Hoover called the work of this Task Force "the most far-reaching and penetrating inquiry into our water problems ever made in our history."

Admiral Moreell served as Member of the Board of Visitors, U.S. Naval Academy, in 1953-55 (Chairman in 1955). He also was a Member of the Board of Trustees of the Thomas Alva Edison Foundation.

The doors of Presidents of the United States were open to Admiral Moreell, and men such as Franklin D. Roosevelt, Harry Truman, and Herbert Hoover looked to him for advice.

Admiral Ben Moreell was elected to membership in the National Academy of Engineering in March of 1976. Memberships and honors are too numerous to record in this memorial; he belonged to all engineers and was a frequent writer and speaker in support of his views on individualism and constitutional government



Jack Andrew Morton

1913-1971

By Morgan Sparks

Jack A. Morton died on December 11, 1971, at the age of fifty-eight. He had spent his entire professional career at Bell Laboratories, where, at the time of his death, he was Vice-President of Electronic Technology.

During his thirty-five-year Bell Labs career, which began in 1936, Mr. Morton made major contributions in the fields of electrical circuit engineering, vacuum tube development, and transistor and solid-state device development.

Jack Morton was born on September 4, 1913, in St. Louis, Missouri. He graduated from Wayne University in 1935 with a Bachelor of Science degree in electrical engineering, and, upon receiving a Master of Science degree in electrical engineering from the University of Michigan one year later, he joined Bell Labs.

His early years were devoted to research and development in microwave technology. He conceived and developed high-frequency transmission measuring methods that exceeded the ranges of previously existing means by a factor of ten. Later he aided the development of the grid-return amplifier at microwave frequencies, an achievement that, by extending the range of early radars, had an important effect on the course of World War II in the Pacific.

After shifting to tube development, Mr. Morton designed a close-spaced microwave tube that, thirty years later, is still the heart of the transcontinental radio relay system for voice and TV trans mission. The new features he pioneered in this tube were interelectrode spacings one-quarter of that used in any previous tube and a specially developed long-life cathode coating with one-third the thickness of then-current practice.

Shortly after the invention of the transistor at Bell Labs in 1948, Mr. Morton became the leader of a team responsible for the development and introduction to manufacture of the first economically and technically feasible transistor. He suggested the first widely used equivalent circuit for the transistor, as well as methods for finding other equivalent circuits. He also pointed out important stability conditions and devised a method widely used for measuring minority carrier lifetime in semiconductors. He recognized very early the importance of single-crystal material in the performance of semiconductor devices and supported enthusiastically the development of that field. He contributed numerous suggestions in the fields of semiconductor surface conduction phenomena, device design, and metallurgical techniques.

In 1952 Mr. Morton became Assistant Director of Electronic Component Development, and in 1953 he was named Director of Transistor Development. Two years later he advanced to Executive Director with broadened responsibilities in component development, and in 1958 he became Vice-President of Electronic Technology.

Mr. Morton served as Chairman of Bell Labs' Education Committee from 1965 to 1968, and during these years he laid the groundwork of a comprehensive in-hours continuing education program for the professional staff. At the time of his death, he was Chairman of the Bell Labs' Committee on Technical Management.

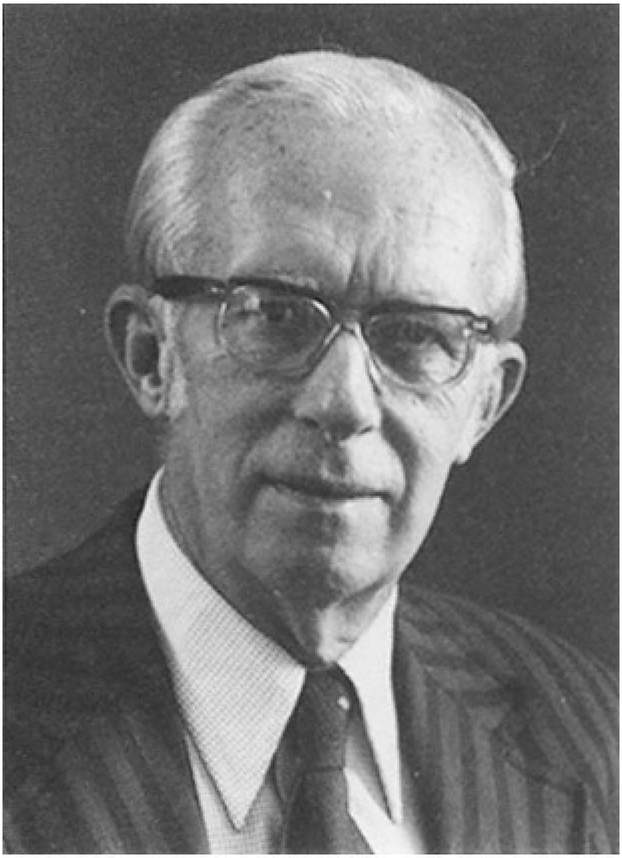
Jack Morton was awarded many honors: honorable mention, Outstanding Young Electrical Engineer, Eta Kappa Nu (1948); Wayne University Alumni Award (1951); University of Michigan Centennial-citation for contributions to science (1953); Honorary Doctor of Science, Ohio State University (1954); Honorary Doctor of Science, Wayne University (1956); David Sarnoff Medal by IEEE for "outstanding leadership and contributions to the development and understanding of solid state electron devices" (1965); election to the National Academy of Engineering (1967); IEEE Reliability

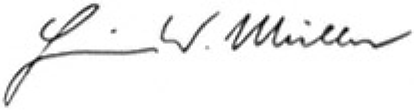
Group Award (1969). Posthumously, the IEEE Jack A. Morton Medal was established to be awarded annually for "outstanding contributions in the field of solid-state devices."

Jack Morton was the author of numerous articles. His book, *Organizing for Innovation,* was published simultaneously in the United States and Japan in 1971. As inventor and coinventor, he held twenty-four patents.

He was a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), a Member of the Advisory Council of the School of Engineering at Stanford University, a Member of the Visiting Educational Committee at the University of Michigan, and Chairman of the Board of Trustees of the Rutgers Preparatory School. He was also a Member of the honor societies Eta Kappa Nu, Tau Beta Pi, Sigma Xi, and Phi Kappa Phi. He served on various committees of the IEEE, the National Academy of Engineering, the National Academy of Sciences, and the U.S. Government.

Jack Morton was a born innovator and a natural leader. Many and diverse were his talents and interests. He approached problem solving with a characteristic and unique mix of originality, vitality, and uncanny insights. This led him to widely acclaimed contributions in the fields of electronics, education, management, and corporate organization. In the words of James B. Fisk, President of Bell Laboratories at the time of Morton's death, "Jack Morton was one of those rare breeds of men who not only generate a vast number of technological innovations themselves, but also develop and inspire others to produce major innovations in concepts, systems, and technology. He was a man who devoted his life to propagating technical ideas and developing technical people, and was able to blend management theory and management practice." He was an incessant reader, an articulate writer, and an inspiring speaker. His counsel was sought by many and was given freely. Tragically, he died at the peak of his productive life. His accomplishments survive him and will continue to benefit technology and society.





Erwin Wilhelm Mueller

1911-1977

By Rustum Roy

Erwin W. Mueller, Evan Pugh Research Professor Emeritus of Physics at the Pennsylvania State University, died on May 17, 1977, at the age of sixty-five following a stroke suffered at a National Academy of Sciences meeting in Washington, D.C. He was the inventor of the field-emission microscope, the field-ion microscope, and the atom-probe field-ion microscope. It is no exaggeration to state that Erwin W. Mueller was the first man to *see* an atom, and the various micrographs he obtained with these microscopes adorn virtually every elementary science school book, encyclopedias, and the world's great museums.

He was born on June 13, 1911, in Berlin, Germany, and had his early education at the Technical University of Berlin. He studied physics under Nobel Laureate Gustav Hertz and obtained his Dr. Ing. in physics in the year 1936. Soon afterwards, he conceived the idea of the field-emission microscope, which enabled him to image the surface of submicroscopic metal crystals with a resolution of about twenty angstroms. For the first time, the diffusion and reconstruction of surface layers could be vividly seen. In 1941 he discovered the principle of field desorption, i.e., the removal of surface atoms at low temperature by the application of a high positive electric field. This laid the basis for his later concept of the field-ion microscope. He had by then realized the use of field-desorbed ions to image their sites at the specimen surface, to improve the resolution of the field-emission microscope by an order of magnitude. However, he was quick to recognize the need for a million-fold image intensification and prognosticated the possibility of a field-desorption microscope if only an image intensifier were available. It is only fitting that after nearly thirty years this was made possible in his own laboratory when under his direction his student R. J. Walko obtained the first field-desorption micrograph using a channelplate image intensifier.

In 1951, while at the Fritz Haber Institute of the Max Planck Society in Berlin, he invented the field-ion microscope by supplying the absorbate continuously in the form of a neutral ambient gas, which in turn could be continuously desorbed in the form of ions to produce a projection image. However, it took him four more years before he could finally achieve atomic resolution by cryogenic cooling of the specimen. "It was a sticky day in August 1955, that I became the first person to *see* an atom," he often recalled.

In 1952 he was invited to the United States for a lecture tour. Immediately after conducting an inspiring colloquium, he was invited to take a position in the Physics Department of the Pennsylvania State University as a Professor of Physics. In 1956 he was made Research Professor of Physics and in 1969 he was named Evan Pugh Research Professor.

In 1967 he introduced the atom-probe field-ion microscope-a combination of a field-ion microscope with a time-of-flight mass spectrometer-which opened a new dimension in field-ion microscopy. Now, like the mythical Maxwell demon, he could not only see an atom, but could also pull it out of the tip of the metal and pass it through the mass spectrometer to ascertain its chemical identity. This atom-probe microscope is in principle the ultimately sensitive analytical tool, being capable of analyzing a single atom.

Erwin Mueller's numerous scientific contributions have been described in his two books, four book chapters, three patents, and more than 200 papers.

His scientific achievements were recognized by the science community with numerous awards, such as the Bronze Medal for outstanding work by the Technical University of Berlin (1936); the C. F. Gauss Medal, Braunschweig (Laudatio by M. V. Laue) (1952);

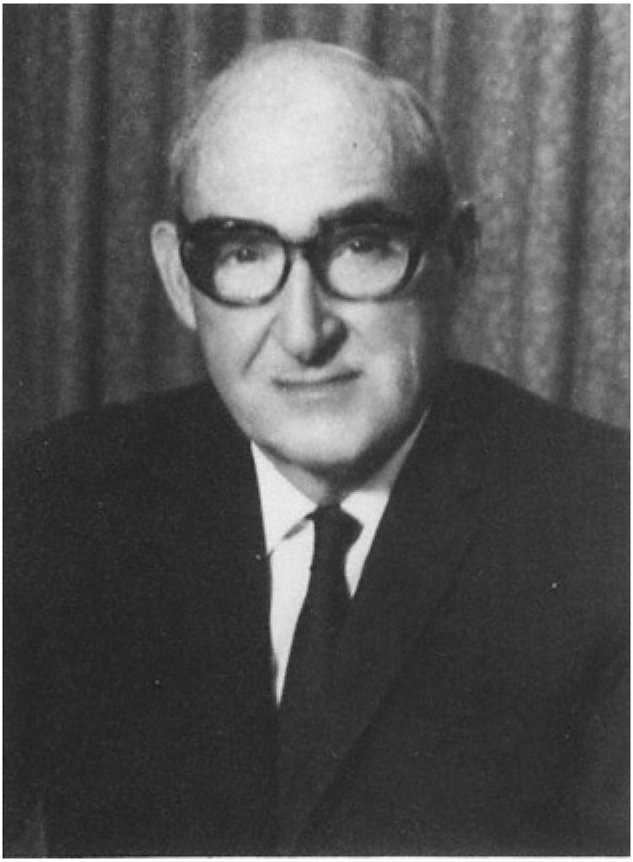
the Achievement Award by Instrument Society America (1960); the H. N. Potts Gold Medal by the Franklin Institute, Philadelphia (1964); the Centenary Lectureship Silver Medal by the American Vacuum Society (1970); the John Scott Medal by the City of Philadelphia (1970); and the Davisson-Germer Prize of the American Physical Society (1972). He became the Scientific Member-at-Large of the Max-Planck Institute, Berlin, in 1957; was elected as a Fellow of the American Physical Society in 1961; as a Member of Academy Deutscher Naturforscher, Leopoldina, in 1968; as Honorary Fellow, Royal Microscopical Society, Oxford, in 1969; and as a Member of the National Academy of Engineering and National Academy of Sciences in 1975. He served the National Academy of Engineering Committee on Membership, General Engineering Peer Group.

Erwin Mueller participated at numerous national and international scientific conferences by invitation. He was the Chairman of the Annual Field Emission Symposium in the years 1957, 1965, and 1973 and Chairman of the Division of Electron Physics, American Physical Society, in 1962-63. He served as a Member of the editorial boards of the journals *Physics Status Solidi* and *Surface Science*.

An energetic scientific ambassador, he spent his summer vacations traveling in Europe, particularly France, Germany, and England, where he helped to establish programs of research in field-emission and field-ion microscopy. Following invitations to various institutes in Venezuela, Russia, Israel, Italy, India, and Japan, he spent weeks lecturing at conferences and seminars in these countries.

A hands-on scientist with undiminished energy till the end of his life, Erwin W. Mueller participated in the construction of elaborate instruments. His knowledge of practical experimental techniques was enormous. A student could not only benefit from discussing scientific problems with him, but also learn from him practical techniques such as glass-blowing of elaborate apparatus.

His unexpected death was a great loss to his Pennsylvania State University colleagues and to the scientific community.



Carl Frederick Prutton

1898-1970

By Chalmer G. Kirkbride

Carl Frederick Prutton, educator, engineer, inventor, industrial executive, and philanthropist, died at the Columbia-Presbyterian Medical Center in New York City on July 15, 1970. He had a multitude of friends who respected and loved him.

He was born in Cleveland, Ohio, on July 30, 1898, and was the second of four brothers whose father ran a milk business. He attended Purdue University as a freshman at the age of sixteen. His economic situation, however, was so tight that he joined the Indiana National Guard in order to have the state pay for his Purdue military uniform.

This did not turn out as he had expected. He returned to Cleveland during the summer vacation of 1916 and was earning fifty-five cents per hour operating a grinding machine. He had been on the job two weeks when he was summoned to the Mexican border to help subdue Pancho Villa, for which he was paid $15 per month. This did not permit him to save anything, and, when he went back to Cleveland the following October, he could not afford to return to college.

Subsequently, he obtained a job as a locomotive fireman on the New York Central at $114 per month. In the fall of 1917, he entered Case Institute of Technology part-time and kept his locomotive fireman's job. By the fall of 1918, his savings were sufficient to permit him to leave the railroad and enter Case full-time.

He obtained his Bachelor of Science degree in chemical engineering in 1920, and, while serving as an Instructor at Case, he obtained his master's degree in 1923. He received his Doctor of Philosophy degree in physical chemistry at Western Reserve University in 1928.

It is apparent that, even though Carl's parents were unable to pay his way, he was sufficiently enterprising and energetic to work and pay for his education himself. This same spirit was always manifested by Carl throughout the balance of his life. Those who had the privilege of working with him never doubted this man's ability to succeed. We always knew he would be successful at whatever he undertook.

Carl served on the faculty of Case Institute of Technology from 1920 through 1948. He was Head of the Department of Chemistry and Chemical Engineering from 1936 to 1948. From 1942 to 1944, he was Chief, Process Development Branch, Office of Rubber Director, and Consultant for the War Production Board.

From 1921 through 1941, Carl served as consultant to the Dow Chemical Company. In the earlier years, he was involved in the development of processes for separation of calcium and magnesium chlorides brine, which matured into full-scale commercial plants.

Later his major efforts were expended in building up and operating a research and field development organization and equipment for the Dowell Division. This Division required a very special form of research organization and techniques. It included a field development group that was tightly integrated into the commercial end of the business.

Developments during Carl's years with Dowell included improvements in acidizing procedures, new inhibitors, plastic water shutoff methods, bottom-hole survey equipment and procedures, and the use of acid and other chemicals for the cleaning of scale from industrial equipment. Dowell blazed the way in the employment of acid and other chemicals to greatly increase the productivity of oil, gas, and water wells.

In 1929, Carl became a Consultant to Lubrizol, which entailed the beginning of research on additives at the Case Institute of

Technology laboratories. At that time, Lubrizol was marketing only a graphite-containing spring lubricant. No additives were being made and sold by Lubrizol. The total additive business in the United States was minute.

Between the years 1929 and 1951, Carl served Lubrizol in the varied capacities of Consultant, Director, and Research Director, while the Company assumed a leading position in the lubricant-additive field. The use of lubricant additives in the United States grew to over $200 million per year by the time of Carl's death.

Initial lubricant research work at Case demonstrated the effectiveness of chlorine compounds in lubrication and later the synergistic effect of chlorine on the action of sulfur compounds in extreme pressure lubrication. Research centered on the fundamental mechanism of action of lubricating additives and on corrosion in lubricating systems.

In 1944 and 1945, Carl served full time at Lubrizol in charge of research and pilot plant development. During that period a number of improved additives for postwar civilian markets were developed under Carl's guidance. Several batch manufacturing plants were converted into simplified continuous processes. Several plants for manufacture of substitutes for unavailable chemical intermediates were set up and operated.

The decision by our armed forces to require additive-treated crankcase lubricants for all internal combustion military units, as well as additive-treated gear lubricants, had made tremendous demands on the additive manufacturers. The result of such military use was to prove beyond all doubt the efficiency and necessity of such materials that Carl had pioneered.

During Carl's years with Lubrizol, he led the Company in both fundamental and applied research concurrently. The chief areas explored were crankcase lubricant additives, gear lubricant additives, cutting oil additives, metal drawing compounds, lubricating greases, engine fuel additives, asphalt additives, and synthetic lubricants.

The research on lubricant additives, under Carl's leadership, produced outstanding benefits, one of which made possible the use of the hypoid gear by increasing the load-carrying capacity of a mineral oil more than tenfold. This had a revolutionary effect on the automobile industry.

Another benefit was greatly increased life and efficiency of Diesel engines by keeping the pistons clean, so the piston rings remained loose and effective. Periods between engine overhauls, in general, increased over tenfold in length. This greatly reduced maintenance and improved reliability of performance.

In 1948 Carl left Case and went into business on his own as a consultant to companies interested in research and development. One of his clients in his new business was Mathieson Chemical Corporation, now Olin Mathieson Chemical Corporation. Carl was employed on a part-time basis in 1948 to appraise the Corporation's research and development program.

In 1949, the Corporation acquired the business and assets of two companies with eight plants. Carl was invited to become Vice-President and Director of all manufacturing and of all their research and engineering. Carl accepted and sold his consulting business and went with Mathieson.

While Carl was with Mathieson, he championed the need for industry-sponsored basic research in engineering schools. He felt that the increased Government support of research projects could lead to indirect or direct control by Government of a large part of our advanced education system. He felt that the uncertainty of Government contracts creates an unwholesome atmosphere for the campuses.

When the Olin Mathieson Chemical Corporation was formed in 1954, it moved into such remote areas of chemistry as Kraft paper, guns, and shotgun shells. At that point Carl concluded that he was spreading himself too thin, since he had fifteen different vice-president titles. Furthermore, he did not believe that the best way to build a company was to buy other companies. When his contract expired in 1954, he terminated his connection with Olin Mathieson.

Carl had about decided to "retire" to a part-time teaching position when Food Machinery and Chemical Corporation (FMC) persuaded him to join them on a full-time basis. He did so in June

1954. At that time the company had been in the chemical business only a few years and conducted its operations through five different divisions.

Carl immediately set out to consolidate the company's chemical operations into a logical and effective organization. His study reached into all management activities. After about eighteen months, Carl presented the management with a plan for reorganization and consolidation of its chemical interests.

Emphasis at every level was directed toward improving efficiency of operation and making the most effective use of the organization's staff without regard to "how it used to be done." Much duplication of effort and responsibility were eliminated with the result that the company was able to reduce the personnel of the chemical divisions by nine percent. The whole spirit of the organization changed from old-line conservatism to a new aggressive approach.

In June 1956 Carl was elected Executive Vice-President of the Corporation in charge of five chemical divisions. As a result of Carl's efforts in management reorganization of chemical activities, the Corporation received from the McGraw-Hill Publishing Company, in December 1959, the first Kirkpatrick Award for Management Achievement in Chemical Industry. The building of a strong technical program, fully integrated with management planning and action, was the principal foundation on which this achievement was based. This involved the construction of modern research facilities and the building up of superior research and development groups.

Carl retired as Executive Vice-President of FMC on June 30, 1960, but continued with the firm as a Corporate Director and Consultant until his death. He served as Special Assistant to the Governor of West Virginia on Industrial Development. He served on the Board of Directors of Commercial Solvents Corporation and Sawhill Tubular Products, Inc. He also served on the Board of Directors of the American Institute of Chemical Engineers and on the Board of Trustees of Clarkson College of Technology. He rendered advisory service to many educational institutions such as

Clarkson and Manhattan College. He also served on several committees of the National Academy of Sciences Advisory Committee to the Office of Emergency Planning.

Carl had over 100 patents and was a prolific writer in the scientific, technical, and trade journals. He was coauthor of the widely used textbook, *Principles of Physical Chemistry,* and was an authority whose advice was sought by educators, industrialists, and those in Government.

He received honorary Doctor of Engineering degrees from Case (1954), from Clarkson College (1960), and from Manhattan College (1960). He received honorary Doctor of Science degrees from Marietta College (1962) and from Western Reserve University (1963).

Carl was elected to the National Academy of Engineering in 1966. He received the Founders Award of the American Institute of Chemical Engineers (1965), the Modern Pioneer Award of the National Association of Manufacturers (1940), the annual Honor Award of the Commercial Chemical Development Association (1961), and the coveted Perkin Medal from the Society of Chemical Industry (1961). In November 1961 he spoke to the assembled chemical society groups in Cleveland and received their annual Chemical Profession Award of Merit.

Carl was active in many professional organizations. He was a Member of the American Institute of Chemical Engineers, the American Chemical Society, the Society of Automotive Engineers, the National Association of Corrosion Engineers, the Institute of Petroleum (British), the American Petroleum Institute, the Society of Chemical Industry, Sigma Xi, Tau Beta Pi, Theta Xi, and the New York Academy of Sciences.

After retirement from FMC, Carl and his wife moved to Coronado Pines, Florida, and he undertook with his usual vigor to upgrade the natural beauty and appearance of the Lake Weir area. He established a nursery, Coronado Gardens, and led this Florida community into a long-range beautification program.

Carl is described by his widow as "a compassionate man who was always willing and eager to help those less fortunate than he....

He loved young people and was untiring in his efforts to help them get a good education."

Carl set up a scholarship fund at the Baptist Church in Candler, Florida, whereby any young person who showed promise would have the chance of getting a good education and of becoming a valuable member of society.

Carl Frederick Prutton is survived by his widow, Marie; two sons, John and Carl F., Jr.; and four daughters, Mrs. George D. Conrad, Jr., Mrs. Robert D. Sutherland, Mrs. J. R. Small, and Mrs. J. M. Castillo.

Richard William Roberts

1935-1978

By Arthur M. Bueche

Richard W. Roberts, Staff Executive of the General Electric Company, died suddenly at his home in Wilton, Connecticut, on January 17, 1978. Dr. Roberts had gained a reputation as an outstanding administrator of research and development, both in private industry and the Federal Government. At the time of his death, he was carrying out a comprehensive study of technology in the General Electric Company.

Dr. Roberts was born on January 12, 1935, in Buffalo, New York. He received his bachelor's degree in chemistry, with distinction, from the University of Rochester in 1956 and his doctorate in physical chemistry from Brown University in 1959, with a thesis on the scattering of atomic and molecular beams.

He served as a National Academy of Sciences Postdoctoral Fellow at the Bureau of Standards in 1959-60 and then joined the staff of the General Electric Research Laboratory (now the GE Research and Development Center) as a physical chemist. His initial work was in chemical kinetics and surface chemistry. He quickly also became an internationally recognized authority in ultrahigh-vacuum science and technology and on the properties of atomically clean metals.

Among his outstanding research achievements was his discovery of iodine-based lubricants for difficult-to-lubricate metals. His high-vacuum research indicated that thin film compounds of iodine and metal would significantly reduce friction. He and

Robert S. Owens went on to show that iodine dissolved in certain organic liquids performed far better than any other known lubricant in rotating equipment and metalworking applications involving titanium, stainless steels, and superalloys.

In 1965, Dr. Roberts received the first of several successive management positions at the General Electric Research and Development Center. Within three years, he had become Research and Development Manager of Materials Science and Engineering, directing the efforts of 250 scientists and engineers.

"Dick Roberts' achievements as a manager," a close associate has written, "grew out of his ability to motivate people." Another has noted, "He never started a conversation by telling me what *he* was doing; he always told me, with understandable pride, what *his people* were doing."

Among his people's achievements during his five years' tenure were the first laboratory production of gem quality diamonds; unique cutting tools for machining space-age materials; new polymers and composites; a wide variety of medical diagnostic devices; and (anticipating the emergence of the energy crisis) the launching of major programs in coal gasification, improved turbine efficiency, and energy storage.

In February 1973, Dr. Roberts was named Director of the National Bureau of Standards. He led that organization through a challenging period, when in addition to maintaining its outstanding programs in the physical sciences, product testing, and environmental areas, the Bureau also underwent a fivefold increase in its energy-related work.

In June 1975 he accepted the challenging assignment of Assistant Administrator for Nuclear Energy in the newly created Energy Research and Development Administration (ERDA). His responsibilities ranged over such areas as technical work on civilian nuclear reactors, research and development on the proposed breeder reactor, and application of nuclear propulsion to naval uses. In this job he displayed extraordinary talent for communicating with people on all levels, and he earned the respect of long-established leaders in the nation's nuclear programs.

In 1977 he accepted a position on the Corporate Staff of General

Electric, with the special assignment of directing a comprehensive Corporate Technology Study, aimed at formulating policies for the management, generation, and use of technology.

Dr. Roberts was elected to the National Academy of Engineering in 1977. He was a 1975 recipient of the Arthur S. Fleming Award as one of the ten outstanding young men in the Federal Government, and he was a 1965 winner of an "I-R 100" Award from *Industrial Research* magazine for his work on iodine lubricants. He was a member of numerous scientific and honorary societies, including Phi Beta Kappa and Sigma Xi. His scientific and technical work resulted in over 70 papers and 3 U.S. patents. He was coauthor with Thomas A. Vanderslice of the book *Ultrahigh Vacuum and its Applications* (1963). He became an effective spokesman on technology policy, presenting his views in more than forty general addresses and papers.

Dick Roberts' rapid ascent into important positions of business and government responsibility evidenced his drive, toughness, and productivity. But these qualities were tempered by realism about what people and technologies could accomplish, graceful cordiality, and empathy with others. "He was attuned to the feelings of others," a friend has said. "He could always come up with a note or notion that was personal and special, for secretaries and Nobel laureates alike." He further balanced his immersion in the pressures of Government and industrial bureaucracy by a love of nature, as expressed through camping in the Adirondack Mountains and through collecting a library of the history and tradition of that region.

In all, Richard W. Roberts possessed a rare combination of scientific talent, managerial ability, and personal qualities. The nation has few young leaders of his caliber, making his death all the more tragic.

Karl Schwartzwalder

1907-1975

By Lawrence R. Hafstad

Karl Schwartmalder, retired Director of Research and Development at the A. C. Sparkplug Division of General Motors, died on May 2, 1975, at his home in Holly, Michigan. He was a world renowned authority with many awards and citations for his contributions to research on dielectric characteristics of porcelain and to the development of ceramic engineering.

Mr. Schwartzwalder was born May 5, 1907, in Pomeroy, Ohio. This midwestern small-town environment was one wherein one expected the necessities and amenities of life to be earned by honest effort and where charity was voluntary. No doubt this had a real influence in making him the self-sufficient, straightforward, concerned person his associates came to recognize.

As a youth he early learned to work and play vigorously and with purpose. He delivered newspapers and worked at odd jobs to provide supplementary family income. He went on to college, receiving a Bachelor's degree from Ohio State in 1930, and a Master's degree in 1931 under the guidance of the late ceramic specialist, Arthur S. Watts. Following this, on the advice of Professor Watts, he promptly joined the A. C. Sparkplug Division of General Motors. Mr. Schwartzwalder's entire professional life was spent at the A. C. Division. He moved steadily up the ranks with increasing recognition in his field for his many publications and especially for his inventiveness resulting in some fifty-six patents.

In 1945 he became Chief Ceramic Engineer, in 1954 Director of Research, and in 1968 Director of Research and Development.

Because of his expertise in the ceramic field, Mr. Schwartzwalder was frequently called upon by the National Academy of Engineering and by the National Research Council to serve on various technical panels and committees, including long service with the National Materials Advisory Bord. He also served as a consultant to the National Bureau of Standards, the Manhattan Project, and the Atomic Energy Commission.

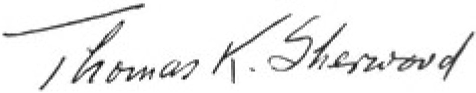
In parallel with his technical and scientific responsibilities, Mr. Schwartzwalder was very active in professional society work, serving in many positions both local and national with the SAE (Society of Automotive Engineers) and the ACS (American Ceramic Society). In the ACS he was a Fellow, an Honorary Member, and a Past President. In recognition of his many achievements, he has been given numerous awards and citations, among the major ones being the ACS Jeppson Award (1959), Ceramic Age Man of the Year Award (1960), Michigan Patent Law Association Outstanding Michigan Inventor Award (1963), and the ACS Bleininger Award (1976). His alma mater, Ohio State, honored him with a Doctor of Science degree in 1968. He was elected to the Academy of Engineering in 1970.

Much of the progress made in the last two decades in the ceramic field can be attributed to Mr. Schwartzwalder's pioneering work, for his were the first means developed that permitted the manufacture of dense ceramic articles without benefit of clay or the use of uneconomical casting methods. This particularly applies to high-alumina ceramics, which is one of the most important branches producing products for technological uses. His ideas led the way in showing that silica was not necessarily to be completely shunned if high-strength alumina products were to be made, as was first indicated by German ceramists who produced "Sinterkorund." A survey of the field will show how important this has been, for not only are all spark plug insulators made today very closely related in composition, but even other high-alumina products do not deviate much from the compositions covered in Schwartzwalder's early patents.

Mr. Schwartzwalder's counsel on the new techniques were invaluable in solving the ceramic problems attendant on the development of the atomic bomb, where many oxides other than alumina were employed. He was one of the few who were permitted to travel from one site to another during the war, when the Manhattan Project was ultrasecret, assisting the various groups with their ceramic problems. He has acted as a consultant to many other people over the years on matters relating to these methods, including General Motors' foreign plants.

While Mr. Schwartzwalder's technical contributions are well recognized, perhaps less known is his influence in advancing the careers of the many people who worked under him through the years. His guidance and selfless concern for them have resulted in an imposing alumni body, whose influence will remain far-reaching. He always enjoyed travel, visiting many foreign countries, inspecting countless research and manufacturing operations, and becoming acquainted with scientific and technical personnel worldwide. He had a peculiar ability to combine business and pleasure in the best sense. His insatiable curiosity pervaded everything he was exposed to in these extensive travels, benefiting both his company and those he contacted along the way. He somehow also found time to be active in civic affairs in such organizations as the local Chamber of Commerce, the Industrial Executives Club, the Science Fair, and a program that he founded and sponsored for talented high school students.

Perhaps among the least-known facets of Karl Schwartzwalder's life and also that of his late wife were their abiding faith in young people and their concerned interest in nature and wildlife. One must have been exposed to their country home, their animals, and the constant influx of young friends to realize the basic goodness of this couple. They represent the best of human instincts.



Thomas Kilgore Sherwood

1903-1976

By Hoyt C. Hottel

Thomas Kilgore Sherwood was by any standards one of America's great chemical engineers. His energy, research contributions, applied engineering achievements, and influence on chemical engineering education were prodigious. He was admired and respected by his peers, and countless numbers of them called him friend. He had warmth, charm, orderliness, and a conscience that drove him to use his talents to the fullest to advance chemical engineering in theory and practice.

Tom Sherwood was born in Columbus, Ohio, on July 25, 1903; he died on January 14, 1976. He was the son of Milton Worthington Sherwood and Sadie Tackaberry Sherwood and spent most of his early youth in Montreal. There he received his Bachelor of Science degree from McGill University in 1923. That fall he came to the Massachusetts Institute of Technology (MIT) for graduate work in the Chemical Engineering Department. During an assistantship under W. H. McAdams in 1924-25 he picked up Mac's habit of intense concentration on a problem until it was in shape for safe engineering use. His first paper, coauthored with McAdams and published in 1926 in *Mechanical Engineering,* was "The Flow of Air and Steam in Pipes." His doctorate thesis under Warren K. Lewis, entitled "The Mechanism of the Drying of Solids," was completed in 1929, a year after he had accepted an Assistant Professorship at Worcester Polytechnic Institute. In 1930 he returned to MIT as Assistant Professor and became Associate Professor in 1933 and Professor in 1941. In 1966 he was honored by a first appointment to the Lammot dupont Chair in Chemical Engineering. On retirement from MIT, in 1969, he became Professor of Chemical Engineering at the University of California (Berkeley).

During his thirty-nine-year period on MIT'S faculty, Tom's activity included, in addition to a full-time load of teaching, research, and writing, the generation of new subjects in the chemical engineering curriculum, membership on several committees related to improvement of the educational process, and twelve years of primary responsibility for graduate students in chemical engineering. In 1946 he was appointed Dean of Engineering, in which position he faced the difficult early postwar problems of the Institute and, characteristically, worked hard to raise the standards of excellence of MIT'S engineering departments. In 1952 he chose to return to his teaching and research.

Tom's primary research area was a logical development of his early stimulation by McAdams and Lewis-mass transfer and its interaction with flow and with chemical reaction and industrial process operations in which those phenomena played an important part. His rapid rise to the position of world authority in the mass transfer area was accelerated by the appearance of his book, *Absorption and Extraction,* the first significant text in this area, published in 1937. Revised in 1952 with R. L. Pigford, and completely rewritten with Pigford and C. R. Wilke for publication in 1974 under the title *Mass Transfer,* the book has had enormous influence. The worldwide use of the Sherwood Number is a small memorial to that effort. In 1939 Tom's prior introduction of a new subject, applied mathematics in chemical engineering, into MIT'S chemical engineering curriculum culminated in a book of the same name, coauthored with C. E. Reed. An almost completely rewritten edition, coauthored with H. S. Mickley, appeared in 1957. In 1958, *The Properties of Gases and Liquids* was published, coauthored with R. C. Reid. In 1963 two more books appeared, *A Course in Process Design* and *The Role of Diffusion in Catalysis,* the latter coauthored with C. N. Satterfield. Tom's last book-writing effort, *Mass Transfer* -already referred to-was completed less than two years before his death. In addition to these many books, Tom published some 120 technical papers and a dozen or so editorials or nontechnical papers and gave many invited lectures.

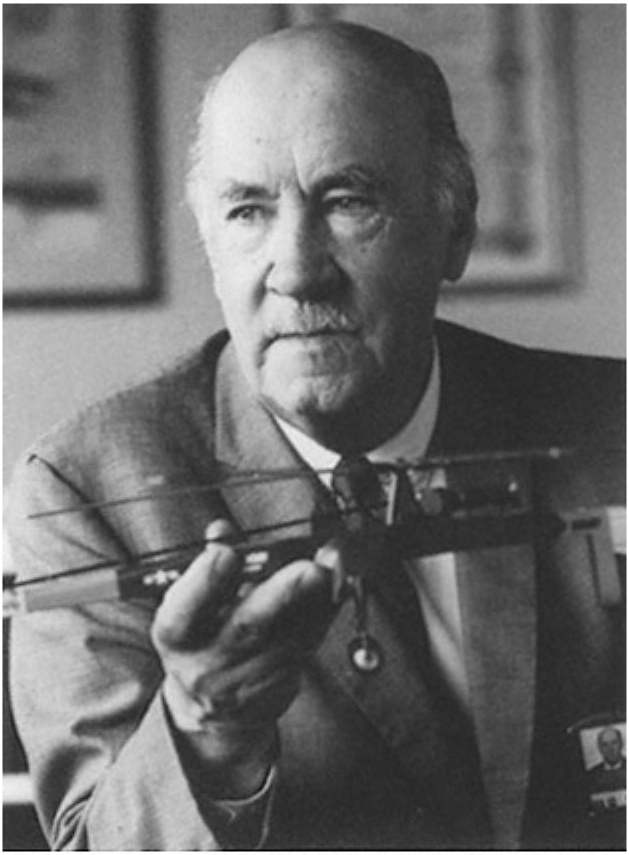
War is an ugly business that incongruously but understandably often draws out of men of good will their best efforts. In 1940 Tom was asked to help begin the organization of chemical engineering manpower for use in the newly organized National Defense Research Committee (NDRC). In 1942 he became a Consultant to the Baruch Committee concerned with synthetic rubber development and in the same year Section Chief for Miscellaneous Chemical Engineering Problems, in NDRC's Chemical Engineering Division. New hydraulic fluids for use at high and at very low temperatures, antifouling coatings for ship bottoms, inerting of gas space in aircraft fuel tanks, development of large screening-smoke generators, production of concentrated hydrogen peroxide-these are a few examples of the many projects that came under his expert supervision. In 1944 he was a Member of the Whitman Committee on the status of jet propulsion. That fall, as a Consultant for the War Department, he went into Europe behind advancing troops on an Army mission on scientific intelligence. Tom was among those of us who looked back on the exciting war days jointly with nostalgia over the intensive research efforts produced and with regret over the source of the stimulation.

Although Tom was primarily an educator, his contact with industry was frequent and effective. He made major contributions in the areas of seawater conversion (he was advisor to the Office of Saline Water), the removal of sulfur dioxide from stack gases, the freeze-drying of blood, the manufacture of penicillin, and the development of various petrochemical processes, including the manufacture of vinyl acetate and oxo alcohols.

The above record in the areas of education, teaching, peacetime research, wartime research, research administration, and industrial consulting eminently justify the adjective "prodigious" to describe Tom's output. This led naturally to recognition by his peers in the form of many honors received through the years. Honorary doctorates were bestowed by Northeastern University, McGill University, and the Technical University of Denmark. Election to the American Academy of Arts and Sciences came in 1948 and to the

National Academy of Sciences in 1958; and Tom was a Founding Member of the National Academy of Engineering. The American Institute of Chemical Engineers, in which Tom was Counselor in 1947-49, awarded him the William H. Walker Award in 1941, the Founders' Award in 1963, and the Lewis Award in 1972. The American Chemical Society bestowed the Murphree Award on him in 1973. The Chemical Institute of Canada made him an Honorary Member. For his war work, he received the U.S. Medal for Merit in 1948.

A personal note: We were graduate students and roommates in early MIT days; our paths crossed frequently, particularly during the war years; and we spent an idyllic month together climbing the Grand Tetons in 1951. Tom lived a full life of outstanding service to his profession and his fellow man. His peers salute his memory. He will long be remembered.



Igor Ivan Sikorsky

1889-1972

By Carlos C. Wood

Igor Ivan Sikorsky died on October 26, 1972, in Easton, Connecticut. When he was born in Kiev, Russia, on May 25, 1889, Dr. I. A. Sikorsky (Professor of Philosophy in the St. Vladimir University of Kiev) and his wife welcomed a new addition to a family already comprised of three daughters and a son.

Professor Sikorsky and his wife were cultured in the true sense of the word, being interested in the great works of the past across a broad spectrum, working hard (and effectively) to advance the scientific and human work of the time, and imbuing young people with knowledge and drive for efforts in the future. This formed the base of Igor Sikorsky's upbringing.

One of the earliest recollections of Igor Sikorsky dealt with his mother. She received an education in a medical college, but motherhood prevented her continuation of scientific work. Before Igor was born, she was much absorbed with the life and work of Leonardo da Vinci, who among all his other activities was among the first to study flying and to produce preliminary designs and sketches of wings. Young Igor was told by his mother of Leonard da Vinci's attempts to design a flying machine. Even at an early age Igor was so interested in flying that he never forgot this information and continued to ask his family, and others he considered competent, questions about flight. It is obvious that this was a great determinant to Igor's later career.

Professor Sikorsky worked long hours as an active physician, lecturing at the University and continuing his scientific research and writing at home. For relief from these efforts, it became his habit to journey abroad each year for several weeks, during which he studied scientific subjects, visited galleries and libraries, and purchased more books. During his lifetime he accumulated a personal library of some 12,000 volumes.

In 1900 he was accompanied on one of these trips by his youngest son, Igor. They spent the summer in the German Tyrol. As a result of conversations with his father at that time, at the age of eleven Igor Sikorsky was introduced to the natural sciences, particularly mechanics and astronomy, which remained of great interest to him for the remainder of his life.

Thus started, for the next few years Igor investigated many things in the natural science area. He made electric batteries. He built a small electric motor. Becoming interested in chemistry, he even made a bomb (successfully exploded in a hole in the family garden). He tried repeatedly to make flying models, and finally in 1901 he succeeded in making a model of a rubber-powered helicopter that could actually rise in the air!

In 1903, fourteen-year-old Igor Sikorsky entered the Naval Academy in Petrograd. He spent three years there, completing the general course. He finally decided that his real work would be in the field of creative engineering, and he couldn't get the flying machine out of his mind. Such a machine appeared to be impossible at the time, but he decided to enter actively into the study of engineering. Accordingly, although in good standing, he resigned from the Naval Academy in 1906 at the age of seventeen.

The abortive 1906 Revolution in Russia seriously disrupted academic work in that country, so Igor spent several months in Paris studying engineering. By 1907 the Russian situation had improved, so he returned to Russia and entered the Polytechnic Institute of Kiev in the fall, at the age of eighteen.

During his first academic year at the Institute, Igor Sikorsky was reasonably successful as a student, but was not particularly interested in theoretical studies or higher mathematics, as they seemed somewhat afield from actual work. Living at home, he still worked in his small workshop and laboratory, where he built and experimented with mechanical devices.

In the summer of 1908, Igor again went to Germany with his father. While there he read almost daily of the flights of Count Zeppelin in one of his early dirigibles. Also, and of far greater importance, for the first time he read of the successful flights of the Wright brothers. Whereas before this time all preponderant information was that powered flight of heavier-than-air machines appeared to be impossible, the success of the Wright brothers changed the whole picture. Thus, well-knowing that many people had spent much time, capability, and money unsuccessfully trying to design flying machines in the past, Igor Sikorsky, at the age of nineteen, decided to hitch his life to the aviation star.

Thus, during his summer vacation in 1908, in the room of a small hotel in Germany, Igor Ivanovitch Sikorsky began his first steady work in aeronautics. This work would occupy him until his death, sixty-four years later.

After some months of study and building of experimental apparatus at home in Kiev, Igor went to Paris with the good wishes of his father and the financial support of his sister Olga to extend his formal and informal aeronautics education and to buy a twenty-five horse power Anzani engine plus some parts for the aircraft he was planning to build.

Against the advice of what aeronautical experts there were at the time, Igor Sikorsky had decided to build a helicopter as his first flying machine. Construction started in May 1909, and the machine was completed and tests began in July. Mechanical dynamics problems were solved satisfactorily, and some solutions were found to dynamic control problems. However, unfortunately the machine would not lift its own weight, and some basic control problems remained. When this became apparent, Igor gave up the thought of flying this particular machine and instead obtained all possible technical and operating information from the machine before disassembly in October.

Design work had been proceeding on a second helicopter in the interim, but construction was delayed until after another trip to Paris to obtain more aeronautical information, engines, and to have some parts made. At this time Igor saw the Wright airplane in flight for the first time. Construction of the airplane was also considered at this time.

In February 1910 construction of a second helicopter was started and also of an airplane, the S-1. The early spring of 1910 saw completion of the second helicopter. It worked better than the first one, but appeared marginal in performance. Accordingly, effort was concentrated on completion of the S-1 airplane, which was fielded for tests in April 1910.

Igor found that the S-1 (after he taught himself to fly it) could barely fly in ground effect-the fifteen horse power Anzani was too small. Accordingly, a twenty-five horse power engine was installed, other logical changes were made, and in June 1910 the S-2 was completed. It first left the ground on June 3 and cracked up in an accident on June 30. It was determined that the installed power was minimal to permit level flight out of ground effect. But, Igor Sikorsky had flown in an airplane of his own design!

More changes, more power-the S-3. Then the S-4 and the S-5 both completed in April 1911. The higher-powered and larger S-5 appeared more promising, and at the end of April its tests started. On May 17 full flight was accomplished, and by mid-summer 1911 one-hour flights at 1,000 feet altitude were accomplished. Success!

In the fall of 1911 Igor Sikorsky was issued FAI pilot license No. 64 by the Imperial Aero Club of Russia.

Construction of the 100 horse power S-6 started in August 1911, and it was flown in November. Necessary improvements were made to result in the S-6-A, which was flown at the end of the year and proved capable of beating the existing world's speed record with a pilot and two passengers aboard at 113 kilometers per hour. The S-6-A received the highest award in the Moscow aircraft exhibition in February 1912.

In the spring of 1912 Igor Sikorsky entered into an agreement with the Russian Baltic Railroad Car Factory in Petrograd as Designer and Chief Engineer of the aircraft factory of the company, on very favorable terms.

During 1912 the S-6-B two-place biplane, S-7 two-place monoplane, and the smaller S-8 training plane were built. In September the S-6-B won a Russian army competition against many other competitors, with a cash prize and orders for some aircraft.

For some time Igor Sikorsky had been thinking about and doing preliminary design work on a large four-engined airplane. This was at a time when the experts were sure that a large aircraft would not be feasible and that control of four engines was not possible. On September 17, 1912, the Chairman of the organization that Igor had joined asked him to proceed on this large four-engine airplane.

On May 13, 1913, the "Grand" flew for the first time, complete with its closed cabin and its outdoor nose balcony. Thus was born the large multi-engined type of aircraft. Other Sikorsky-designed aircraft, the S-10 and S-11, won the Russian military competition in 1913.

An improved four-engined airplane, the "Ilia Mourometz," was started in August 1913. It had a wing span of 102 feet, a wing area about 1,700 square feet, and a gross weight over 10,000 pounds. Quite an airplane for the time, it was flown in January 1914. On June 18, 1914, a world's record was set for flight duration of six hours and thirty-three minutes with pilot and six passengers. This was just prior to the outbreak of World War I.

During World War I about seventy-five of these four-engined airplanes were delivered as bombers. A total of about 400 raids were made, with only one plane lost due to enemy action.

All work was stopped by the Revolution in the spring of 1917. Finally making up his mind, Igor Sikorsky left Russia in March 1918, taking with him a few hundred English pounds, and leaving behind the substantial investments resulting from his several years of intensive and successful work.

He went to Paris via London. In Paris he was asked to design a heavy bomber for the French. Plans were completed in August 1918. During the fall, preparations for starting construction were made. When the Armistice was signed in November 1918, work was stopped.

Because of curtailments in aviation, Igor decided to emigrate to the United States and start over. He landed in New York City on March 30, 1919.

The next few years held many disappointments for Igor Sikorsky. The aviation business in the United States was demobiliz ing from the expansion of World War I, and essentially no new work was available. During the summer of 1919 Igor did organize a company and started preliminary engineering work, but the company was disbanded before start of any construction. In the fall of 1919 he visited Washington and McCook Field in Dayton, where he spent six weeks working on the preliminary design of a large three-engined bomber for the Army Air Service. Igor returned to New York early in 1920 and unsuccessfully made several more attempts to reenter aviation in the next several months. Late in the fall of 1920, in order to obtain some income, he started teaching mathematics to Russian immigrants. Soon after, he began to give lectures on aviation and on astronomy. With these activities he was able to support himself.

These efforts took time mostly in the evening and on weekends. So, in the remaining available time, Igor turned again to designs for commercial airplanes. But up to 1922 it was not possible either to obtain a position with existing aviation concerns or to finance a company by normal methods. But all of these efforts were bringing Igor Sikorsky into contact with many people who offered either to subscribe small amounts or to assist as workers in an aviation endeavor. Accordingly, on March 5, 1923, a new company was incorporated as "Sikorsky Aero Engineering Corporation." The aims were to collect as many subscriptions as possible and to start as soon as possible on the construction of an all-metal, twin-engined, passenger transport plane-the S-29-A (A for America).

Work was started at a time when only $1,000 in cash had been received. After months of literally living from hand to mouth, with little or no pay for the workers, the S-29-A was first flown on May 4, 1924. Too many people crowded aboard on this first flight, and a forced landing on a nearby golf course badly damaged the airplane. This seemed the end.

But more money was raised, more effort expended, and on September 25, 1924, the repaired, re-engined S-29-A was successfully flown. It could fly on one engine, could carry fourteen passengers, and could cruise at 100 miles per hour. It proved the practicability of twin-engined commercial transports. Many people were given their first rides in this airplane. In 1926 it was sold to Roscoe Turner, who used it successfully for several more years.

In the meantime other efforts were being made, including the design of the S-34 twin-engined amphibian. It did not turn out to be practical, but furnished valuable experience and information, which was used later.

In the spring of 1926 work was started on the three-engined S-35 for a New York to Paris flight by the French Captain Rene Fonck. With insufficient time for testing, and under pressure of publicity, this airplane crashed on the attempted trans-Atlantic takeoff on September 21, 1926. This again put the Sikorsky company in bad shape financially, but help from New England friends permitted it to continue.

By the end of 1926 work was proceeding on the twin-engined S-37 for Captain Fonck to try again. By the spring of 1927 the S-37 was successfully flown and shown to be entirely suitable for the transatlantic flight.

On May 21, 1927, Charles Lindbergh made his remarkable solo flight across the Atlantic. This was to have a great, favorable, and long-term influence on aviation in the United States, but it also removed the most important reason for Captain Fonck's flight and the S-37 project died. The S-37 eventually was sold, flown to Argentina, and extensively used to carry passengers across the Andes.

In the meantime the experience gained from the S-34 amphibian was being applied to another twin-engined amphibian, the S-36, which was very satisfactory, and a few aircraft were sold in 1927. From this experience it was decided to make one more try.

During early 1928 construction of the twin-engined S-38 amphibian was under way. Because of the enthusiasm resulting from the Lindbergh flight, ten of these ten-seater aircraft were being built. The S-38 was successfully flown in May 1928 and proved to be an excellent airplane. Demonstration to the U.S. Navy showed its performance to be better than any other airplane of its size and power, and the Navy bought some. Pan American Airways also bought some and used them to open up the commercial air routes to South America. Other orders followed. The first ten aircraft were quickly sold, a second series of ten were also sold in a short time, and soon the company had more business than it could handle.

This great increase in business required enlargement of the factory, so the Sikorsky Manufacturing Corporation was reorganized as the Sikorsky Aviation Corporation, with increased capital. Land was purchased in Stratford, Connecticut, and a large modern plant with all necessary facilities was built there during 1929. Also, in 1929 the Sikorsky Aircraft Corporation became first a subsidiary and later a Division of United Aircraft Corporation. This latter relationship still exists.

During 1929 and 1930, more than 100 S-38's were built and sold. The S-38 airplanes were used in the pioneering and operations of about ten airlines, as well as by many private operators.

About this time Pan American asked for the construction of a much larger transport airplane. Sikorsky was chosen to produce it. At this time a personal relationship began between Igor Sikorsky and Col. Charles Lindbergh (who was an advisor to Pan American) that continued throughout the remainder of Igor's life. This new four-engined airplane was known as the S-40 *Flying Clipper*. It could carry its normal load of about 4,800 pounds for 700 miles at a cruising speed of 115 miles per hour. It could carry a payload of 300 pounds for 1,500 miles. The S-40 was completed in the spring of 1931 and went into Pan American service in late fall 1931.

Pan American really wanted to fly transoceanic, and with the success of the S-40 attention was turned to development of a transport airplane for such service. Building on the excellent characteristics of the S-40, and using all of the latest aeronautical information, the latest power plants and propellers, and the Pan American operating experience, plans were made for a true transoceanic flying *Clipper*-the S-42.

The S-42 was designed in 1932, and construction began in 1933. By the end of the year the airplane was completed, but winter and ice in the river held up first flight of the S-42 flying boat until March 1934. The capability of the S-42 was shown on April 26, 1934, when it carried a load of 16,608 pounds to 16,000 feet altitude. On May 17 it carried 11,023 pounds to 20,407 feet altitude. On August 1, 1934, the S-42 set eight more world records for loads up to 4,409 pounds for distances up to 1,249 miles at speeds over 157 miles per hour.

Shortly later the first S-42 was delivered to Pan American and in the fall of 1934 introduced new air travel that reduced the schedule time between the United States and Argentina from eight days to five days.

The second S-42 was equipped with long-range tanks and delivered to Pan American shortly afterwards. After much testing at Miami it was flown to San Francisco, from where it made the first flight to Honolulu on April 17, 1935. Later, another Pan American S-42 inaugurated the longest over-ocean airline in the world between San Francisco and New Zealand.

Finally, in July 1937 the first regular airline crossing of the North Atlantic between the United States and England started. Service also started to Portugal by the Bermuda-Azores route. Ten S-42's were built, all for Pan American.

Two additional types of fixed wing airplanes were built. The twin-engined S-43 amphibian carried fifteen passengers, a crew of three, and cruised at 160 miles per hour. It first flew on June 1, 1935, and in April 1936 set four world altitude records, one of 24,950 feet with zero payload. Fifty-three were built, with the U.S. Navy and Pan American being the prime users.

The large four-engined S-44 flying boat won a U.S. Navy competition and was first flown as the XPBS-1 on August 13, 1937. Sikorsky lost the production contract on price, but the design was used in the S-44-A commercial flying boat. This airplane cruised at about 210 miles per hour and could carry a load of thirty-two passengers from New York to Rome (4,600 miles) nonstop. Three aircraft were built and operated during World War II.

Writing in 1938, Igor Sikorsky remarks: "The successful flights of the S-42 across both major oceans may be considered as concluding the pioneering period of aviation. They are also to a large extent the conclusion of the story of the *Winged-S*.

Thus, with all of his insight, Igor Sikorsky could be wrong. He was just on the verge of a complete new period of aviation pioneering. His third aviation career was about ready to start.

The Sikorsky Division had made no money on the S-42 and had lost money on the S-44. It was necessary to close down the Sikorsky Division airplane production operations in 1938. But the decision was made to keep Igor Sikorsky and his creative technical group together-if they had any ideas of an aircraft development program that would warrant such action. Igor Sikorsky did have an idea, and he sold it to United Aircraft management.

In all of the busy years since 1909, Igor had continued to think about and make notes on the helicopter. Since 1928 he had been working informally with a couple of his close associates on ideas. He told the United Aircraft management that now was the time to add a new dimension, the vertical, to flying. The United Aircraft management agreed, and asked Igor, with a few close associates, to try and do it.

The first effort was the VS-300 helicopter, designed in spring 1939, built during that summer, and first flown (to an altitude of a few inches) by Igor Sikorsky himself on September 14, 1939.

It is interesting to note that the VS-300 closely resembled a helicopter design on which Igor had applied for a patent June 27, 1931, the patent being granted on March 19, 1935. It had a single main rotor (three blades) and a tail rotor (two blades). Although many variations (added rotors, etc.) of this basic main and tail rotor configuration were tried on the VS-300 (and by others before and since), the single main and tail rotor configuration was finally adopted and is still the basic arrangement of all subsequent Sikorsky helicopters (and many other manufacturers around the world). It is the configuration of at least ninety percent of all helicopters built to date.

Development flights continued until December 9, 1939, when a gust of wind upset the VS-300 because of lack of aircraft control power, and the VS-300 was badly damaged. The aircraft was rebuilt in a second configuration, adding two horizontal tail rotors supported on booms. The revised VS-300 began tethered flight on March 6, 1940, flew free on May 13, and was demonstrated to the public on May 20. Igor amazed onlookers by flying backwards, sidewards, and even turned on a spot. Igor was presented with Connecticut Helicopter License No. 1.

Most spectators did not notice that the machine had not flown forward. Asked about this later, Igor replied, "That is one of the minor engineering problems that we have not yet solved!" Actually, the added horizontal tail rotors had to operate in the turbulent wake from the main rotor in forward flight, making forward flight a problem. After adequate main rotor control power was provided, the two horizontal tail rotors were removed, and the aircraft performed very well in forward flight.

However, while still in this second configuration, the VS-300 established an American helicopter endurance record of 1 hour, 5 minutes, 14.5 seconds on April 15, 1941, and a world's record of 1 hour, 32 minutes, 26.1 seconds on May 6.

During May 1941 the VS-300 was again modified, removing the two horizontal tail rotors, increasing cyclic control power on the main rotor, and installing a single horizontal tail rotor high on the machine. This third configuration flew on June 12, 1941, was much better than the second configuration, and reached a forward flight speed of seventy miles per hour. Igor and his people then knew that they had the makings of a successful helicopter.

Versions of these aircraft can build bridges, install power lines in inaccessible places, lift and carry outsized articles without regard for dimensions, operate in construction and logging with no requirement for access roads, and can furnish transport literally from point (with or without landing at either point), in weather where fixed-wing airplanes cannot operate and even surface movement is difficult. These machines can find and operate with (or against) submarines, equipped with automatic hover, automatic navigation; can lay marine or land mines, or sweep them, in day, at night, or in almost any weather.

The helicopter has saved many lives, and Igor Sikorsky was always very proud of this. Many have been saved by rapid transport of injured people to medical facilities, in peace and in war. At least 10,000 lives have been saved by rescue operations from floods, off of ships in distress, from hurricanes, from behind enemy lines, in good weather and bad, during day or at night.

Igor Sikorsky long felt that the helicopter can help solve many of the increasingly complex world problems. From our experience to date, it appears that, as usual, he was right.

This then is the legacy that Igor Ivan Sikorsky leaves the world, as the result of his lifelong dedication and creative efforts in aviation. He was awarded membership in many organizations, many patents, and many honors. His was a life for which the people of the world should be very grateful.

In closing, a brief look at the man himself: He was soft-spoken-in my knowledge he never gave orders, but he made suggestions that were always worth listening to. He was courtly in an unassuming way-he always bowed on introduction. He retained a charming accent when speaking in English-and probably because he learned much of his English through reading the Bible, he always slightly accented the "ed" at the end of words. He was most considerate of others-he would wait often a considerable length of time until others, no matter how humble, finished speaking before even wishing them "Merry Christmas." Although shy, he was forceful in technical discussion.

Igor Sikorsky was a devoted family man, with five children: Tania, Sergei, Nikolai, Igor, Jr., and George.

Igor Sikorsky has been called a mystic, but I feel that he was a philosopher searching for the higher truths that should guide man if he is to continue to survive within the growing mismatch between technology and social consciousness. Aside from the *Story of the Winged-S,* he wrote three other books-some small but powerful: *The Message of the Lord's Prayer,* published in 1942 and reprinted in 1963; *The Invisible Encounter,* published in 1947; and *In Search of Higher Realities,* published around 1969.

In these books his insight into man's social capabilities was just as powerful as was his insight into man's technical capabilities. He felt that man is capable of overcoming the dichotomy between society and technology if he will seriously look to the Creator for guidance.

In 1969 a noted man long acquainted with him contributed a forward to a book on Igor Sikorsky in which he said, in part:

> All of us who have known Mr. Sikorsky well enough to call him "Igor"-and a mere acquaintance would not encourage this familiarity because of his quiet unassuming dignity-admire him very much and greatly value his friendship.
>
> He is a truly unusual person. He is a genius. He has great natural ability. He has, throughout his life, increased his inherently high capabilities by study, observation, and analytical consideration. He is able, and willing, to

concentrate and think through. He is not only intelligent, but wise-a person who instinctively-without the necessity for conscious thought-does the kindly, the right thing. A true gentleman, of the old school.

His three greatest aeronautical achievements were the multi-motored airplane, the flying boat, and the practical helicopter. He spent a full lifetime in developing and producing each in its turn. Almost every possible problem and frustration was faced and overcome. A less courageous and determined man would not have succeeded, as he did, in any of the three areas.

He dared to dream dreams-to dream the near impossible-and he made those dreams come true.

Lt. Gen. James H. Doolittle, USAF (Ret.)

For those of us who knew Igor Sikorsky, we can only comment, "Well and truly said."

Igor Ivan Sikorsky was a whole man, one who it was a privilege to work with and to know. He will long be admired, respected, and loved.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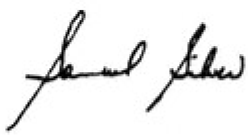


Samuel Silver

1915-1976

By John R. Whinnery

Samuel Silver, Professor of Engineering Science at the University of California, Berkeley, died of a heart attack on November 5, 1976. He left a legacy of elegantly framed research results in antenna theory and upper atmosphere physics, of institutions he had built that carry on creative research in electronics and the space sciences, and of many contributions of talent and of wisdom to engineering education and to his profession.

Dr. Silver was born in Philadelphia, Pennsylvania, February 25, 1915. He received his Bachelor of Arts and Master of Arts degrees in physics from Temple University in 1935 and 1937, respectively, and his Doctor of Philosophy degree in solid-state physics from the Massachusetts Institute of Technology (MIT) in 1940. He served as a postdoctoral Research Assistant at the Ohio State University in 1940-41 and as an Instructor and Assistant Professor of Physics at the University of Oklahoma from 1941 to 1943. He then joined the antenna group of the Radiation Laboratory, MIT, and remained there until that laboratory closed at the end of World War II. Following a year in the Antenna Research Branch of the Naval Research Laboratory, he was appointed Lecturer and then Associate Professor in the Electrical Engineering Department of the University of California at Berkeley, becoming Professor in 1950. He was a member of that department until his death. Administrative service at the University included assignments as Director of the Electronics Research Laboratory from 1956 until 1960 and as Director of the Space Science Laboratory from 1960 until 1970.

The University of California used Dr. Silver's talents for many committee assignments in addition to the formal administrative assignments. Among these was an important committee leading to the formation of the Radio Astronomy Laboratory and another resulting in the Electronics Research Laboratory. He was advisor and consultant to industry and to government organizations, including the Naval Research Laboratory and the National Aeronautics and Space Administration. Activities in the Institute of Electrical and Electronics Engineers (IEEE) included membership on the Awards Board and several assignments on the WESCON technical program committees. His continuing service for the National Research Council of the National Academy of Sciences was through the International Radio Scientific Union (URSI). He was Chairman of U.S. Commission 6 from 1950 to 1954, and then held posts of Secretary and Vice-Chairman of the National Committee. He became Chairman of the International Commission 6 in 1952, Vice-President in 1963, and was its President from 1966 to 1969. In 1972 he received the unusual distinction of becoming its permanent Honorary President.

Dr. Silver's first research contributions were in the theory of solid state, extending methods developed by the great John C. Slater, his Ph.D. mentor. Upon accepting assignment in the antenna group of the MIT Radiation Laboratory, he concentrated upon fundamental diffraction problems as applied to microwave radar antennas. Several elegant papers and the definitive book, *Microwave Antenna Theory and Design,* record much of the work of that period. He continued work on diffraction and scattering theory at Berkeley, concentrating on limits of accuracy in geometrical optics and other approximations. He also studied existence and uniqueness theorems for the exterior problem of electromagnetics. His students built a carefully designed experimental facility to make measurements designed to check the validity of these theories. Although he always retained an interest in the continuing work on this facility, his main interest in recent years was in radio astronomy and the upper atmosphere. Using microwave and millimeter-wave techniques, he and his students studied radiation from the planets and the absorption characteristics of ozone in the upper atmosphere. The program that he organized at the Space Science Laboratory included research in the spectroscopy of planetary atmospheres, lunar geology, the physics of the upper atmosphere, information-processing of satellite data, and the social uses of the space program.

Dr. Silver received many honors for his personal and professional contributions. He was a Fellow of the Institute of Electrical and Electronics Engineers, of the American Geophysical Union, and of the American Physical Society. He was a recipient of a John Simon Guggenheim Memorial Fellowship in 1953 for his work on scattering and diffraction of electromagnetic waves and again in 1960 for his research in physics of the upper atmosphere. He was, as noted earlier, permanent Honorary President of URSI. He was elected to the National Academy of Engineering in 1968 and was the second recipient of the John T. Bolljahn Memorial Award for contributions to antenna theory. He received an honorary degree of Doctor of Science in 1963 and a Distinguished Alumnus Award in 1964 from Temple University.

The characteristic of Samuel Silver's contributions to everything he did-teaching, guiding research, advising his colleagues in and out of the university, or undertaking hobbies such as photography and writing-was a concern for excellence and an equal concern for human values and the highest of ethical standards. His family was always his first priority, so that his wife, Marjorie, his son, Daniel, his daughter, Deborah Brewer, and all of their families have experienced a deep sense of loss, as have his friends and colleagues. But he will be remembered through this lasting contribution to the institutions he helped build and to the attitudes of everyone he worked with.

Mott Souders, Jr.

1904-1974

By Max S. Peters

Mott Souders, retired from Shell Development Company, died on December 11, 1974, one day after his seventieth birthday. Following his retirement from Shell Development Company in 1963, Dr. Souders had acted as a consultant. At the time of his retirement, he was Director of Oil Development for Shell Development Company.

Born on December 10, 1904, in Red Lodge, Montana, Dr. Souders received a Bachelor of Science degree in chemical engineering from Montana State College in 1926 and a Master of Science degree in 1927 and a Doctor of Philosophy degree in 1931, each from the University of Michigan. He was a leader in developing new industrial process ideas, particularly chemical processes involving mass transfer and extractive distillation.

Dr. Souders' career with Shell Development Company started in 1937, when he was named Assistant Manager of the Chemical Engineering Section. He became Manager of the section in 1946. In 1950 he was named Associate Director of Oil Development and became Director in 1957. In 1961 he was appointed a Member of the Advisory Council to the Vice-President and General Manager of Shell Development Company. He was elected to membership in the National Academy of Engineering in 1970.

Dr. Souders had the prime technical responsibility for the wartime programs to develop processes for producing toluene, butadiene, and penicillin in connection with which he held a number of patents. In all, he held twenty-two patents in various phases of chemical engineering. He wrote more than seventy technical papers, and he was the editor of numerous textbooks and handbooks, most recently *The Engineer's Companion,* a compilation of useful information for the practicing engineer. He was recognized as a leader in anticipating the process engineer's need for basic data for his predictions.

While at Shell, Dr. Souders made major contributions to methods of fractionation requirements, and he also contributed to the technical vocabulary such expressions as "K-value," "stripping factor," and "extractive distillation." He pioneered in relating physical and thermodynamic properties of components to molecular structure, and he was largely responsible for the establishment of Shell Development Company's strong Chemical Engineering Department.

Among the awards received by Mott Souders are the Professional Progress and Founders Awards from the American Institute of Chemical Engineers and the AIChE Institute Lectureship in 1963. He received the honorary degree of Doctor of Science from Montana State College in 1954 and a citation from the University of Michigan at the Centennial of Engineering in 1953. During the period 1935-37, he was a Sterling Fellow at Yale University.

Despite his busy technical life, Mott Souders had time to serve his profession with distinction. He always took an interest in beginning engineers and worked closely with education activities through the AIChE. He was active on numerous committees in the AIChE and served as a member of its Council from 1964 to 1966.

Mott Souders' engineering ability seemed to be the product of innate capacity enhanced by intense study and broad experience. He had an uncanny ability to take an engineering problem, whether in petroleum or in penicillin, determine the likely direction in which the solution would lie, and quickly fashion a number of approaches to be carried out by those working with him to solve the problem. He was a real inspiration to other engineers to think deeply and constructively. His significant contributions in the chemical engineering field will be of importance for many years to come.

In addition to his technical accomplishments, Mott Souders was a warm, sensitive human being and a true friend. He leaves behind him a rich heritage of technical accomplishments, leadership, and personal determination.

William Joseph Sparks

1905-1976

By Frederic A. L. Holloway

William J. Sparks, retired Scientific Advisor of the Exxon Research and Engineering Company, died on October 23, 1976, of heart failure, at his home in Coral Gables, Florida. Known and admired throughout the scientific world for his lifetime of dedicated service to his profession, he is particularly remembered for his contributions to the development of butyl rubber.

Dr. Sparks was born on February 26, 1905, in Wilkinson, Indiana, and his early life was shared between farmwork and schoolwork. When he finished high school, he was told he could have a car and work on the farm or go to college. He chose college and received a Bachelor of Arts degree with distinction from Indiana University in 1926 and a Master of Arts degree in 1929. This was followed by a doctorate in chemistry from the University of Illinois in 1936. Later in his career, he completed the Program for Management Development offered by Harvard's Graduate School of Business Administration.

Dr. Sparks was initially employed as a chemist by the Sherwin-Williams Co. After going back to school for his Master's degree, he worked for E.I. dupont de Nemours & Co. in Niagara Falls, New York, from 1929 to 1934. In 1936, he joined the Standard Oil Development Company, now Exxon Research and Engineering Company, as a research chemist at Linden, New Jersey. Except for a brief tour as Principal Chemist with the U.S. Department of Agriculture in Peoria, Illinois (1939-40), the rest of his career was spent with Exxon. He was appointed Director of the Chemical Research Division in 1946 and served in that capacity until 1957. At that time the post of Scientific Advisor, the Company's highest technical position, was created, and Dr. Sparks was selected to fill it. He continued in this capacity until his retirement, in 1967.

Dr. Sparks received many honors for his professional accomplishments. These include the Gold Medal of the American Institute of Chemists (1954), the Distinguished Alumni Service Award of Indiana University (1956), the Charles Goodyear Medal of the American Chemical Society (1963), the Perkin Medal of the American Section of the Society of Chemical Industry (1964), and the highest award in American chemistry, the Priestly Medal of the American Chemical Society (1965). He was elected to the National Academy of Engineering in 1967. He was awarded honorary doctoral degrees by Indiana University and by Michigan Technological University.

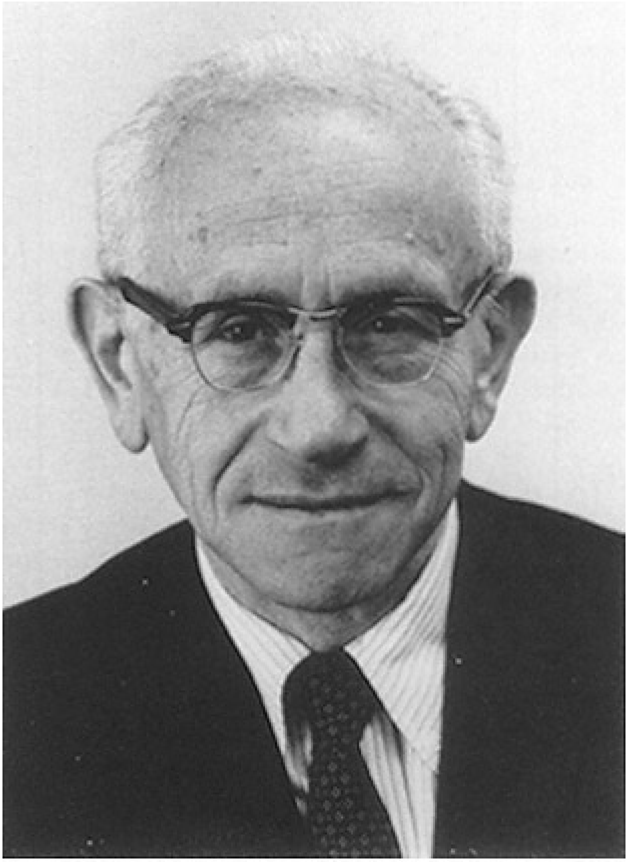
A very active Member of the American Chemical Society, Sparks served it in many capacities, including as a Member of its Board of Directors, as a Member of the Advisory Boards for Advances in Chemistry Series and the Petroleum Research Fund, and as President in 1966. He has served as National Chairman of the Scientific Research Society of America, as Chairman of both the National Research Council's Division of Chemistry and Chemical Technology and the Armed Forces Chemical Association's Committee on Chemical and Biological Warfare. He was an active Member of the National Academy of Engineering's Project Committee, as well as the National Research Council's Division of Engineering and Industrial Research and the Office of International Relations. He has been active as an advisor to the Department of Agriculture and the Department of State.

From an Indiana farm boy, Sparks rose to become a world authority on both rubber and petroleum chemistry. Although always proud to be referred to as a chemist, he preferred to be known as an inventor. Holder of 145 patents, he never relinquished his desire to innovate, even after retirement. His love for the game of golf and his knowledge of elastomers resulted, in the several years just prior to his death, in five U.S. and seven foreign patents for improved grips for golf clubs! A firm believer that good science should benefit the world in which we live, he contended that "Science without purpose is an art without responsibility."

In the mid-1960's Dr. Sparks was concerned that the education of the coming scientific generation did not include an awakening of social consciousness. "The scientific profession has become much larger than medicine, law or the clergy. Yet many young scientists are not taught by their professors to feel an obligation to society in their work." He believed that a heavy emphasis on the humanities is necessary to produce a truly sound scientist. To quote again, "If he [a scientist] knows the world he lives in, he will know how to serve it." His interests in chemical education led him to serve on the Chemical Advisory Committee of Rutgers University and on the Science Development Council of Rensselaer Polytechnical Institute.

William Sparks was a leader in attempting to bring the knowledge and opinions of the country's chemists to bear on national problems. As President of the American Chemical Society, he pushed the then newly formed Committee on Chemistry and Public Affairs to bring such views to the Government's attention.

A very kind and concerned man, he will be especially remembered and revered by the many younger associates whose lives he influenced.



Philip Sporn

1896-1978

By Theodore J. Nagel

Philip Sporn, retired President of American Electric Power Company and a giant in the electric power industry, died of an unexpected heart attack on January 23, 1978.

Typical of the man, he was on his way to work-at the age of eighty-one-at the time he was stricken. He died in a subway station in mid-Manhattan while waiting for a train to take him to his consulting office downtown. Outside was raging one of the most violent snowstorms in recent New York history, through which he had just made his dogged, determined way.

That's the way Phil Sporn was his entire life. He was a Jewish immigrant from Austria, born there November 25, 1896, and brought to the United States as a child. Then nine years old, his vivid memory of Ellis Island-as recalled more than seven decades later on the occasion of his eightieth birthday-was that the lighting at the nearby Statue of Liberty was bad. He devoted his subsequent life to making things brighter, everywhere.

He received his Electrical Engineering degree from Columbia University in 1917, worked briefly for Consumers Power Company in Michigan, and in 1920 joined American Electric Power (AEP), New York. His rise with the Company was rapid, and the growth and stature of the Company itself paralleled that rise. While AEP's Chief Engineer, he built an engineering organization that was then, and remains today, eminent in the electric utility field.

On May 22, 1947, Philip Sporn became the fourth President in

AEP's history, as well as President of its seven operating companies and other subsidiaries, providing electric service in seven east-central states from Michigan to Virginia. He retired as President, at age sixty-five, on November 30, 1961, but remained as a Director until 1968.

During his career as Chief Engineer and then Chief Executive, he led the AEP System in its quest for and its success in attaining a number of technological advances. Among them: large-sized generating units, supercritical-pressure boilers, natural-draft cooling towers, tall stacks, and extra-high-voltage transmission and lightning protection. Appropriately, the Philip Sporn Plant was the first coal-fired generating station to achieve a heat rate of less than 10,000 British thermal units per kilowatt-hour. Historically, since the 1950's, AEP System plants have been among the nation's leaders in this measure of generating efficiency.

Philip Sporn was recognized as preeminent in developing the principles and practices in the design and operation of integrated and highly interconnceted power systems. His book, *The Integrated Power System,* one of ten books he wrote, is regarded as the authoritative work in the field. (Today, the AEP System operates sixteen major power plants, including thirteen coal-burning stations, with four more under construction or planned. Today, the AEP System operates over 100,000 circuit miles of transmission and distribution lines, including 1,330 miles at 765,000 volts-the nation's highest voltage. And today, the AEP System is interconnected with twenty-three neighboring utilities at ninety-nine high-voltage interconnection points.)

He was very active in nuclear research and development, in lightning protection developments, and in the development and promotion of electric space heating. He introduced the heat pump to AEP System office buildings in the 1930's.

He was instrumental in the achievement of three industry milestones:

- the founding of the Ohio Valley Electric Corporation to provide the then-record electric energy requirements of the massive uranium-diffusion operation of the U.S. Department of Energy (then the Atomic Energy Commission) near Portsmouth, Ohio;

- the successful persuasion of the aluminum industry, a heavy power consumer, to move into the Ohio Valley for its electric requirements; and
- the marriage of the investor-owned and member-owned electric utility industries, represented by the joint ownership and operation of the Cardinal Plant in Ohio by AEP and Buckeye Power, Inc., the power-supply organization of Ohio's rural electric cooperatives.

Philip Sporn spent forty-eight years with AEP, including almost fifteen years as its President, and six decades in all in the power industry. To that industry he gave many of its technical advances; from that industry he received many of its highest honors.

To list all of the honors is impractical; to list a few is meaningful.

He was a Member of the National Academy of Engineering. He was one of a handful of nonacademicians ever elected a Member of the National Academy of Sciences. He was a Fellow and one of three honorary members of the Institute of Electrical and Electronics Engineers; a Fellow and Honorary Member of the American Society of Mechanical Engineers; a Fellow of the American Society of Civil Engineers; a Fellow of the American Nuclear Society; and an eminent Member of Eta Kappa Nu, the engineering honorary.

Fifty years before his death, Philip Sporn was recognized by the IEEE with its national first prize in the field of engineering practice. He subsequently won, among other honors, IEEE's Edison Medal; the Columbia University Engineering Alumni Association's Egleston Medal; Columbia's Medal of Excellence; the ASME. Medal; the Faraday Medal; and in 1955 the John Fritz Medal, the highest engineering honor in the country, presented jointly by the IEEE, ASCE, ASME, and the American Institute of Mining and Metallurgical Engineers. He was also a Chevalier of the French Legion of Honor.

He held thirteen honorary degrees from universities and colleges in six states and two foreign countries, Israel and France. He was particularly active in higher education for decades and no more so than in his "retirement" years. At the time of his death, he was on the advisory councils at both the Cornell College of En gineering and the Columbia Graduate School of Business. In earlier years he had been a Visiting Professor or Advisory Councilor at Columbia, Cornell, Princeton University, and Massachusetts Institute of Technology.

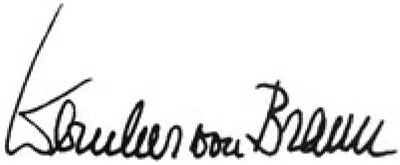
He was also active in the administration of the Philip and Sadie Sporn Educational Trust Fund, established for student loans at six engineering schools. The fund began with a gift of $100,000 to Mr. Sporn at his retirement in 1961, made up of employee contributions and company grants, and currently stands at $275,000.

But, Phil Sporn never really retired. He didn't even slow down. Until his death he remained hard at work: as a consultant and advisor to utility and industrial clients and to the Government of Israel; as a lecturer, visiting professor, and advisory councilman at some of the nation's leading engineering universities; and as an author of books and articles for professional journals.

Nothing has been more symbolic of Mr. Sporn's "retirement" years than his work on behalf of the state of Israel, especially with the Weizmann Institute of Science, of which he was a Governor and a Director of its American Committee. Years earlier, he had helped organize and was the Founding Chairman of the American Society for Technion (Israel Institute of Technology).

Back in the middle 1960's, after he had stepped down from the AEP presidency, his grandson, Michael, one day protested that his grandfather did not have the time to join the rest of the family on an outing. "Grandfather, I thought you had retired," young Mike complained. His grandfather replied, "I did retire, but I haven't stopped working."

Philip Sporn is survived by his widow, Sadie; a daughter, Mrs. Andrew Gilbert, New York; two sons, Arthur, an attorney in New York, and Michael, a physician and head of the Lung Cancer Branch of the National Cancer Institute, Bethesda, Maryland; six grandchildren; and a brother.



Wernher Von Braun

1912-1977

By George E. Mueller

Wernher Von Braun, whose name has become synonymous with rocketry and space exploration, died in Alexandria, Virginia, on June 16, 1977, after a long illness. At the time, Dr. von Braun was Vice-President of Engineering and Development at Fairchild Industries and a Director of Flight Safety International.

Dr. von Braun's career spanned the entire history of rocketry. He never doubted his early vision of man in space, and cited Jules Verne's statement, "Anything one man can imagine, other men can make real." In less than forty years, Wernher saw his dream become reality. His work was instrumental in transforming a scientific curiosity into the power vehicles that took man to the moon.

Wernher von Braun was an extraordinary engineer. Trained as a mechanical engineer, he had the unique ability to visualize entire complex systems and make sense of them. He was one of our first system engineers, and he continued to apply this rare skill throughout his many years managing major programs.

He was more than a manager-he was a leader. With this technical ability, passionate optimism, immense experience, and uncanny organizing ability, he was able to forge an extremely capable technical team-not once, but repeatedly throughout his career. One of his associates once remarked, "Working for the government, you don't wind up a rich man. But working for von Braun, you feel you're a member of a great team."

Dr. von Braun's talents and interests extended beyond engineer ing to all phases of science and the arts. While playing a major role in the U.S. Space Program, he was also the driving force behind building a cultural center and bringing a university extension to his adopted home of Huntsville, Alabama. He was always willing to give of his much-sought-after time and energy to support projects and causes he believed in.

Wernher von Braun was born in Wirsitz, East Prussia, on March 23, 1912, one of three sons of a Prussian aristocrat who became Secretary of Agriculture in the Weimar Government. Baron Magnus von Braun had always assumed that his son would take up the dignified duties of a Prussian landholder. The young von Braun decided that space travel was his life's goal, however, and he enrolled at the Berlin Institute of Technology, where he immediately became fascinated with the exciting new field of rocketry.

He performed many experiments on liquid-fuel rockets during his two years as an undergraduate student at the Berlin Institute and his two years as a graduate student at the University of Berlin. His Ph.D. thesis was a landmark document, containing a complete theoretical investigation, supported by experiments, of the injection, combustion, equilibrium, and expansion phenomena involved in a liquid-fueled rocket engine.

During the next ten years, Dr. von Braun rose rapidly in the German rocket program. By the time he was twenty-five, he was developing a fully inertial-guided rocket designed to climb to an altitude of fifteen miles, with a 100-pound payload. By the time he was thirty, he had developed the V-2 long-range ballistic missile.

After the war, von Braun plunged immediately into the infant U.S. missile program. For the next fifteen years, he led the U.S. Army development programs that resulted in such missiles as the Redstone, Jupiter, Jupiter C, Juno II, and Pershing. These were the missiles that launched many of the early satellites and space probes of the 1950's.

All the while, Dr. von Braun had not forgotten his dreams of space travel. He wrote several books on the subject between 1952 and 1958, and in 1952 he forecast a space station in "ten or fifteen years." He took his case for space exploration directly to Washing ton, proposing Project Orbiter-a plan to hurl a small satellite in space by 1956-a full year before the Sputnik launch. The plan was disapproved, and Dr. von Braun's space work was delayed until Explorer 1 in 1958. Explorer 1, which discovered the Van Allen radiation belt, was the first success of the U.S. space program.

In 1960, von Braun was transferred to the National Aeronautics and Space Administration (NASA) and named Director of NASA's Marshall Space Flight Center. For the next decade he developed the launch vehicles that put man in space, then on the moon. Von Braun's Redstone booster successfully placed two Mercury astronauts in the first manned suborbital flight. Then, under von Braun's direction, the Saturn I, Saturn IB, and Saturn V launch vehicles were developed.

Wernher von Braun had always worked independently, leading his technical staff on specific scientific projects. Because of the national priority of the Manned Space Program, however, he was asked to channel his work and integrate it with that of the other Space Flight Centers. Because of yon Braun's stature in the field, this could have created a ticklish situation. It did not; von Braun immediately saw the importance of a coordinated Manned Space Program effort, and was instrumental in establishing an entirely different method of operation at the Marshall Center.

Dr. von Braun never dwelt on what had been done; he was always much too busy addressing what needed to be done. The contribution of the Marshall Center to the Manned Space Program proved to be incalculable. The Saturn V, undertaken in 1962, was to be by far the largest rocket ever built, four times more powerful than any rocket ever launched. Despite this technical challenge, the Saturn V program was a complete success. In thirteen flawless launchings, Saturn V rockets sent nine crews of astronauts to the vicinity of the moon, with six of the crews landing and exploring the lunar surface.

While that historic moment was certainly the pinnacle of von Braun's extraordinary career, it was by no means the end of his work. He considered space exploration to be vital to the future of mankind, and, if anything, he increased his pace to expand our foothold in space. Long before the Apollo program was over, von

Braun was working toward space stations and space transportation systems. It was his keen interest in expanded space exploration, as well as his talent, that caused NASA in 1970 to name von Braun to direct its planning operations.

Despite Dr. von Braun's continuing efforts to build a foundation for public understanding of the importance of the space program, however, public and congressional support was declining. So, too, was NASA's budget. Seeking new challenges, Dr. von Braun resigned from the Agency in 1972 and joined an aerospace company, Fairchild Industries.

Wernher von Braun was one of the most honored scientists this country has ever known. He received more than fifty honorary awards and more than twenty honorary degrees. He was a pioneer in rocketry and propulsion and was indefatigable in promoting the new science, both through professional societies and hundreds of publications. Most of all, he was a warm, sensitive human being; a great leader; and a true friend. He leaves behind him a rich heritage, indeed.


Walter G Whitman

Walter Gordon Whitman

1895-1974

By Bruce S. Old

Walter Gordon Whitman, Professor Emeritus and former Head of the Chemical Engineering Department at the Massachusetts Institute of Technology (MIT) and a science advisor to the top levels of the State Department, the Department of Defense, and the United Nations, died at the age of seventy-eight in Scottsdale, Arizona, on April 6, 1974.

Professor Whitman was born November 30, 1895, in Winthrop, Massachusetts. He received a Bachelor of Science degree in chemical engineering at MIT in 1917 and a Master of Science degree in 1920. Subsequently, he was awarded honorary Doctor of Science degrees by Northeastern University in 1954, by Centre College in 1956, and by the University of Pennsylvania in 1956.

Following his graduation from MIT, Whitman remained on the staff as Instructor and Assistant Professor until 1926. During that time he made significant contributions to the theory of gas absorption, developing the "Whitman Two-film Theory of Absorption."

Whitman left MIT in 1926 to join Standard Oil of Indiana, where he rose to become Associate Director of Research. During this period he made important contributions to the prevention of corrosion in refineries and to the fundamentals of the cracking of oils.

In 1934 Whitman returned to MIT to become Professor and Head of the Department of Chemical Engineering. He kept this position for twenty-seven years, during which time he made signifi cant contributions to engineering education. During this period the department grew in stature and was generally rated the best in the world. He was elected President of the American Institute of Chemical Engineers in 1956 and was presented the Founders Award of the Institute in 1960. He was a Member of the American Chemical Society, an Honorary Member of the American Institute of Chemists, a Councilor of the American Academy of Arts and Sciences, and a Fellow of the American Philosophical Society.

During his long tenure at MIT, Walter Whitman was much sought after to serve his country in important positions. During World War II he served as Director of the Basic Chemicals Division, War Production Board. Also, he acted as Chairman of the Subcommittee on Aircraft Fuels and Lubricants of the National Advisory Committee for Aeronautics, chaired the so-called Whitman Committee on the status of jet propulsion, and was a Member of the U.S.-Canadian Ordnance Committee on Production of Explosives. He returned to MIT in 1948.

Returning to Washington on leave of absence from MIT, Professor Whitman was appointed to the General Advisory Committee of the U.S. Atomic Energy Committee, remaining a Member from 1950 to 1956. In addition, he served the Department of Defense as Chairman of the Research and Development Board from 1951 to 1953.

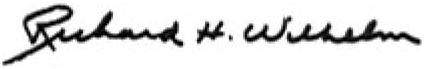
In 1955 Professor Whitman was appointed by United Nations Secretary General Dag Hammarskjold to the position of Secretary General of the United Nations Conference on Peaceful Uses of Atomic Energy. The Conference was held in Geneva, and it was unique in that some 3,000 representatives from both sides of the Iron Curtain came together, presented about 1,000 papers, and cooperated wholeheartedly in making the conference a success. The successful outcome of the conference was due to the consummate skill with which it was organized and conducted. The outstanding part played by Professor Whitman prompted the U.S. Delegate to the Conference, Mrs. Eleanor Roosevelt, to mention on her radio program that he should be considered as a candidate for the Nobel Peace Prize.

As a result of Professor Whitman's many contributions toward international understanding in science and engineering, on September 4, 1960, Secretary of State Christian A. Herter appointed him to the position of Science Advisor. He held this pioneering position in the State Department under the Eisenhower and Kennedy administrations until June 1962.

Obviously, Walter G. Whitman was a very rare individual, combining numerous theoretical engineering contributions, as demonstrated in his many research publications and innovative industrial and educational advancements with superb administrative skills. He provided outstanding leadership to numerous and varied U.S. Government and United Nations studies of many critical scientific and technological problem areas. For all of these many technologically based contributions to industry, government, and university sectors, Whitman was elected to membership in the National Academy of Engineering in 1973.

The leadership characteristics exhibited by Walter Whitman stemmed from his engineering training and knowledge, his quiet, good-humored, and effective administrative skills, and his broad interests in the social-economic progress of all peoples.

Indeed, it was a great privilege to have had so rare and broad an intellect within the membership of the Academy.



Richard Herman Wilhelm

1909-1968

By Thomas H. Chilton

Richard Herman Wilhelm, Professor of Chemical Engineering and Chairman of the department at Princeton University, died August 6, 1968, following a heart attack while vacationing at Center Harbor, New Hampshire. He has been honored a number of times for his outstanding achievements in chemical engineering. Over the years, in the opinion of his associates in the profession, he "stimulated the scientific growth of the whole field of chemical engineering."

Born on January 10, 1909, in New York City, Professor Wilhelm was educated in the New York City public schools and held a prize scholarship during his undergraduate years at Columbia University, where he graduated with a Bachelor of Science degree in engineering in 1931. He also took his degree in Chemical Engineering in 1932 and three years later obtained his Doctor of Philosophy degree at Columbia. He joined the Princeton faculty in 1934. He was promoted to the rank of Assistant Professor at Princeton in 1937, following three years at the instructor's level. He became an Associate Professor in 1943, was advanced to full Professor in 1946, and became Chairman of his department in 1954.

Professor Wilhelm was a licensed professional engineer in New Jersey and served as a consultant to several corporations, including Merck & Co., Socony Mobil Oil Co., and E.I. du Pont de Nemours & Co. From 1941 to 1943 he was Official Investigator of National

Defense Research Committee operations at Princeton and from 1943 to 1944 was Co-Director of a project at Princeton for the Office of the Rubber Director. He was also concerned with the direction of part of the research program of the Princeton-headquartered Textile Research Institute.

A consistent contributor to a variety of technical journals, with twenty papers to his credit in one ten-year period, Professor Wilhelm was a Fellow of the American Academy of Arts and Sciences and a Member of the American Chemical Society, the American Institute of Chemical Engineers, and the American Society for Engineering Education. He was elected to membership in the National Academy of Engineering in 1968. He had served as President of the Princeton Chapter of Sigma Xi and was a Member of Tau Beta Pi, honorary engineering society. A Member of the American Association for the Advancement of Science, he served as Chairman of Section C (Chemistry) and of the nominating committee of the Society. He was also a Member of the Management Committee of Princeton's James Forrestal Research Center, a Director of the American Institute of Chemical Engineers (1956-59), and a Member of several committees, as well as a Member of the Advisory Board of the *AIChE Journal* and of the Board of *Chemical Engineering Science* (published in London). In 1958 he was the E. P. Schoch Lecturer at the University of Texas and the following year the Humble Lecturer at the Humble Oil and Refining Co.

In 1949 Professor Wilhelm, who had directed Princeton's Bicentennial Conference (1946) on "Engineering and Human Affairs," was instrumental in organizing within Princeton's Engineering Science Program a series of studies combining elements of chemical engineering, biology, chemistry, and mathematics, expressly designed to provide an educational background for entry into the biological industry or graduate study in this field.

His first published paper, the fruit of his doctoral research at Columbia, was on conditions for carrying out an industrial chemical reaction. His main interest in the length of his professional career continued in this field, the field of the design of reactors, whether fixed-bed, as they are called, or "fluidized," altogether a crucial problem in chemical engineering. A look at a listing of his publications, however, will show that his interests were not narrowly confined, but extended over a wide variety of topics-mixing in agitated vessels (a form of reactor, to be sure), radiation drying of textiles, and oxygen transfer in biological systems.

In the field of fluidization, Professor Wilhelm emphasized the importance of the difference between particulate and aggregative fluidization and, by analyzing careful experiments, he defined the conditions under which the two regimes are found. Examples of the application of this work are in designing equipment for fluidbed chemical reactors, for pneumatic transport, for handling slurries, and for heat transfer by fluidized particles.

It is largely owing to the work of Professor Wilhelm and his students that we now have a rather good understanding of the various mechanisms that determine the behavior of fixed-bed catalytic reactors. Perhaps the outstanding contribution in this field was the description of the transverse diffusion of heat and of matter in a packed bed in terms of a Peclet number based on the particle diameter and the recognition that the apparent diffusivity could be expected to be different in the transverse and longitudinal directions. This work, published in papers with R. A. Bernard and with E. Singer, provides an important part of the foundation for any analysis of tubular catalytic reactors.

A central idea carried through Professor Wilhelm's work in this field is that we must have a detailed knowledge of the local conditions and the local processes taking place in a packed catalytic reactor if we are to do an acceptable job of predicting the behavior of the reactor as a whole. This idea appears in his early papers on reactor design and follows through in the experimental determination of transport properties, both among and through the particles, and of local flow conditions. This determined effort to define the local conditions in the reactor and to use them in predicting over-all behavior of the system characterizes the development of this field under Professor Wilhelm's direction.

A masterly review of the state of this "art" was presented before the International Union of Pure and Applied Chemistry meeting in Montreal in 1961.

Professor Wilhelm was working on an ingenious technique for studying the details of small-scale mixing. This is a virgin area that promises to be crucial to our understanding of the effect of physical mixing on chemical reactions. This technique employs light-scattering of a laser beam from two species that are being mixed. By this means Professor Wilhelm was able to resolve concentration fluctuation spectra at eddy sizes far smaller than obtained previously with customary probe techniques, which he had already carried to the practical limit. A preliminary report describing this new tool was presented to the American Institute of Chemical Engineers at its meeting in Houston, Texas, in December 1963.

In recent years, Professor Wilhelm's success in testing a principle called "parametric pumping" for separating fluid mixtures attracted attention of scientists throughout the world. The principle has possible uses for separating salt from ocean water and petrochemical separations. The work also has possible implications for biology, inasmuch as the process is similar to the active diffusion in living cells.

The term "parametric pumping," borrowed from the field of electronics, may appear at first sight somewhat confusing. It denotes a separation principle that involves cyclic exposure to an adsorbent material (with a temperature coefficient of adsorptivity) of a fluid mixture (or solution) heated, at one end of a column filled with adsorbent, and cooled at the other.

In a simple preliminary test, a ratio of concentrations at the two ends of a column filled with ion-exchange resin charged with 0.2 percent NaCl and cycled through 90°C and 40°C of 1.2 was achieved. In a more extensive trial, a separation ratio of 105 was obtained between two ends of a column packed with chromatographic grade silica gel after 50 cycles, starting with a 20 percent mixture of toluene in *n*-heptane.

Professor Wilhelm was married, first, to Marjorie Rachel Hixson, of Leonia, New Jersey, who died in 1964. They had three children: Karen Elise, Joan Andrea, and Richard David Washburn. In 1966 he married Sarah Kollock Strayer, widow of the late Professor Paul Johnston Strayer, who died in 1961.

Dick, as his associates knew him, must have taken for his own the dual injunction:

Work as if you were going to live forever;
Live as if you were going to die tomorrow.

His work stands as his memorial in the literature of his profession; his personality lives in the memory of his friends.

Appendix

National Academy of Engineering Compendium of Dates for Deceased Members and Foreign Associates as of December 31, 1978

Members	Elected	Born	Deceased
H. Julian Allen	1966	April 1, 1910	January 29, 1977
Othmar H. Ammann	1965 (April)	March 26, 1879	September 22, 1965
Robert A. Bowman	1970	December 29, 1907	November 29, 1977
* Roger E. M. Brard	1976	June 17, 1907	July 14, 1977
Thomas H. Chilton	1966	August 14, 1889	September 15, 1972
Edward N. Cole	1970	September 17, 1909	May 2, 1977
† Hugh L. Dryden	1964	July 2, 1898	December 2, 1965
Gordon M. Fair	1967	July 27, 1894	February 11, 1970
Merrell R. Fenske	1967	June 5, 1904	September 28, 1971
Antonio Ferri	1967	April 5, 1912	December 28, 1975
Alfred M. Freudenthal	1976	February 12, 1906	September 27, 1977
Clifford C. Furnas	1967	October 24, 1900	April 27, 1969
† Antoine M. Gaudin	1964	August 8, 1900	August 23, 1974
William F. Gibbs	1965 (October)	August 24, 1886	September 6, 1967
Richard P. Gifford	1973	February 9, 1922	August 27, 1976
Lillian M. Gilbreth	1965 (October)	May 24, 1878	January 2, 1972
Edwin R. Gilliland	1965 (April)	July 10, 1909	March 10, 1973
Peter C. Goldmark	1967	December 2, 1906	December 7, 1977
Harold B. Gotaas	1967	September 3, 1906	August 24, 1977
George A. Hawkins	1967	December 11, 1907	April 6, 1978
Henry T. Heald	1965 (October)	November 8, 1904	November 23, 1975
Hubert Heffner	1971	December 26, 1924	April 1, 1975
Arthur T. Ippen	1967	July 28, 1907	April 5, 1974
Lydik S. Jacobsen	1975	June 17, 1897	December 22, 1976
Stephen M. Jenks	1968	February 18, 1901	April 12, 1974
† Thomas C. Kavanagh	1964	August 17, 1912	May 23, 1978
Joseph H. Keenan	1976	August 24, 1900	July 17, 1977
Clarence F. Kelly	1968	October 18, 1906	May 5, 1976
Rudolf Kompfner	1966	May 16, 1909	December 3, 1977
John M. Kyle, Jr.	1967	December 3, 1904	September 30, 1970
Leon Lapidus	1976	September 26, 1924	May 5, 1977
Warren K. Lewis	1966	August 21, 1882	March 9, 1975
Percy H. McGauhey	1973	January 20, 1904	October 8, 1975
John E. McKeen	1965	June 4, 1903	February 25, 1978
William B. McLean	1965	May 21, 1914	August 25, 1976
William C. Mentzer	1968	May 27, 1907	December 23, 1971
† Clark B. Millikan	1964	August 23, 1903	January 2, 1966
Julius P. Molnar	1969	February 23, 1916	January 11, 1973
Ben Moreell	1976	September 14, 1892	July 30, 1978
Jack A. Morton	1967	September 4, 1913	December 11, 1971
Erwin W. Mueller	1975	June 13, 1911	May 17, 1977
Carl F. Prutton	1966	July 30, 1898	July 15, 1970
Richard W. Roberts	1977	January 12, 1935	January 17, 1978
Karl Schwartzwalder	1970	May 5, 1907	May 2, 1975

Members	Elected	Born	Deceased
† Thomas K. Sherwood	1964	July 25, 1903	January 14, 1976
Igor I. Sikorsky	1968	May 25, 1889	October 26, 1972
Samuel Silver	1968	February 25, 1915	November 5, 1976
Mott Souders, Jr.	1970	December 10, 1904	December 11, 1974
William J. Sparks	1967	February 26, 1905	October 23, 1976
Philip Sporn	1963 (April)	November 25, 1896	January 23, 1978
Werhner von Braun	1967	March 23, 1912	June 16, 1977
Walter G. Whitman	1974	November 30, 1895	April 6, 1974
Richard H. Wilhelm	1968	January 10, 1909	August 6, 1968

* Foreign Associate
† Founding Member

Acknowledgments for the Photographs

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