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PERCIVAL CLEVELAND KEITH, JR.

1900–1976

BY MANSON BENEDICT

PERCIVAL CLEVELAND KEITH, JR., retired Founder and President of Hydrocarbon Research, Inc., died in Peapack, New Jersey, on July 9, 1976. Throughout his long professional career, he was a brilliant engineering innovator. He pioneered in the development of petroleum refining processes, first thermal cracking and reforming, then, in the years just preceding and during World War II, in catalytic processes for converting petroleum to aviation and automotive fuels and to chemicals such as ammonia, methanol, and butadiene. Later he did original work on synthetic fuels and the use of hydrogen for improvement of petroleum derivatives and reduction of ores to metals. His most notable engineering achievement was the inspiring leadership he gave to development and engineering of the K-25 Gaseous Diffusion Plant for production of uranium-235, whose successful operation did so much to bring victory in World War II.

Percival C. Keith, Jr., was born in Tyler, Texas, on December 24, 1900. His father was a well-to-do pharmacist, born in Scotland. His mother wrote poetry in her free moments. Both parents were determined that their precocious son should have the best education obtainable in Sherman, Texas, where the family had moved. A local retired French engineering officer, Captain LeTellier, who had been a French military attaché in Washington and later taught in Sherman, was engaged as young Keith's tutor. LeTellier instilled in Percival Keith his lifelong interest in history, philosophy, and science. Many of Mr. Keith's professional associates remember the

quotation from Heraclitus framed on his office wall: "There is nothing permanent but change." Without formal schooling, Percival Keith entered Austin College in Sherman at age sixteen and graduated in three years with an A.B. degree in English.

His interest in engineering was kindled by the growing oil production of Texas. He entered Massachusetts Institute of Technology (MIT) in 1919 and spent three exciting years there taking all the courses he could manage in mathematics, chemistry, and engineering. He was greatly influenced by MIT's legendary chemical engineer, Warren K. Lewis, whose dynamic personality so closely matched his own. It was at MIT that Percival Keith acquired the nickname "Dobie," which he was called for the rest of his life.

Mr. Keith's professional advancement was rapid. He worked in the research laboratory of the Texas Company for a year and in the field for Universal Oil Products Company for two years. From 1925 to 1927 he was Vice-President for Operations for the Cross Engineering Company. In 1927 he joined the M. W. Kellogg Company, one of the leading U.S. engineering firms, as Chief Engineer. In 1929 he left Kellogg to form his own company, Refinery Engineers, in Kansas City. In 1932 he returned to Kellogg in New York as Vice-President for Research and Engineering. The early 1930s was the period of rapid growth for petroleum refining, and Keith and Kellogg pioneered in the development of thermal cracking and reforming and delayed coking. Later, with other companies, Keith and Kellogg contributed to the development of catalytic cracking, catalytic reforming, and catalytic polymerization of olefins. Kellogg's catalytic reforming process, under the trademark Hydroforming, was a major source of toluene for production of TNT during the early years of World War II. Prior to 1946 Mr. Keith was issued more than forty patents on petroleum refining processes.

Mr. Keith's involvement with uranium-235 began immediately after Pearl Harbor, late in 1941. At that time he was invited to join the planning board of the S-1 Committee of the Office of Scientific Research and Development, headed by Eger V. Murphree, Vice-President for Research of Standard Oil Company (New Jersey), who had worked with Mr. Keith on petroleum refining projects. Mr. Keith was asked to evaluate and undertake engineering develop-

ment of the gaseous diffusion process for separating uranium-235, one of the several processes being considered for production of materials for an atomic bomb.

The work of Mr. Keith and his associates at Kellogg in 1942 was reviewed in December of that year by a committee, headed by W. K. Lewis, which had been appointed by Leslie R. Groves, Commanding General of the Manhattan Project. Mr. Keith convinced first Lewis and then Groves that the gaseous diffusion process could succeed. Kellogg was asked to form a subsidiary company, the Kellex Corporation, to complete development and engineering of a full-scale diffusion plant to produce uranium-235. Mr. Keith served as Vice-President and Technical Director.

The task was monumental. The only compound of uranium that could be used was the hexafluoride, a corrosive gas that reacted with water and attacked steel. Although gaseous diffusion appeared to be the best process, it was very inefficient. A plant to produce useful amounts of uranium-235 would have several thousand stages and would use enormous amounts of electric power. It would be necessary to develop a special diffusion barrier with ultrafine holes made of material that would not react with uranium hexafluoride. Pumps, valves, heat exchangers, and instruments of novel design would have to be developed. And a smoothly operating plant with thousands of stages of such novel equipment would have to be designed, built, and put into operation in two years.

The success of this unprecedented engineering venture would have been impossible without Mr. Keith's dynamic leadership. He understood the exacting requirements of the process. His personal conviction that the plant would be successful and the example he gave of determination to overcome enormous difficulties persuaded some of the best chemical, electrical, and mechanical engineers of the country to join the Kellex Corporation and, with him, to solve the many technical problems of the Oak Ridge diffusion plant. He led this team of expert engineers with consummate skill, setting overall objectives, making key decisions, and contributing many original ideas.

To this day, the gaseous diffusion process that he pioneered is the process most widely used for enriching uranium-235.

Even while he was leading the Kellex team, Mr. Keith was planning his postwar activities. In 1943 he formed a new company, Hydrocarbon Research, Inc. (HRI), to develop new processes for synthesizing liquid fuels from natural gas or coal. He served as President of this company from 1943 until his retirement in 1964. The Carthage Hydrocol plant, built by Hydrocarbon Research at Brownsville, Texas, in the 1950s to convert natural gas to gasoline by the Fischer-Tropsch process, proved uneconomical. But the partial oxidation process, originally developed for production of synthesis gas (carbon monoxide plus hydrogen) at Brownsville, was adapted to make synthesis gas from residual oil or coal and was licensed by HRI and its partner, Texaco, in more than seventy plants throughout the world. The principal use has been to make hydrogen for ammonia synthesis and other commercial purposes. Another offshoot from Brownsville was the H-Iron direct reduction process for making powdered iron from iron oxides in a fluid bed.

Two other processes utilizing hydrogen were commercialized during Mr. Keith's later years as President of HRI. One of these was the H-Oil process for hydrodesulfurization and hydrocracking of heavy and residual oils. The other was the HDA process, jointly developed with Atlantic-Richfield, for the manufacture of benzene from toluene by hydrodealkylation. After retirement in 1964, Mr. Keith remained active in engineering through work on projects for secondary recovery of petroleum by injection of carbon dioxide.

He was elected to the National Academy of Engineering in 1968. He was also a member of the American Institute of Chemical Engineers, American Chemical Society, American Gas Association, Society for Chemical Industry (American Section), and American Association for the Advancement of Science. He obtained more than seventy patents and wrote several articles on petroleum refining, the Manhattan Project, oxygen production, and synthetic fuels. He received honorary Ph.D. degrees from Austin College in 1946 and from Colby College in 1947.

Mr. Keith was an extraordinarily dynamic man, with a restless, far-reaching mind. He worked long hours and expected similar dedication from his associates. Stories of his absorption in his work are legend. He once gave a design problem to one of his mechanical