Richard H. Wilhelm

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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.