REINHARDT SCHUHMANN JR.

1914–1996

Elected in 1976

"Contributions to the science of extractive metallurgy and applications to process analysis and design."

BY DOUGLAS W. FUERSTENAU AND MYSORE DAYANANDA

REINHARDT SCHUHMANN JR. died July 7, 1996, at his home in West Lafayette, Indiana, at the age of 81. He was a highly respected teacher and metallurgical engineer who made numerous seminal contributions to the processing of ores for mineral recovery and to the pyrometallurgical production of metals.

He was born on December 16, 1914, in Corpus Christi, Texas, and received his high school education in Long Beach, California. After studying for two years at the California Institute of Technology he moved to the Missouri School of Mines at Rolla, where he received his BS degree in metallurgical engineering in 1933 at the age of 18. He apparently inherited his interest in chemistry and metallurgy from his father, who was a chemistry professor. Upon graduation, he went to work for a gold mining venture near Pitkin, Colorado, where he helped build and operate the stamp mill for the Roosevelt Mine. Shu, as he was called by those who knew him, thought that this was the last stamp mill to be built in the United States. Because of financial difficulties due to the Depression, the mine soon closed and he then enrolled at the Montana School of Mines in Butte to pursue a graduate degree. In those years, Butte was the world center of copper mining and his time there spawned his lifelong interest in copper production metallurgy.

At the Montana School of Mines, Schuhmann studied under Professor Antoine M. Gaudin (an NAE founding member). There he conducted a groundbreaking investigation of the mechanism by which a flotation collector strongly interacts with the surface of chalcocite, an important copper sulfide mineral. He earned his MS in metallurgical engineering from the Montana School of Mines in 1935 and then enrolled as a doctoral student in the Metallurgy Department at the Massachusetts Institute of Technology (MIT), where his research was a self-directed, pioneering experimental investigation of the kinetics of flotation of minerals. For this he designed a small-scale continuous flotation cell with which he delineated how operating variables control the rate at which hydrophobic mineral particles attach to air bubbles and are recovered in the froth. In fact, that research was the first of its kind, and an important topic that has been pursued by numerous others ever since. He received his ScD degree in 1938.

Schuhmann joined the MIT faculty as an instructor in 1938 and rose through the ranks of assistant and associate professor by 1945. During those years, he worked mainly in the areas of comminution and flotation and published several papers in the field of mineral dressing. A classic paper concerned the size distribution of particles produced in comminution, widely known as the Gaudin-Schuhmann size distribution. He was a coauthor of the *Textbook of Ore Dressing,* published by McGraw-Hill in 1940.

During World War II, he was heavily involved with programs to improve the flotation recovery of tin from Bolivian ores, the strategic source of tin at that time. During the period 1945–1947, he served as the associate director, MIT Raw Materials Project (Manhattan District), and was involved in research in the extraction of uranium from its ores. Upon the retirement of Process Metallurgy Professor Carl Hayward, Schuhmann moved into that area, expanding his research interests to include thermodynamics of high-temperature processes for metal extraction and phase equilibria in multicomponent, multiphase systems. He wrote major papers on the thermodynamics of copper smelting and iron-silicate slags

in the early 1950s. He wrote a second textbook, *Metallurgical Engineering* (Addison-Wesley, 1952), in which he expounded the unit processes approach to extractive metallurgy. In 1955 he published a brilliant analysis and application of the Gibbs-Duhem equation for ternary systems, which became highly recognized in the area of thermodynamics of solutions, the kinds of complex solutions found in molten slags encountered in smelting operations.

After 16 years at MIT, he moved to Purdue University in 1954 as professor of metallurgical engineering and chairman of the Division of Metallurgical Engineering in the School of Chemical and Metallurgical Engineering. In 1959 the Metallurgical Engineering Division became the School of Metallurgical Engineering, with Professor Reinhardt Schuhmann Jr. as its first head. As founding head of the school, his leadership was crucial in laying the sound foundation for both the undergraduate curricula and the graduate research programs in the 1950s and 1960s. He served in that capacity until 1964, when he stepped down and accepted a distinguished professorship with the title of Ross Professor of Engineering. In 1966–1967 he was the Battelle Visiting Professor at the Ohio State University and in 1977 the Kroll Visiting Professor at the Colorado School of Mines. He retired in 1980 and as distinguished professor emeritus continued his scientific interactions with the faculty on the Purdue campus.

Shu was a teacher par excellence, a researcher of enviable insight and inquiry, and an engineer with incredible capacity to translate his insights into industrial applications. He was a teacher of teachers in classical thermodynamics; he inspired students to seek solutions to problems by seeking the right information, by framing the right questions, and by applying the appropriate scientific laws and engineering principles. In other words, he focused on the student's problem-solving potential. Both undergraduate and graduate students held him in very high regard. His research interests covered a wide spectrum—from mineral dressing and extraction of ferrous and nonferrous metals to theoretical analysis and practical

applications of classical and irreversible thermodynamics, from sulfur fixation in coal gasification to energy and environmental conservation. Professor Schuhmann often stated that he enjoyed moving back and forth between small-scale laboratory experiments and large-scale industrial processing, demonstrating that the same scientific ideas apply in both cases.

As a proof of creative engineering, he and his colleagues owned five US patents; these led to industrial breakthroughs in the areas of oxygen sprinkle smelting of sulfide ores and the commercial production of lead by the Queneau-Schuhmann-Lurgi (QSL) process. The QSL process utilizes oxygen converters for the direct and continuous production of lead from sulfide ore concentrates and has been adopted by Lurgi Chemie and Huttentechnik GmbH of Germany with plants throughout the world (Germany, Australia, Canada, China, and Korea). This one-step process, which can treat all grades of lead concentrates and also secondary raw materials, replaces the former two-step sinter oxidation and blast furnace reduction operations.

Shu was a recipient of many awards and honors; these include the Extractive Metallurgy Division Best Paper Award (1957) and EMD Lecturer (1965) of the Metallurgical Society (TMS, renamed the Minerals, Metals and Materials Society); the James Douglas Gold Medal, American Institute of Mining, Metallurgical and Petroleum Engineers (AIME) (1970), and Mineral Industry Education Award (1975); the Extractive Metallurgy Science Award, TMS (1977); recognition as a charter fellow of the Metallurgical Society of AIME (1963); fellow of the American Society for Metals (ASM) (1972); and member of the National Academy of Engineering (1976). He was very active in many professional societies including TMS and the Iron and Steel Society of AIME, ASM, the American Society for Engineering Education, the American Chemical Society, and Sigma Xi; and he held numerous committee chairmanships.

In November 1986, the Reinhardt Schuhmann International Symposium on Innovative Technology and Reactor Design in Extractive Metallurgy was held in Schuhmann's honor in

Colorado Springs to recognize his many contributions in the areas of extractive metallurgy and thermodynamics. The symposium was sponsored by engineering societies from eight countries and Shu's contributions were noted by his peers in the Foreword to the publication, as follows:

> It is now more than thirty years since the publication of Professor Schuhmann's epoch-making series of papers on the fundamentals of copper smelting. This work set the foundation for much of the fundamental work in this area. Professor Schuhmann's many other achievements range from a brilliant manipulation of the Gibbs-Duhem equation to derive what is now known as the Gibbs-Schuhmann equation, to co-invention, with Professor P.E. Queneau, of the Q-S-L Process and the Oxygen Sprinkle Smelting Process. The Q-S-L Process has been extensively piloted on a 240 tonne per day demonstration unit and is now ready for commercialization. It is expected that this process will revolutionize lead smelting technology.

In 1988 a research laboratory in the School of Materials Engineering was named the Reinhardt Schuhmann Jr. Laboratory to honor the founding head of the school for all his contributions over the years. In 1993 Professor Schuhmann received an honorary doctorate from Purdue University for his various contributions. This honor not only recognized his technical activities but also said:

> Shu played a major role in many of Purdue's activities since the 1950s. He started the materials area at Purdue and was the founding head of the school. His talents were recognized in many arenas in that he also was one of the founding members of the University Senate; his people skills were called into play in the late 60s when he was on the firing line of the student unrest of the times. In many ways Shu has left his mark on people who came in contact with him throughout his career. This legacy is perhaps the most lasting and most important of all of his contributions.

First at MIT and then at Purdue, Professor Schuhmann advised the research of numerous graduate students for their

master's and doctoral degrees. These students, who have had significant careers in industry, academia, and government, are an important part of Shu's legacy.

Shu was a loving family man with two daughters, Martha and Alice, and three grandchildren. He considered his wife, Betsy Hancock Schuhmann, whom he married in 1937, as the one who inspired him and kept him in line, as she was quite involved in reading, studying, and discussing politics. His favorite sports were tennis and hiking in the Colorado mountains with Betsy. Six years after him, Betsy Schuhmann died on July 3, 2002, at the age of 86.