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Memoriams

In Memoriam: Milton C. Shaw

Milton Shaw, who passed away on September 7, 2006, at the age of 91, was exemplary as an engineer/scientist; an outstanding mentor of students and postdoctoral researchers; and an individual of warmth, generosity, tenacity, and modest habits. Shaw made extraordinary contributions to manufacturing, materials processing, and tribology over a research career spanning sixty years. He was elected to the U.S. National Academy of Engineering in 1968 for his contributions to chemical synthesis, lubrication, and bearing design, and machine tool design and performance. He very much emphasized the conceptual approach to problem solving, emphasizing engineering solutions that could be effectively used by practitioners. His academic scholarship inspired and will continue to inspire generations of engineers and engineering educators.

Professor Shaw obtained a BS degree from Drexel University in Philadelphia in 1938. His graduate work was carried out at the University of Cincinnati, with an M.E.Sc. in 1940 and an Sc.D. in chemistry in 1942. The subject of his Ph.D. thesis was organometallic reactions, exploiting the unusual and extreme conditions found at the point of a cutting tool to carry out certain chemical reactions involving metals that are not easily performed in other ways. After receiving his Sc.D., Shaw was offered and accepted a position in the Department of Mechanical Engineering at the Massachusetts Institute of Technology. However, he was asked to proceed to Langley Field for an assignment with the war effort. In his first career appointment as Chief of Materials Branch at the Lewis Laboratory of the National Advisory Committee on Aeronautics (NACA, now NASA), Professor Shaw pioneered studies into lubrication and design of bearings. An outgrowth of this effort was the book *Analysis and Lubrication of Bearings*, jointly authored with Macks and published in 1949. It is the considered opinion of many that this book is a classic in tribology and ranks alongside his monograph *Metal Cutting Principles* in terms of its wide-ranging impact on the field of Mechanical Engineering. Professor Shaw's contributions to tribology were recognized with an ASME Mayo D. Hersey award in 1967, the third recipient of this prestigious award after Hersey and Blok.

After the war, Professor Shaw took up his professorial position at MIT founding the Materials Processing and Manufacturing Division. While his work in the 1940s was focused on tribology, the 1950s research at MIT was almost entirely devoted to machining and related problems of large strain plasticity. It was during this period that his highly-acclaimed monograph on metal cutting appeared along with a number of pioneering theses supervised by him. A glimpse of his insights into the fundamental mechanics and materials issues underlying machining may be found in a short gem that appeared in the *Proceedings of the National Academy of Sciences* (Vol. **40**(6), pp. 394–401, 1954). While at MIT, Professor Shaw was also involved in a leadership role with a company that designed and produced dynamometers, and testing equipment that could be retrofitted onto machine tools. This keen interest in dynamometry and equipment design would continue throughout his career.

Milton C. Shaw
May 27, 1915–September 7, 2006

The MIT era came to a close with his acceptance of the Headship of the Department of Mechanical Engineering at the Carnegie Institute of Technology (later CMU) in 1961. The golden age of grinding followed the golden era of metal cutting as Shaw's interests now focused almost exclusively on abrasive processes. The mechanics of grinding and thermal phenomena were explored to dizzying heights along with pioneering studies structured around single abrasive grit experiments and analysis. The large research program in abrasive processes was supported by the government and industry under the auspices of the just-founded Abrasive Grain Association and the Grinding Wheel Institute, an extraordinary early example of industry-government collaboration in manufacturing. In contrast to the metal cutting research, the work on abrasive processing did not appear as a monograph until almost 25 years later in 1996.

In the 1970s Professor Shaw's interests also intruded into mechanical design. An example of this activity may be found in his ASME Thurston lecture entitled "The Mechanical Fuse" (1971), in which he described an ingenious technique that exploited the high energy dissipation during chip formation for energy absorption in vehicle crashes. A somewhat little known, but important contribution of Shaw's Carnegie tenure, was his co-organization with W. W. Mullins, Dean of Engineering at Carnegie, of the Second Buhl International Conference on Materials, published informally as *Metal Transformations* in 1968. This contains reports on the history and evolution of Metals Processing by luminaries such as Cyril Stanley Smith, John Christian, Bruce Chalmers, Egon Orowan, Robert Mehl, Hugh Ford, I. Bernard Cohen, and others—a truly wonderful read.

Professor Shaw moved to Arizona State University (ASU) in 1978 after his retirement from Carnegie Mellon. His research interests now turned towards fracture. At ASU, he was much con-

sumed by the consequences of the second of the pioneering papers written by A. A. Griffith, the founder of linear elastic fracture mechanics, and Bridgman's pioneering work on fracture and flow of materials under superimposed hydrostatic pressure. Shaw's group during this period was a small one, about 4–5 students, which I was privileged to be a part of. He was readily accessible for discussions on research problems as well as topics in mechanical engineering and materials. This was also a period in which he was quite willing to reminisce about the earlier decades, the research, education, the classic papers and the personalities involved. Just a small sprinkling of these: great fondness for peers such as Orowan, Den Hartog, Tabor, and Backhofen; the key role of dimensional analysis in engineering; the importance of the classic moving heat source papers of Jaeger and Blok to materials processing and manufacturing problems; and enjoyment of the early years of CIRP with friends such as Professor Opitz. He would often comment that he preferred to change his research area once about every ten years and that this was a healthy path that we should all consider.

Professor Shaw was one of the early and, perhaps, among the last of the great generalists in mechanical engineering, publishing in magazines ranging from *Nature* to the *American Machinist*. He was an internationalist, mentoring numerous postdoctoral researchers from Japan, India, and elsewhere at MIT and CMU; indeed, in excess of 20 Japanese researchers he mentored went on to become prominent professors of production engineering in Japan and pioneered the development of the field there. However, he graduated his first Japanese and Indian Ph.D. students only in 1981 at ASU, a fact not commonly known. Mary Jane, his wife of over 60 years, played an equally strong role in mentoring the students and visitors, and in editing and polishing up his manuscripts at record speeds. The Shaw family was wonderfully hospitable and kind. While at ASU, they would always invite the students to their home in Tempe and their summer home in Flagstaff, and later Prescott. They were among a small group that hosted international scholars at MIT, a fact that both Mary Jane and Professor Shaw were very proud of.

And now Professor Shaw has gone to his rest. Time, like an ever rolling stream, bears its children away, and even he has not been immune. He has joined the Eternal Soul, the Garden of Eden, the snows of yesteryear, or another realm, depending on what one's spiritual philosophy may be. A quote recently made about Hans Bethe may apply equally well to Professor Shaw: "Do they make them like that anymore?"

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