

Professor Richard J. Goldstein on his 60th birthday



PROFESSOR Richard J. Goldstein has recently celebrated his 60th birthday; it is therefore fitting and a great pleasure to honor here his achievements.

Professor Goldstein was born on 27 March 1928 in New York City and graduated from Peter Stuyvesant High School. He attended Cornell University and received the B.M.E. degree in 1948 and later during that year entered the graduate school of the University of Minnesota from which he received Master's degrees in Mechanical Engineering (1950) and Physics (1951). After a period of service with the Oak Ridge National Laboratory and a brief tour with the U.S. Army he returned to complete his doctoral study in 1959 under the guidance of Dr Ernst R. G. Eckert. After two years at Brown University's Engineering Department Professor Goldstein returned to the University of Minnesota in 1961, establishing there a research program distinguished by the breadth, precision, and novelty of the experimental techniques employed.

Professor Goldstein is a major contributor to the body of knowledge about heat transfer; for three decades his research findings, and those of his students, have become milestones by which progress is measured in various sectors of the discipline. His research is characterized by fundamental curiosity concerning the underlying physical mechanisms coupled with a clear sense of engineering relevance. As a consequence, many of the nearly 200 published papers are read by scientists and engineers from diverse fields who hold a common interest in the prob-

lem under investigation. One of the consequences of his superior insight into natural phenomena is the development of measurement techniques generously shared with interested colleagues, which have advanced the fundamental understanding of particular physical phenomena which occur in widely different scientific and engineering disciplines. Thus Goldstein was among the earliest investigators to conceive of joining the coherent light source of the laser with the effect first discovered by Doppler resulting in the development of a non-invasive instrument for measuring fluid velocities across a spectrum of systems from small biological ones to large-scale rocket engines. First to develop and use the reference beam system, he obtained precise measures of fluid velocity, probed the intensity of turbulence in flows, studied the character of blood and other non-Newtonian flows, observed and characterized reversing convective flows and measured the flow in rotating systems. Goldstein's development and pioneering use of laser-Doppler velocimetry, particularly his contribution of the reference beam method, revolutionized the measurement of fluid velocities; it is now the standard, non-invasive measurement technique for this property. His work with liquid crystals, interferometric measurements in liquid systems, heat/mass transfer analogies, and electrochemical systems for studying buoyancy driven convection illustrate further his skill in adapting novel measurement techniques for studying heat transfer processes.

Professor Goldstein's qualities as an experimental scientist and engineer are strikingly revealed in his study of buoyancy-driven convection in an enclosed layer. Beginning in 1958 with a paper on transient free convection, his sustained interest is evidenced by some 30 scientific and technical papers on aspects of convective heat transfer. His findings attract respect across a range of disciplines because of his knack for posing the question in the most fundamental way: "What is the mechanism by which energy, liberated at the central core of an enclosed system, is transported to its surface?" Goldstein's experiments observe the formation, growth, and behavior of a pattern of cells, containing turbulently circulating material, which is responsible for the energy transfer between core and surface. His measurements, and the correlations derived from them, have attracted the lively interest of a spectrum of scientists from widely different disciplines: astrophysicists, geologists, oceanographers and meteorologists, and mathematicians.

These measurements are distinguished in two respects: their precision and the wide range of observations as indicated by Rayleigh number. The precise measurement of a basic physical phenomenon would alone attract scientific interest; the broad range over which the precision holds accounts for the diversity of interest, the combination causing Goldstein's observations and correlations to be unique and of unusual value.

The exceptional breadth of Professor Goldstein's contributions is suggested by a partial listing of his areas of research: boundary layers, natural convection, laminar and turbulent flows, mass transfer, heat transfer with phase change, hydrodynamic and thermal instability, jet impingement, film cooling, jet-mainstream interaction, wall curvature effects on film cooling, modeling of two- and three-dimensional film cooling, separated and vortex flows and a range of investigations of particular importance in heat transfer related to gas turbines. In these areas and others his contributions have enhanced our understanding and technical skill.

Professor Goldstein's research has from its inception attracted a steady stream of aspiring graduate students. As teacher, advisor and mentor he has had a profound impact upon their personal view of scientific research and their professional careers. They have found him an inspirational teacher, investigator and scholar but treasure even more his ability to convey to each of his students a sure sense of the high standards which ought to attend research scholarship and academic endeavor. His students are found the world over in universities, private industry and government service and he continues to follow their progress with keen interest, appreciation and encouragement.

Professor Goldstein has contributed significantly to the transmission of technical information and improvement of professional practice through his work in the American Society of Mechanical Engin-

eers and its Heat Transfer Division and by consulting with various private enterprises and government agencies. His contributions to the former have been recognized by the ASME award for service, the Heat Transfer Memorial Award, the ASME Centennial Medallion, and the 50th Anniversary award of the ASME Heat Transfer Division made in recognition of distinguished contributions to the field of heat transfer and notable service to the Division. He is a member of the editorial advisory boards for *Experiments in Fluids*, *Heat Transfer—Japanese Research*, *Heat Transfer—Soviet Research* and the honorary editorial advisory boards for the *International Journal of Heat and Mass Transfer* and *International Communications in Heat and Mass Transfer*. His advice has been sought over the years by his appointment to various National Science Foundation, Department of Energy, and ASME advisory and standing committees.

Professor Goldstein's international activities include service as the U.S. delegate to the Assembly for International Heat Transfer Conference, the International Centre for Heat and Mass Transfer, the U.S.—China Workshop on Heat Transfer and the U.S.—Japan Joint Heat Transfer Conference. Currently he serves as President on the Assembly for International Heat Transfer Conferences.

In 1977 Professor Goldstein became Head of the Mechanical Engineering Department of the University of Minnesota and from that position has developed a faculty of strength and diversity under circumstances not always favorable. He has served with distinction on a wide range of University committees concerned with the governance of the institution. In the course of the service he has earned the confidence and respect of faculty and administrators alike because of his good judgment, wise counsel, and sound academic leadership.

Professor Goldstein's contributions to the field of heat transfer, engineering education and the engineering profession are of the highest order. While he has pursued excellence in these various spheres it is worth noting that he has done so in a manner which fosters and enhances the opportunities for others to excel. His summary contributions to engineering were recognized most fittingly by his recent election to the U.S. National Academy of Engineering.

His students, colleagues, and friends across the globe join with the editors of this journal to wish Professor Goldstein many years of continued good health, professional accomplishments, and happiness in his family.

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