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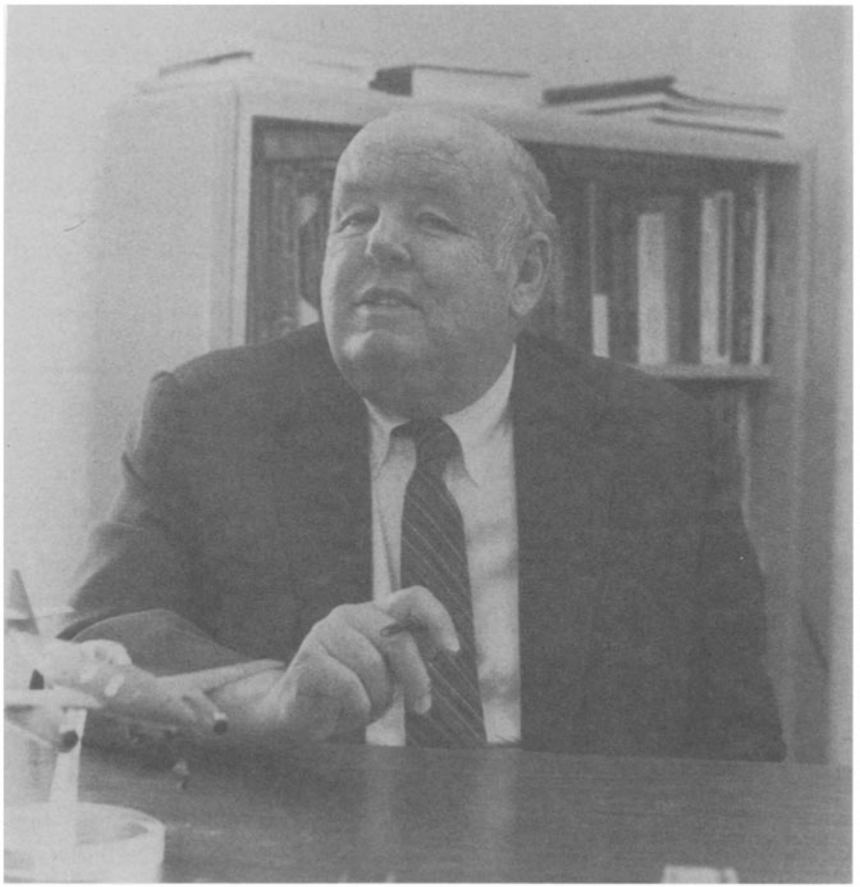
EDITORIAL

In Memory of Henry J. Kelley



Professor H. J. Kelley, 1926–1988

Dr. Henry J. Kelley, Christopher Kraft Professor of Aerospace and Ocean Engineering at the Virginia Polytechnic Institute died suddenly on

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February 9, 1988. He had celebrated his sixty-second birthday the previous day.

Hank Kelley's university education began at New York University (NYU), where he was awarded a Bachelor of Science in aeronautical engineering in 1948. His studies continued as a part-time student leading to a Master of Science in mathematics (1951) and to the Sc.D. in aeronautical engineering (1958). All of his degrees were awarded by NYU, and it was clear from his work and his comments that many of his teachers, including R. Courant, J. Moser, and J. J. Stoker, had a profound effect on his scientific views.

Hank began his professional career at Grumman Aircraft in 1948. Initially he worked on aircraft dynamics and control problems; his first journal publication (with E. F. Baird) concerned flutter prediction on an analog computer. He was attracted to guidance and optimal flight problems; these were to be the grist for his considerable talents throughout his career.

In 1958, Hank completed his Sc.D. dissertation, "An Investigation of Variational Methods for Optimization of Flight Performance." He also participated in the successful Grumman–Navy efforts to capture the minimum time-to-altitude records with an F11F-1F "Super-Tiger" jet. These dual interests in both theoretical and applied problems were a Kelley hallmark.

The first of Hank's major contributions to the field came in 1959 with the publication of his work "Gradient Theory of Optimal Flight Paths." A later version, published as the "Method of Gradients" chapter in Leitmann's *Optimization Techniques* became required reading in the field. Numerical codes based on this theory and on the related second-variation procedures found important use in mission-planning for early US space flights. His second-variation procedures were also the basis for his theory of neighboring optimum guidance. Ideas from the neighboring optimum theory were used in the design of the reentry guidance system for the Apollo spacecraft.

Among the more troublesome early applications of optimal control theory were problems with linearly appearing control variables. In some cases, so-called singular controls arose as possible minimizers, but the early theory provided no 'second-order' test as a check on true minimality. Hank Kelley's extraordinary insight provided just the right family of test variations to yield the answer. The chapter on "Singular Extremals," written with R. E. Kopp and H. G. Moyer, and published in Leitmann's *Topics in Optimization*, is arguably Hank's most significant mathematical contribution. The resulting higher-order test for optimality of singular extremals is known as the Kelley–Contensou test in Europe and simply as the Kelley condition in the Soviet Union. The paper also considers the important and difficult

question of appropriate 'junction' conditions needed at points where singular and nonsingular arcs join together.

The practice of trajectory optimization again felt the Kelley influence in the late 1960s as he was an early proponent of parameter optimization approaches. In 1963, he had left Grumman (as Assistant Chief of the Research Department) to become one of the founders of Analytical Mechanics Associates. Working closely with researchers at NASA Houston, he led the development of parameterized steering approaches for Apollo mission planning. These formulations had become attractive because of considerable progress in algorithms for solving nonlinear programming problems. Hank also contributed to this field with his work on accelerated gradient methods, particularly on techniques for efficiently handling nonlinear constraints.

Among Hank's most keen technical interests was the field of differential game theory and its applications to aerial combat problems. Early on, the Kelley intellect recognized both the significance and the difficulty associated with the problem of role determination. His notions of 'threat-reciprocity' and of 'reprisal' strategy are being used today in efforts to automate the cockpit of future aircraft.

Finally, Hank Kelley contributed significantly to our understanding of the various simplified models used in flight optimization. His chapter "Aircraft Maneuver Optimization by Reduced-Order Approximations" in the 1973 Leondes volume is another marvelous contribution. His interest in the study of singular-perturbation theory for optimal flight problems continued to the end of his life.

In 1978, Hank Kelley began the third phase of his career as a professor in the Aerospace and Ocean Engineering Department at the Virginia Polytechnic Institute. There he continued his research in the various aspects of flight optimization that he had long pioneered. He was always a source of inspiration to everyone who worked with him, both students and colleagues.

The significance and scope of Hank Kelley's contributions have long been recognized and appreciated by the technical community. He was presented New York University's Founder's Day Award in 1959, the IAS New York Section Award in 1961, the AIAA Guidance and Control of Flight Award in 1973, and the AIAA Pendray Award in 1979. He was a Fellow of the AIAA, and member of the AAS, the IEEE and SIAM. He generously contributed his time to the profession, as a prime mover in the founding of the *AIAA Journal of Guidance, Control, and Dynamics*, as an associate editor for the AIAA and for OCAM and as an AdCom member for the IEEE Control Society. Hank was a strong proponent for the American Automatic Control Council and for IFAC and was founder and first chairman of IFAC's Mathematics of Control Committee.

Beyond his enormous technical presence, there was an extraordinarily generous and gentle man. Hank and Maureen Kelley threw great parties and they were great fun to be with. A husband to Maureen G., a father to Henry B. (Kel) and to Maureen E., and a friend to many, he will be missed by all.

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