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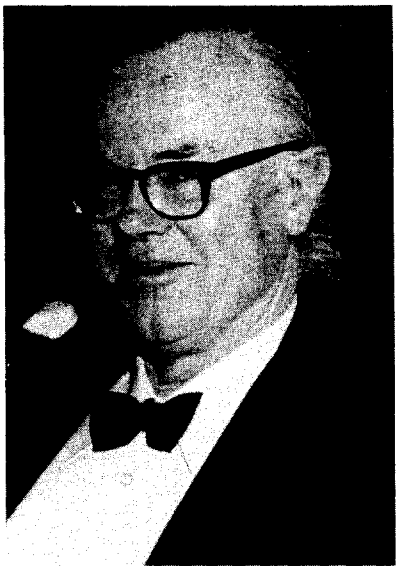
EDITORIAL

In Memory of John V. Breakwell



Professor John Valentine Breakwell, 1917–1991.

Dr. John Valentine Breakwell, Emeritus Professor of Aeronautics and Astronautics at Stanford University, died of cancer at his home in Palo Alto, California on April 16, 1991.

John was born in Switzerland in 1917. He received a bachelor's degree in mathematics with first class honors at Oxford University and a Ph.D. in mathematics from Harvard University. He taught mathematics at Tufts University from 1941 to 1949, then worked for North American Aviation until 1957 when he joined the Lockheed Missiles and Space Co. He became a professor at Stanford in 1964.

John was a brilliant applied mathematician who made important contributions to our knowledge of orbital mechanics, trajectory optimization and guidance, and differential games.

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He wrote one of the first papers on the modern calculus of variations in 1959, applying it to the new problem of optimal thrust direction programming to put a satellite into orbit (Sputnik appeared in 1957). In this paper, he gave an interpretation of the Lagrange multiplier functions (adjoint variables) as sensitivities, which connected them to the gradient of the cost function in Bellman's dynamic programming (also 1957).

Along with Rufus Isaacs, he created the modern theory of differential games which treats minimax strategies—his famous paper on the "homicidal chauffeur" is a classic in the field (1969).

His work with colleagues and students on astrodynamics, the modern version of celestial mechanics, dealt with predicting spacecraft orbits in the presence of perturbations, a complicated but important subject for space exploration. He invented the concept of "halo orbits" about a point in space where the gravitational forces of two celestial bodies are in equilibrium with the centrifugal force. This work was carried on at NASA by one of his doctoral students, Robert Farquhar.

Over the years, he was an important contributor to the NASA–Stanford Gravity-Probe B project which will make a new test of Einstein's theory of general relativity during the 1990's.

John was unpretentious and shared credit for many of his insights with his students. It was not long before he was recognized internationally as a leader in orbital mechanics and differential games. He received the Mechanics and Control of Flight Award of the American Institute of Aeronautics and Astronautics in 1972, the Dirk Brouwer Award of the American Astronautical Society in 1973, a Humbolt Fellowship from Germany in 1977, and the Control Heritage Award of the American Control Council in 1984. He was elected to the National Academy of Engineering in 1981. He was an Associate Editor of this journal since its inception in 1967.

He was a remarkable teacher-consultant, since his quick mind enabled him to rapidly understand almost any problem and to suggest solutions or approaches that almost always worked. As an example, he looked at Theodorsen and Garrick's unsteady airfoil theory, nearly forty years after they published it, and saw immediately that their integrals could be analytically continued into the left half of the complex plane. This enabled his student John Edwards to calculate, for the first time, the exact behavior of an aeroelastic system stabilized with feedback to a trailing edge flap.

His many students have made and are still making important contributions in astrodynamics, optimization, and differential games.

His avocation was music. He was active in singing groups, both as pianist and singer. He was charter member of the Schola Cantorum, played in the Two-Piano Society and chamber music groups, and for many years led and sang with the Palo Alto Madrigal Singers. He could play the

accompaniment in any key and, at the same time, sing any part in a choral work. He sang the lead in several Gilbert and Sullivan operettas at Stanford, including the judge in "Trial by Jury." He could sing most of the famous "patter" songs by heart at a moment's notice.

John also loved hiking, biking, and golf. He was always upbeat and fun to play with, despite the fact that he wasn't a very good golfer. His golf swing was legendary—he would stand way back from the ball and take two practice swings, pumping his knees up and down; then, without stopping, he would take a third swing, reach out about two feet, and hit the ball.

He was a gentle man with a wry sense of humor, and did amazing and comical imitations of pompous British and Russian politicians and scientists.

He is survived by his son, John Alexander Breakwell of Los Altos, California, and three grandchildren. His wife, Lilyan Ann Wiley, died in 1984.

He was also a generous, cheerful, kind friend to many of us, and we shall miss him very much.

Arthur E. Bryson
Department of Aeronautics and Astronautics
Stanford University
Stanford, California

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