



John V. Breakwell

JOHN VALENTINE BREAKWELL

1917–1991

BY RICHARD H. BATTIN

JOHN VALENTINE BREAKWELL, professor of astronautics at Stanford University, died on April 16, 1991, at the age of seventy-three. John was admired and respected throughout the community of guidance, control, and astrodynamics specialists. His contributions have been fundamental and broad. He was a rare combination of the scholarly professor and the practical engineer. His modest and unassuming manner, coupled with a giant intellect, endeared him to all his colleagues and students.

Elected to the National Academy of Engineering in February 1981, John will be remembered as a key founder and major developer of astrodynamics. During a career spanning more than four decades, he was one of the most skillful contributors in trajectory optimization, differential-game theory, and their aerospace applications.

John was born in Ville Nueve, Switzerland, on December 6, 1917. He received his B.A. with first-class honors in mathematics from Oxford University in 1939. England was then at war, and John left for the United States in 1941 to become an instructor (later assistant professor) in applied mathematics at Tufts University in Medford, Massachusetts. At the same time he was a doctoral student at Harvard University and received his Ph.D. in mathematics from Harvard in 1947.

John was attracted to the new field of ballistic missiles, but a security clearance was required for classified work. He applied

for U.S. citizenship, and it was granted in 1949. Then he moved to the West Coast to join the North American Aviation Corporation in Downey, California, to be a part of their missile development activities under contract with the U.S. Air Force.

In 1957, the year of the Russian Sputnik, John left for Sunnyvale, California, to become a member of the staff of the Lockheed Missiles and Space Company. The advent of the Space Age provided inspiration for the wealth of contributions for which John will always be remembered.

Early in his career John demonstrated an ability for profound insight. One of his early internal memos at Lockheed gave a detailed description of how the earth's gravity gradient could be used passively to stabilize the attitude of a satellite as well as to damp its oscillations.

The major program at Lockheed when John arrived was to construct the first American military satellite—the *Discoverer*. There were many engineers and scientists who contributed as a team to the design and development that made that program a success. John, however, worked as an individual and tackled some of the most difficult analytical problems that the satellite field had to offer. Applying his extensive mathematical ability and technical insight, he developed methods that would support the design basis for many future satellite programs, such as the Agena.

John published the first paper on trajectory optimization using the calculus of variations in 1959 to address the new problem of placing an artificial satellite in orbit. His continuing work in optimization theory led to a wide range of applications—missile trajectories, aircraft flight-path optimization, and interplanetary flight.

In 1964 John accepted an appointment to the faculty of Stanford University and there continued the research begun at Lockheed. But now he had the opportunity to influence many Stanford graduate students who were fortunate enough to have him as their teacher and adviser. The roster of his past students reads like a *Who's Who in Astrodynamics*.

The invention of "halo orbits" (small, closed orbits in the vicinity of the Lagrange libration points) is attributed to John

Breakwell. In 1978 one of the Sun-Earth collinear points was used as the center of a halo orbit by a spacecraft known as the International Sun-Earth Explorer. One of his former students, Robert Farquhar, directed that project at the NASA Goddard Space Flight Center. John was also an important contributor to the joint NASA/Stanford Gravity Probe-B experiment designed for a new test of Einstein's theory of general relativity. It is intended to be launched from the space shuttle sometime in the next few years.

With Rufus Isaacs, John significantly advanced the modern theory of differential games. His famous 1969 paper on the "homicidal chauffeur" is a classic in that field. The work had important applications for the U.S. Air Force. It could be used to suggest possible "minimax strategies" for aerial "dogfights" between jet fighter aircraft.

John was recognized for his many outstanding achievements by the American Institute of Aeronautics and Astronautics (AIAA) with its Mechanics and Control of Flight Award in 1972. This was followed in 1974 by the American Astronautical Society presentation of the Dirk Brouwer Award for significant technical contributions to spaceflight mechanics and astrodynamics. Later he received the Humboldt Research Award for U.S. Scientists for 1977–1978.

Professor Breakwell supported his profession well through his service as an editor of the *Journal of Optimization Theory and Applications*, the journal of *Celestial Mechanics*, and the *AIAA Journal*. For several decades he was the astrodynamics session organizer for the annual International Astronautical Congress.

John Breakwell loved new and interesting problems to such an extent that many of his important technical contributions were never published in archival journals. He was simply too busy with something else to bother with the details of submitting papers for publication. As a result, one must often seek out various conference proceedings to locate some of his finest work.

Besides being a remarkable and inspirational teacher, John was an avid outdoorsman, hiker, and golfer. He was an accomplished musician and singer. He spoke French well enough to

lecture in that language and could converse in many other languages as well. He had hoped to learn Mandarin Chinese in time for a conference in Beijing.

On the piano John could play almost any song that anyone could name and was also a fine choral singer. It is difficult to imagine how he could play the accompaniment in any key and sing any part of a choral work simultaneously. He loved Gilbert and Sullivan and sang the lead in several of their operettas produced at Stanford, including the judge in *Trial by Jury* and the major general in *The Pirates of Penzance*. He could—and frequently would—sing from memory many of the famous "patter songs."

John had a marvelously droll sense of humor, and it was truly a delight to hear any of his many anecdotes—always told with wonderful accents and authentic dialects. I will never forget the story of his misadventures in Greece when he fell into the company of some unsavory Athenians.

John Breakwell was a wonderful friend, unpretentious, generous, and kind. It was a pleasure to know him and he will be sorely missed.

