Tribute to Walter R. Evans

Robert H. Cannon Jr.

Walter R Evans is best known for his invention of the Root Locus Method for designing automatic control systems. First published in 1948, it has since been used world-wide as the first step in creating good automatic control systems: It remains by far the most direct way of seeing exactly and very quickly what the cogent behavior of a controlled system will be, as a direct function of the control parameters at the designer's disposal.

1Robert H Cannon

While it is his Root Locus Method that has made his name widely known, and his contributions widely drawn upon, Evans also contributed deeply himself to the advanced design of a range of automatic control systems for aircraft and spacecraft, including the unmanned supersonic Navaho, and for inertial guidance systems, including the one that navigated the submarines Nautilus and Skate under the North Pole, and to the rapid frontier education of the engineers who worked with him to make them. The Navaho was the first supersonic aircraft, manned or unmanned. The Nautilus and Skate were the first two submarines to make a subpolar voyage, which they did with extremely small error.

Evans' landmark Root Locus Method played - and plays - a central role for rapid advances in the fast-growing field of automatic control. It provided, for the first time, a truly direct and quick way to look at a system's natural behavior and choose its control: by studying, in the "s plane," how the roots of its characteristic equation vary directly with the value of control "gain." And, because each (complex) root of the characteristic equation indicates the vibration frequency (imaginary part) and damping speed (real part) of one of its natural motions, one knows instantly and precisely, from a system's set of spy plane roots, what natural behavior that system will exhibit. The first rule is of course to be sure all closed-loop roots are well into the left half plane, i.e., are well stable.

Evans' simple method, one can plot in seconds, and see at once the whole range of possible controlled behavior, and easily choose the best control. Evans developed a set of very simple sketching rules by which the loci can always be quickly approximated "by eye" on the s plane. In 1948 there were no digital computers; but quite complex root loci could be quickly sketched anyway by Evans' rules - in seconds!

Today there is enormous computing power at hand and programmed to sketch loci; but it is still much quicker to approximate first by eye, using Evans' rules. To nail down specific points on the locus - to establish the gain to use and the exact natural frequency and damping that will result - Evans invented the Spirule, a simple plastic device with which the product of a set of s vectors can be quickly determined graphically. By 1950 the root locus method was already in wide use in the company, North American Aviation, where Evans was a highly respected engineering leader. (And the Spirule still gets a quick answer: Over the years, 100,000 have been shipped by Evans' wife, to engineers and engineering students in 65 countries.

Before Evans' Root Locus Method, these natural-behavior design decisions were most often made by the astute, but very indirect methods of Nyquist and Bode and Nichols, which inferred them from the system's response to sinusoidal inputs (a natural derivative of the EE community that designed early feedback controllers for electronic systems).

Good design throughout the years since has used the two methods concurrently - the Root Locus Method and the range of "Frequency Response" methods. But it is the root locus that gives the first quick, direct insight. And it is the root locus structure that supports advanced optimal control design methods in a very fundamental way. Formally, Evans taught courses at Washington University and at UCLA and presented seminars that always surprised. His book, Control System Dynamics (McGraw Hill, 1954) and his seminal papers recorded succinctly his brilliant conception of automatic control. But the really fortunate students were the colleagues working beside Evans, and watching a wonderful, creative, agile and unfettered mind working with zest and very special wit (which was always brought directly to bear).

His goal-oriented mind always approached any problem from a way no one else had ever thought of and often the only way that would work. Every so often he would make a giant leap. He once solved a stymieing rocket engine control problem after only an hour's exposure to it. It typically took quite a while for others to assimilate the power of what of his mind had provided. (This showed up also in his approach to project management: "progress can be planned and reported only at the expense of being made.")

Along with Evans unique mind and wit went a profound caring for others: for his family and for his coworkers and students. And his four children and wonderful wife Arline knew well and cherished their unique blessing. (Son Greg noted that "while professionally plotting the roots of characteristic equations, he also was planting in us the roots of character." Greg described their family times as "life in the left half plane."

Then, in 1980, tragedy struck. At age 60, at the peak of a superb career, Walter Evans suffered a massive stroke. Damage to the left part of his brain now denied him speech, reading, and the use of his right limbs. With his indomitable will and Saint Arline's unstinting support he continued to bring love and philosophic inspiration to us all to paint beautifully and to play chess well and swim often - until his death on July 10, 1999.

He was most appropriately awarded the Oldenburger medal from the ASME in 1987, the Richard Bellman Control Heritage Engineers Award from the American Automatic Control Council in 1988, and the Engineering Alumni Achievement Award from Washington University in 1990. And the highest distinction of all was the deep and warm respect of his colleagues: Walter Evans inspired us so much. And he gave us so much. We have been greatly blessed.

Robert H. Cannon Jr. is Charles Lee Powell Professor and was Chair of the Dept. of Aeronautics and Astronautics and Director of the Aerospace Robotics Laboratory at Stanford University.