My mother, my younger brother, Gary, and I are very pleased to be with you this afternoon to witness my father's acceptance of your 1987 Rufus Oldenburger Award. Although Dad is unable to speak, I will endeavor to share with you in the course of my talk some of his views on a subject of lifelong interest to him, the learning process.

As a student, my father's first love was geometry. In fact, the root-locus method began, in a way, in his Soldan High School geometry class. There he discovered a formal discipline matched to his pictorial way of thinking. Years later, he wrote about geometry's appeal in a letter to my high school math teacher:

"Math has always been a game for me and now is a good part of my livelihood. Geometry used to provide (me) a steady diet of looking for a pattern that would lead to a solution before settling down to the detail of writing down all the steps."

His next academic step was a degree in Electrical Engineering at Washington University in St. Louis. (By the way, he abandoned his initial major, Engineering Administration, when one of his professor's recommended he prove himself as an engineer first and prepare for the vice presidency later.) [Post-speech note: His father, Gomer Evans, was an Engineering Vice President at the Wagner Electric Company.]

Twenty years later, in a letter to its Engineering School's former Dean, Alexander S. Langsdorf, my father, reflected on how he learns best and how his Wash. U. teachers helped him "I personally learn most effectively by starting from simple examples and working up. Washington University was excellentin that professor such as yourself, Professor (Roy) Glasgow, Dr. (Frank) Bubb, and Dr. Middlemiss could and did take a student all the way back to the beginning if necessary and work up to the question at hand."

His education continued at General Electric in Schenectady, New York, where he and his fellow students cooperated to survive the rigors of what was known simply as "The Advanced Course". Its particular appeal to him is evident in his later statement on the key to learning:

"The main key to learning in my opinion is to treat the problem as a game using all the simplifications possible to get the approximate answer. ... The General Electric Advanced Engineering Program put great emphasis on solving practical problems in approximate form starting from a few basic principles."

After completing the Advanced Course, my father returned to Washington University as an instructor. There, in one of his classes, a student asked him what would happen to a typical control system if a certain quadratic approximation broke down. My father credits this question as being the specific inspiration for root locus. Working from first principles, he obtained a graphical solution to what he referred to as the "slightly cubic system" envisioned by the student. It was the first root-locus plot. [Post-speech correction: this question was asked in a class at North American Aviation in 1948]

And so, it's no accident that Dad's approaches to problem solving-- starting from the beginning, applying basic principles and geometric reasoning to achieve approximate answers before proceeding to the mathematical detail are at the heart of his rapid graphical analysis technique root-locus method.

It was an unorthodox concept at the time, and as was true of many of his ideas, it did not catch on right away. Reflecting back thirty years later, as to why it eventually did, he wrote, I have had more than my share of luck in hitting it big with Root Locus. I mean luck because many other ideas, not directly I think that the servo, have failed to arouse any interest. The explanation is that I strive for a

kind of understanding that most people don't seek. In the case of root locus, it provided a needed link to a complete solution of a system which many others did seek."

Dad, I remember some of your ideas that didn't catch on at the time: spray painting tennis balls bright yellow and orange to improve their visibility, mounting wheels on luggage to enhance their transportability, and staggering work hours to ease traffic congestion. Let's face it, you often were ahead of the times.

But getting back to the learning process, I'll never forget another of his ideas that's only now gaining acceptance using computers in the classroom. I won't forget it because it became my eighth grade science fair project. Together, we built an algebra teaching computer. Its opening message to the student reads as follows: "This is no ordinary machine. It is a teaching machine. can learn at (your) own individual pace. Depending upon the answer given, the machine advances to a more difficult question or to an explanation of why the answer given is wrong. (You) learn instantly whether you are right or wrong. button A to begin."

The questions were written on a roll of shelf paper (. patterns under each answer provided the appropriate counts to a stepping relay and direction to a motor drive. The motor engaged when the student closed a sliding wooden panel that triggered a microswitch. Building logic circuits proved to be a lot of fun, and, 27 years later, I'm still at it.

To my disappointment, Dad was only secondarily interested in the details of the electrical and mechanical design. His primary interests were the contents and structure of its questions and answers; how they could most whatever the state of his initial effectively respond to any student understanding of algebra. Well, I learned more than algebra from the experience. I learned that punching holes, writing programs, and connecting switching

relays together were one hell of a lot simpler than aligning and maintaining uniform tension on a roll of shelf paper wrapped around a couple of rotating wooden spindles, and I've stayed as far away as possible from mechanical engineering problems ever since.

Dad's kind of problem solving, grounded in fundamental understanding, didn't always go down well with us kids. We were often content with a more superficial understanding. superficial understanding. Perhaps he was referring to those resistive encounters with us when he wrote again to Dean Langsdorf. "... I find that working with my children is a good testing ground for teaching methods because the subject matter is simple, the opportunities frequent, and the reaction clear."

Well, our occasional reaction may have been resistant but let me set the record straight. His four children went on to earn undergraduate degrees in physics, mathematics, computer science, and engineering. I think it's fair to say he was a role model to all four of us. My father's philosophy toward learning and teaching is, perhaps, best summarized in a 1965 letter he wrote to his favorite Wash. U. Professor, Roy Glasgow:

"it seems to me the real bulk of learning takes place in self-study and problem solving with a lot of positive feedback around that loop. The function of the teacher is to pressure the lazy, inspire the bored, deflate the cocky, encourage the timid, detect and correct individual flaws, and broaden the viewpoint of all."

I'd like to shift gears now and pick up the root-locus story where we left off in St. Louis. John R. Moore offered my father a summer job in Downey, California with North American Aviation. He accepted it and never turned back. There, with the support and encouragement of several auto-pilot designer colleagues (e.g., Jeff Schmidt, Bill Mullins, and others), another idea was born: a plastic tool that became known as the Spirule.

As the root-locus method provides a rapid means of plotting the roots of a servo-mechanism's characteristic equation, the Spirule simplifies the task of constructing accurate plots. Word of its utility spread more rapidly than he imagined. When the head of the University of Cincinnati's Electrical Engineering Department wrote him in 1950 to find out if any Spirules were available for instructional use, my father responded with the following note:“None are available because of the following costs: $30 for a single machine shop model, or 50 cents each for a stamped version in a lot of 500. It's not worth $30 and the demand is far short of 500."

Soon thereafter, however, professors from UCLA and U.C. Berkeley placed orders for 150 and the Spirule Company was born. Mom was the shipping and receiving department, the executive secretary, and the accounting department. Later my older brother and I became the assembly line inserting eyelets and stuffing instruction sheets into envelopes.

One Sunday morning I answered the front doorbell while in my pajamas, only to confront a bewildered looking engineering undergraduate student who asked, "Is this the Spirule Company?" Since they were readily available in college bookstores, I can only surmise that a student desperate enough to drive to our house was cramming on the weekend before his final exam.

At least one such student at UCLA, perhaps driven by his exasperation in mastering its use, was driven to rewrite the lyrics to Merle Travis's popular song, Sixteen Tons. I'll agree to read from just one of the stanzas, if you will agree to imagine Tennessee Ernie Ford singing it.

O, I was born one morning' as the root-locus flew.
Buried neck-deep in snow and a-turnin dark blue.
Raised in the Nyquist by an old zero--
Get a grade in this course and I'll be a hero.
You do sixteen tons, and what do you learn?
Slide-rule busted and the Spirule won't turn.

Well, you get the idea. Despite this student's travail, Spirule orders poured in. My father set prices over the years barely above his costs out of consideration for cash-poor students. Orders continue to this day, arriving at the same address that first appeared in his 1954 Control Systems Dynamics book 9728 El Venado, Whittier, California. My parents still live there and that's where my roots are. Roots not in the reckless fast lane, but roots in the stable left half plane.

By now Mom has personally wrapped, packed, and delivered to Whittier's post office over 100,000 Spirules for shipment to universities and engineers around the world -- 65 countries in all. Over the years she's received a lot of interesting correspondence, including two letters in 1973 from a Philippino Ho Hwa Hui. In the first, he simply asked what a Spirule cost. Mom took it as a typical order and sent him one the same day. He was delighted and included this note with his return payment:

"You have unknowingly given me a two-fold surprise package. First, you sent the Spirule to a complete stranger thousands of miles away without even a guarantee that you'll get paid! Secondly, you are Mrs. W. R. Evans, wife of one of the most respected and prestigious control engineers in the forefront of the W. R. Evans! Of course I don't this highly technical field have to tell you."

Yes, Ho Hwa, you're right. You didn't have to tell her, his colleagues, or the ASME. Today, by bestowing upon him the 1987 Rufus Oldenburger Medal, you recognize him for his method of plotting roots of characteristic equations. My brothers, sister, and I love him for planting in us the roots of character. Both you and we honor the same man, Walter Richard Evans, who today it can truly be said, takes his rightful place among the giants of Control Theory. Congratulations, Dad, and thank you all for coming today to acknowledge what many of us, even Ho Hwa Hui, have known for a long, long time.