

**Title:**           **Control-System Dynamics (1948-1954)**

**Subtitle:**       **Walter R. Evans and the Race to Publish Root-Locus in a Textbook**

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Engineering History Series: The Development of the Root-Locus Method

From research behind *Into Stability: Walter R. Evans and the Story of Root Locus*

**Abstract:**

Published in 1954, Walter R. Evans's Control-System Dynamics represented one of the earliest attempts to present the root-locus method as a central tool for control-system analysis and design. This paper examines the development of that textbook, from Evans's initial agreement with McGraw-Hill in 1949 through a lengthy editorial and review process that delayed publication for several years. Drawing on correspondence between Evans and his editors, the paper explores debates over pedagogy, notation, and the role of mathematical formalisms such as the Laplace transform. It also considers the competitive landscape of early servomechanism textbooks and the rapid diffusion of root-locus concepts through engineering education. The history of Control-System Dynamics reveals the challenges faced by innovators attempting to reshape technical curricula.

**Keywords:**

- Root Locus Method
- Walter R. Evans
- Control System Stability
- Graphical Control Design
- Feedback Control Theory
- Aeronautical Control Systems
- North American Aviation
- Classical Control Engineering



# Control-System Dynamics

## Walter R. Evans and the Race to Publish Root-Locus in a Textbook

In 1948, John Wiley and Sons published *Principles of Servomechanisms* by Gordon Brown and Don Campbell of MIT. It quickly became a landmark text in the field. Meanwhile, McGraw-Hill's distinguished *Electrical and Electronic Engineering Series* had no entry in the rapidly developing field of servomechanisms.

Frederick Emmons Terman, consulting editor of the series, had launched the series with his 1937 book *Radio Engineering*. (Terman is known as the "father of Silicon Valley" because he encouraged his Stanford engineering students to start companies that would create jobs for graduates. Two students who did, Bill Hewlett and David Packard, founded HP in 1939.)

The publisher turned to engineering Professor R. J. W. Koopman of Washington University in St. Louis about writing a textbook on the subject. Shortly thereafter, however, Koopman succeeded Roy Glasgow as department chairman, and progress on a manuscript slowed dramatically. Koopman suggested to McGraw-Hill that they ask a former Washington University instructor, Walter R. Evans, whether he would be interested in writing a book using course notes developed at Washington University, Emerson Electric, and North American Aviation."

On August 2, 1949, McGraw-Hill editor John Wight wrote to Walt: *We have nothing in the way of an immediate prospect which could be considered competitive with the distinguished book by Brown and Campbell. I gather your work would include material both below and above the academic pitch of Brown and Campbell. ...I know that Dean Terman will be most pleased to have an opportunity to look your material over.*

On August 21, 1949, Walt sent sample material to Wight, with a warning that his approach would be unconventional:

*The book's main purpose is to demonstrate the root locus method. The key idea is a simple graphical plot to locate the roots of the characteristic equation ... If the book could be made as competitive as the method itself, ... [we] would be both pleased. Frankly, however, there is a gamble involved for each of us in that books emphasizing the physical picture of a subject are in the minority relative to those for which mathematics predominates. I am personally convinced from teaching*

*General Electric's Advanced Engineering Courses and undergraduate courses at Washington University that the students themselves want the physical picture.*

Both the author and the publisher sought an early completion date. Editor John Wight expressed McGraw-Hill's business goals in an October 1949 letter.

*The Servomechanisms market is growing with great rapidity. There are, as you know, good books already on the market and certainly more will be written. For this reason, we are most anxious to get your book underway and hope you will find the time to finish the manuscript at a reasonably early date.*

On November 1, 1949, Walt signed a contract, already signed by McGraw-Hill President Curtis Benjamin, for a book titled *Control System Dynamics*.

Walt turned 30 on January 15, 1950. He marked the occasion by writing to Wight, suggesting a meeting while in New York for the AIEE winter meeting. There, he was set to present his groundbreaking paper, "Control System Synthesis by Root Locus Method." During their meeting, he estimated that a first draft could be completed by June 1.

Fully committed to the project, Walt set up an office in a neighbor's spare bedroom. Each morning, after pretending to leave with his carpool, he simply walked across Maple Street to his writing space. By mid-June, he had completed a first draft and began revising it with input from colleagues at NAA.

In December 1950, he submitted sample chapters to McGraw-Hill and committed to a full manuscript deadline of March 1, 1951. Initially estimating a 170-page book, he soon realized that with 488 figures, the total length might reach 300 to 350 pages. Concerned about affordability, he hoped the book could be priced at around \$5.00.

McGraw-Hill Editor Ken Zeigler, who had replaced Wight, responded within a week: "We're very pleased with your progress and hope our Editing Department can handle it as is."

By March 1951, Walt knew of three prospective servomechanism books: one by Harold Chestnut, one by Floyd Nixon, and one by George Thaler. Recall that Harold Chestnut had been Walt's supervisor at GE in 1942. Nixon and Thaler sent letters to Walt, informing him of their intentions to have chapters on the root locus method in their books.

Walt had copies of AL-787 sent to them. Nixon and Evans exchanged letters sharing their mutual difficulty of choosing a title. Walt quipped, "*most fellows I know just name the authors and probably couldn't name the title on a bet.*" Thaler's letter included a request: "if it is possible, would you please send me a copy of your notes so I can check my work and extend it." Walt, perhaps seeking a differentiator to provide *Control-System Dynamics* a competitive advantage, proposed bundling the Spirule with his book. McGraw-Hill rejected the idea, citing cost concerns. Zeigler wrote, "It would raise expenses (and thus the book's price) without necessarily increasing sales."

Moreover, time to market was critical. Zeigler told Walt about upcoming books, including works by Ahrend and Taplin, by the aforementioned Chestnut and Mayer, and Thaler and Brown—with the first expected within six months. With competitors crowding in, Walt had to complete *Control-System Dynamics* quickly if it was to establish itself as a leading text on servomechanism design.

### **Spring 1951**

By the spring of 1951, Walt had completed the remaining sections of his manuscript. He also adjusted notation and equations to align with McGraw-Hill's editorial standards. However, he disagreed with Editor Ken Zeigler's stance against including the Spirule.

*Most engineers here at North American Aviation believe it should be enclosed,"* Walt wrote. *"Some have even suggested that readers might resent having to make a separate purchase.*

Two years after signing their Memorandum of Agreement, McGraw-Hill informed Walt that their technical reviewer recommended significant revisions, including the addition of problem sets. Interestingly, the reviewer supported including the Spirule, writing:

*The instrument called the 'Spirule' should probably be included with the text since its use is treated rather fully.*

### **The Laplace Transform Controversy**

Beyond the absence of any problem sets and the problematic Spirule question, the reviewer also questioned Walt's decision to introduce transfer functions without the Laplace transform. But Walt stood firm. He had deliberately avoided

the standard approach, believing that students often memorized rules rather than developing a deep understanding of system behavior.

Consulting editor Frederick Terman tactfully sided with the reviewer:

*The suggestion that the Laplace transform might be used is one that the author should consider seriously."*

In the following week, Walt prepared a defense of his case in an essay he called *An Opinion Concerning the Laplace Transform*. Although it is the most passionate discussion Walt ever wrote about the education process, he had second thoughts about its sharp tone and wired Zeigler to destroy it rather than deliver it to Dean Terman. He kept a copy for himself. In retrospect, its candor contributed to its persuasive power:

*The Laplace Transform is admittedly the simplest way to present many conclusions regarding transform functions; I do not believe however that it is the simplest way for the student to understand them. Of course many students do not seek understanding; show them a routine, assign a few problems for practice, give them a straightforward exam, and they leave the course feeling educated.*

*If however some of the problems are not essentially duplicates of the homework problems, they fail miserably and then complain of the examination as being "unfair." The fault does not lie entirely with the students and not with the Laplace Transform itself, but I do not believe that the above method of education should be encouraged. The graduates of such a system are of little more value to industry with the course than without it. If he has to solve a problem, he must take time to reestablish the routine. If he makes an algebraic error, he may arrive at a ridiculous result without recognizing it.*

*Admittedly there is no foolproof way of presenting a method. I have already had the disgusting experience of having an engineer come in and ask advice on some detailed phase of plotting a root locus plot only to find out gradually that the method had nothing to do with the problem he was supposed to solve!*

*Fortunately however there are many students who make very reliable engineers once they understand the fundamentals of their subjects. I have tried in Chapter IV to present a chain of reasoning which will establish transfer functions and all their properties on the sure foundation of the solution to a few simple differential equations by the classical method of trial and error. This chain of reasoning led to*

*the development of Root Locus and it has often been of value in explaining the method. If the method of presentation is poor, I would surely appreciate criticism; but to substitute the Laplace transform in my present state of understanding of it would be unfair to the conscientious student for whom the book is intended.*

Concerned about the sharp tone of his argument, Walt wired Zeigler, instructing him to destroy the essay before delivering it to Terman. However, he kept a copy for himself. Two weeks later, he sent Terman a softened version of his position, citing examples of students' struggles with the Laplace transform and how it hindered their problem-solving abilities.

As Thanksgiving 1951 approached, two years after Walt signed the Memorandum of Agreement, the fate of *Control-System Dynamics* remained uncertain. Would McGraw-Hill continue with the project, or would they favor the competing servomechanism manuscript by Thaler and Brown? The publisher's technical reviewer had criticized Walt's presentation as unconventional, and doubts lingered about including the Spirule. Two days before Thanksgiving, Zeigler offered encouragement:

*We have received praise of your ability from several sources recently. The comments we have heard support the confidence we have placed in your successful completion of the project.*

Ten days later, Zeigler relayed Dean Terman's assessment:

*Evans' viewpoint on the Laplace transform is a perfectly reasonable one. I think that some explanation about the place and usefulness of the Laplace transform and alternative methods should be incorporated somewhere in the book. If this is done, and Evans then wishes to leave out the Laplace transform completely, I would say fine and proceed on that basis."*

Terman's endorsement reinvigorated both Walt and McGraw-Hill, providing the momentum needed to move forward. The AIEE Annual Conference was scheduled for December 6–7 in Atlantic City. Walt proposed an in-person meeting in New York on December 5. It would be his first opportunity to meet Zeigler and other members of the editorial team. In his letter, he once again raised the question of including the Spirule:

*The matter of enclosing the Spirule in the back cover of the book should perhaps be decided now, or at least all the facts presented. I'll bring several with me, also.*

In New York, Walt met the two men most involved with his book—Ken Zeigler and Jeff Norton, whom Zeigler had assigned as editor. Walt's handwritten notes from their meeting suggest that all parties anticipated an early 1953 publication, with an initial print run of 2,000 to 3,000 copies. However, after considering that including the Spirule would raise the book's price by \$1.50, Zeigler once again advised against it.

Walt's notes reflect the final decision, "Recommends I sell it separately (may make as much as from royalties)." With that, the Spirule matter was settled.

Perhaps the clearest explanation of Walt's motivation for writing the book is found in a January 1952 letter to Professor Elias Sabbagh of Purdue University. Walt had sent him a draft copy of the textbook upon learning from NAA recruiter Ray Hamada that Sabbagh was "building up a strong servomechanism program." In the letter to Professor Sabbagh, Walt shared his own experience.

*The first observation in seeking to teach the root locus idea to engineers at North American was that far too many recent graduates had learned a routine for use of the Laplace transform or for making logarithmic plots but had little understanding of what they were doing. ... I decided to go all the way back to the basic fundamentals including even the basis for the choice of 'e.' The subject is then developed until the final problem is that of manipulating determinants in order to study the effect of various coupling effects in the roll-yaw motion of an airplane. Frankly the root locus idea is primarily just an excuse for writing a book in which physical concepts are dominant with mathematics secondary. There are also many criticisms that the book has too many 'novel explanations,' but I have long ago learned that you can't please everybody.*

The prospects for *Control-System Dynamics* seemed bright as the winter of 1952 transitioned into spring. Walt had completed all the revisions requested by Dean Fred Terman. To his pleasant surprise, the first Spirule production run of 513 quickly sold out, defying his expectation that strong book sales would be the key to strong Spirule sales.

When Arline and Walter celebrated their 10<sup>th</sup> wedding anniversary on April 11, they had another cause for celebration—Arline was about to enter her third trimester with a mid-July due date for their third child. However, when Arline's blood pressure spiked in May and she was hospitalized, her health became Walter's only concern. When a scathing review of his manuscript arrived from

McGraw-Hill publishers on June 5, he set it aside. At Murphy Memorial Hospital in Whittier, doctors, concerned for her health, decided to deliver the baby weeks before its July due date. On June 12, Arline delivered a 5 lb. 4 oz baby girl, Nancy Arline Evans. To Arline and Walter's great relief, the premature baby proved to be healthy. Arline recovered rapidly.

As for the scathing review that had arrived a week before Nancy's birth, McGraw-Hill's Ken Zeigler wrote, "I am afraid that you will find his comments rather disappointing. It may be that he is a particularly severe critic. The reviewer expressed his high expectations after meeting Walt.

*His personality and his ability to think quickly have made a favorable impression at professional meetings. He has recently been appointed a member of the AIEE Committee on Feedback Control Systems. Because of this personal background, I looked forward to seeing a text by Mr. Evans.*

Following those positive comments, he wrote: *The basic conclusion of my review is that this book, if published in present form, would not do justice to the author's reputation. ... It is not an easy task for a technical industrialist to find time to write a book. It is also difficult for someone as steeped as I in the field to review such a book with the proper perspective. While I think a stranger to the control field with only a general technical background would have a very difficult time with Mr. Evans' presentation, I am not at all sure of this. I am quite sure, however, that a scholar in the field would find too little new in this book by Mr. Evans.*

Walt, who had surely reassessed his priorities after Arline's health scare, dismissed the criticisms in a June 24 response to Ken Zeigler:

*The [critic's] comments ... are not surprising; the disappointment to me is the time consumed in receiving reviews by one critic after another. The style and presentation have been set by five years of study and teaching in the General Electric Advanced Course, in which the prime object was understanding rather than rigor or elegance.*

McGraw-Hill had made clear that, to secure university adoptions, the book needed to be available by the spring of 1953, when professors would decide on textbooks for the fall semester. Zeigler, after consulting Dean Terman, instructed Walt to address the reviewer's most essential concerns to avoid further delays.

But Walt's priorities had changed. Three months came and went. *Control-System*

*Dynamics* missed the deadline for fall 1954 course selections. Perhaps Walt felt he had short-changed his responsibilities as husband and father too many times in the last five years revising manuscripts to satisfy reviewers and critics at the AIEE and McGraw-Hill. Shortly after he submitted his revision, it came back in November with instructions to retype portions of it.

Walt may have missed its deadline, but other authors had met theirs, including George Thaler at McGraw-Hill. In 1953, McGraw-Hill's *Electrical and Electronic Engineering Series* published his book as its first servomechanism textbook. Its "Chapter 14 The Root Locus Method" was based in part on the AL-787 report Walt had sent Thaler in March 1951. However, the book never once mentions Evans by name. The omission of "Evans" was never an issue for Walt. He read Chapter 14 and sent Thaler improvement suggestions for future book printings. Thaler became one of Walt's most prominent supporters. After Walt's 1987 Rufus Oldenburger Medal ceremony, Arline wrote to Thaler: "I wish to thank you for all your efforts on Walter's behalf."

On February 6, Walt sent the retyped manuscript via Railway Express. His cover letter ended with a familiar refrain:

*I hope that you will now find the manuscript completely satisfactory*

But instead of final approval, McGraw-Hill's new copy editor, Jeff Norton, redirected Walt's attention to minutiae—particularly the rules for hyphenation. Norton insisted on inserting a hyphen between *Control* and *System* in the book's title and between *root* and *locus* when referring to the *root-locus method*. With no fight left in him, Walt readily acquiesced.

Unsatisfied with some of Walt's sentence structures, Norton also suggested that he share in the \$200 cost of the copy editing. More delays followed. The copy editor fell ill for an entire month, stalling progress further.

Meanwhile, Walt faced a deadline for a new root locus paper targeting problems of interest to mechanical engineers. The urgency that had once driven both Walt and McGraw-Hill had long since dissipated. As 1953 ended—four years after the project's inception—*Control-System Dynamics* remained unfinished.

On February 19, 1954, the manuscript was finally sent to the printer. Galley proofs arrived in mid-April, and by September 30, the first printing of 2,500 copies was distributed. McGraw-Hill advertised the book extensively, with promotional

materials appearing in technical journals and trade publications.

In the preface of *Control-Systems Dynamics*, Walt expressed gratitude for the education he had received.

*The author is grateful to Profs. Roy S. Glasgow and Frank W. Bubb, both formerly of Washington University in St. Louis, for their emphasis on understanding rather than superficial knowledge. The General Electric Advanced Engineering Program continued this emphasis, furnished extensive practice in the solution of problems, and provided association with such fellow students as G. E. Walter.* <sup>29</sup>

He also credited Paul Profos of Switzerland, for his initial inspiration, writing: “Specific references are given, [such as] the basic paper by Paul Profos on conformal mapping to find roots.” <sup>29</sup>

On November 28, 1954, Kenneth Zeigler wrote to Walt requesting corrections for a second printing. Walt responded on December 11: “The news that the total requirement for Control-System Dynamics might exceed 2,500 by the time second-semester orders are placed is the biggest surprise that I have had for years. ... Please have 12 (books) sent (to me) as quickly as possible because I want to send some of them out at Christmas.”

Walt had mixed feelings about his publishing experience. He was satisfied that the book was heading for a second printing. Yet, in one of the books he sent as gifts, he wrote to his brother and sister-in-law

*Dear Sam and Betty, If Mrs. Levy, my English teacher at Soldan High had had to approve this book—it might never have been published.”* He then added a more somber comment. *“It’s too bad when you reach a goal like this, it doesn’t seem worth reaching as much as when you started. Your lil brother, Walt.*

Despite a promising start, *Control-System Dynamics* soon faced stiff competition. By 1955, multiple textbooks had adopted and expanded upon the root locus method, limiting the book’s impact. Sales declined, and between 1954 and 1957, McGraw-Hill sold approximately 5,000 copies. McGraw-Hill found that most sales came from outside the academic market.

*Comments I have received on the book are: “‘too brief’ and ‘excellent after you already understand the subject’! “I was amazed in teaching the course again how much students want to have every step detailed for them. The unfortunate thing is*

*they won't get problems that clear cut in industry and had better get into the habit of filling in the details.*

Walt remained proud of his book, which emphasized practical understanding and built upon principles learned from his mentors. In February 1955, his Washington University professor, Frank Bubb, now Chief Scientist, Office of Air Research, Wright-Patterson Air Force Base, having received one of the copies Walt had sent as gifts, wrote both to thank Walt and to express his support for the pedagogical approach Walt had taken in the book.

*It seems to me that anyone who undertakes an exposition of systems analysis and synthesis should not only explain the mathematical technique but also show how to attain true understanding.*

*I have debated this issue with Stark Draper, Gordon Brown, Bill Ahrendt, and others. Most of them argue that understanding comes through some mysterious process of osmosis alongside diligent application of design techniques. This is, of course, pure rot.*

*A sufficient number of parallel discussions—one in the time domain, the other in the transform domain—can bridge this gap. ... Your book's instructive parallel discussions are commendable...I am sorry that none of them asked me to review your book. I really would have spread it on.*

Walt expected textbook sales to drive the acceptance of the root locus method. It did not, nor need it have. By 1954, the root-locus method had already secured its place in history. Events outside Evans' control made the book's disappointing sales irrelevant to the acceptance of his method.

The March 1950 publication of Walt's paper in AIEE Transactions precipitated a virtual avalanche of papers—some important extensions, some merely derivative. By one count, Walt's paper had been cited in 61 others by 1957. In 1951, the Institute of Aeronautical Sciences scheduled an entire session at its annual conference in Los Angeles to discuss the root locus method.

The impact of the September 1951 publication of Dr. William E. Bollay's 14th Wright Brothers Lecture, originally given on December 16, 1950, at the Institute of Aeronautical Sciences in Washington, D.C., cannot be overstated. Bollay, founder and head of the Aerophysics Laboratory at North American Aviation, was a nationally known and respected figure. He was in a position to influence

perceptions about root locus across the entire aerospace community. In preparation, Bollay stayed late at NAA and met with Bill Mullins to understand the root locus method thoroughly.

Dr. Bollay began his remarks on his topic, "Aerodynamic Stability and Automatic Control," with words chosen to get the attention of the audience.

*The practical achievement of satisfactory stability and control is probably the greatest contribution of the Wright Brothers in the development of the airplane. ... At present, the airplane is going through another period of transition similar to that a half-century ago. ... Probably the major development in aircraft stability in the past 10 years has been the evolution of analytical and experimental techniques that permit an engineering calculation of the motion of an airplane when under the control of an autopilot. ... The principal techniques that have made this development possible are the following: ... The graphical methods of analyzing the dynamic performance of a system, particularly the diagrams associated with the names Nyquist, Bode, and Evans.*

There it is! The equal billing Walt received referred to a March 1952 letter to friend Jack Clark, "[Bollay] gave root-locus billing in parallel with the classical stuff, and that really got it started."

Uncommented upon by Walt, but more significant to the flying public, was the "billing in parallel" Bollay gave these three little-known engineers with the legendary Wright brothers. Viewed in their entirety,

Dr. Bollay's opening remarks on December 16, 1950, may be summarized as follows: Harry Nyquist, Henrik Bode, and Walter Evans deserve recognition for ensuring the stable flight of high speed aircraft, just as Orville and Wilbur Wright deserve the recognition afforded them for ensuring stable flight on low-speed aircraft.

But Bollay did not stop there. He then compared the relative utility of Walt's root locus method to the analysis methods of his two servo-analysis "siblings."

*The Evans root-locus method presents directly a complete picture of the stability and transient response characteristics that are most important ... The root-locus gives the roots of the closed-loop system directly and by a simple calculation, the transient response. The degree of stability can be read from the root-locus directly. Complicated systems can be set up in such a fashion that the effect on*

*transient response and stability of changing any parameter can easily be visualized. There is no ambiguity in the interpretation of plots even for complex systems having any number of roots and poles in the right or left half plane.*<sup>26</sup>

When Bollay's December 1950 Wright Brothers Lecture appeared in print in the September 1951 Journal of Aeronautical Sciences, it did more than put the root locus method on the map. *It put it on a mountain top!*

In 1953, McGraw-Hill published *Servomechanism Analysis* by Thaler and Brown, Two years later, Wiley came out with *Automatic Feedback Control System Synthesis* by John Truxal. Prentice Hall, VanNostrand, and the aforementioned published still more textbooks in the 1950s and 1960s, all with a chapter on root locus. Many college bookstores soon followed the example set by UCLA and UC Berkeley, where Joe Beggs and Otto Smith required use of Spirules in classes.

And so, as it turned out, sharing his servomechanism course notes in 1951 with George Thaler, John Truxal, and Floyd Nixon was not only generous, but it was also smart business. In Frank Bubb's words, these three men "spread it on."

To cite one example, John Truxal's textbook stated, "among the many methods presented, the root-locus approach stands out, for it combines the theoretical advantage of simultaneous control over both transient and frequency responses of the system with a strong appeal to the designer, an appeal that derives from the simplicity of the method as well as the logic of the underlying the approach."

Prospective textbook authors today face the same truth Evans faced -- no book can substitute for a creative, one-on-one relationship between teacher and pupil. The mysteries of the educational process fascinated Walter Evans for years after he had written *Control-System Dynamics*. In a 1965 letter to Professor Roy Glasgow on the occasion of Glasgow's retirement as Dean of the Naval Postgraduate School, Evans summarized his observations:

*Thinking about our four children, it seems to me that 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. This function looks like that of a coach using the whole gamut of psychology to get each new class of rookies off the bench and into the game.*

About this Paper:

This paper is derived from research presented in *Into Stability: Walter R. Evans and the Story of Root Locus* (Evans, 2025) and examines the historical development of the root-locus method within the engineering culture of the early Cold War.

About the Author:

Gregory W. Evans is a graduate of the California Institute of Technology (1969) and Stanford University (1975) and served as a Distinguished Technical Fellow at TRW. He is the author of *Into Stability: Walter R. Evans and the Story of Root Locus* (Evans Heritage Press, 2025) and is the son of Walter R. Evans.

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