7 the lower horizontal line represents the initial value of the variable, while the upper horizontal line represents the set point. Fig. 3 shows an offset, representing the behavior of the system with proportional control, and Fig. 4 shows more oscillatory response as the sampling frequency was increased. Fig. 5 represents the response with P-D control, showing better response over proportional control. Fig. 6 shows no offset with P-I control while Fig. 7 represents the response with

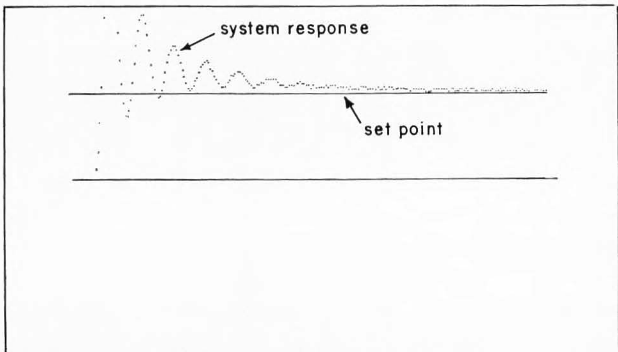

FIGURE 7

P-I-D control. The best response is clearly obtained with P-I-D control.

Another point to be taken into consideration is that a complex mode of control requires more amplifiers than can be provided by a small analog computer. This difficulty can be overcome by hooking up a digital computer together with it. In fact, there is no end to the modes of control that can be simulated by a digital computer used in conjunction with even as small an analog computer as an EAI-20.

ACKNOWLEDGMENT

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ChE book reviews

THE MATHEMATICAL UNDERSTANDING OF CHEMICAL ENGINEERING SYSTEMS— SELECTED PAPERS OF NEAL R. AMUNDSON

Edited by R. Aris and A. Varma
Pergamon Press, 1980. 830 pages

Reviewed by John H. Seinfeld
California Institute of Technology

Neal Amundson has exerted a profound influence on the course of modern chemical engineering. As virtually a lone pioneer in the late 1940's and early 1950's, he opened the frontier of the mathematical understanding of chemical engineering systems. Although legions have rushed in behind him, a vast number of the Chief's own papers remain the seminal milestones along the path that has led slowly and steadily to a rigorous mathematical description of chemical engineering processes. This volume, prepared with love and care by Rutherford Aris and Arvind Varma, is a Baedeker for the traveller retracing that path.

Of over 2000 pages of Amundson's published papers, Aris and Varma have selected 800 for reprinting. For those papers not reproduced in their entirety, leading pages, with the usual abstract, and sometimes pages containing conclusions or summarizing statements, are included. The scope of the papers is impressively broad, including major contributions in ion exchange and chromatography, distillation, chemical reactor stability and control, polymerization reaction engineering, the modeling of fixed and fluidized bed reactors, steady state uniqueness and multiplicity of catalyst particles and chemical reactors, and the combustion of single carbon particles.

The modeling of physical systems is, as Aris has noted, an art and a craft, and Neal Amundson stands as the senior artist and craftsman in the modeling of chemical engineering systems. In his analysis of complex systems Amundson has always sought the mathematical description that captures the fundamental essence of the system's behavior, the art of selecting the proper balance between simplicity and reality. Once a model has been chosen, the elucidation of its properties can be attacked with all the heavy machinery of mathematics, the craft of the modeler. This

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minute talk which is required of one of the two assistants for each of the first six experiments and of the group leader for the last two. Thus, each student presents at least three and perhaps four talks over the two quarter sequence. Heaviest use of the Communications Project tutors is made in this phase of course activity, e.g. in 1979-80 there were three speaking tutors for a class of 29 students. The student presents his talk first to the speaking tutor individually and then to the entire class during one of the two weekly lecture periods. Immediately after the presentation, questions of a technical nature are posed by the general audience. Then two previously selected class members give oral critiques of the communications aspects of the talk. Finally, each faculty member, teaching assistant, speaking tutor and student evaluator fill out grading forms on the structure of the talk, use of visual aids, delivery and technical content. A summary of these written evaluations is given to each student.

Although the course is only two years old, it has become a focal point for the synthesis of other elements of the undergraduate program. It differs appreciably, however, from the orientation of the traditional engineering courses, which typically emphasizes mastery of the technical aspects of a subject. Although development of sound experimental technique is certainly one of the course objectives, the final course grade depends to a substantial degree on the ability of the student to communicate the results of his laboratory efforts. The selection of a laboratory course as the vehicle to teach communication skills is particularly appropriate for engineers. The class format is designed to present students with varied requirements which are closely analogous to what they will experience in their professional employment. Perhaps the most important skill learned is the ability to present results and conclusions clearly and concisely in a short written progress report or oral presentation. Rarely will supervisors or, especially, managers have the time for more extensive discussions during the interim status review of individual phases of an overall design project, for example. However, in the final documentation of the design for internal or external distribution, the ability to organize large amounts of data, design calculations and recommendations becomes essential. The major report format is directed toward this objective. Two pedagogical features of this course bear special note. These are the emphasis on rewriting of graded written reports, which is the rule rather than the exception, and the use of tutorial sessions for advance preparation on the oral talks and followup analyses of the written reports. Only through a clear understanding of his deficiencies and extensive practice will the student develop the desired facility in expressing his ideas and describing his achievements. □

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2. For more information contact Ms. Ellen W. Nold, Director, Communications Project, School of Engineering, Stanford University, Stanford, CA 94305.

REVIEW: AMUNDSON

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volume contains many examples of Amundson the artist and Amundson the craftsman.

Although a number of the papers in the collection appear in a condensed form in textbooks, the original papers are a preferable source. Many are important references for graduate-level courses in chemical engineering. The polymerization papers with Liu, Warden, Zeman, and Goldstein are, for example, required reading in a course on polymerization reaction engineering. (During my graduate study in 1965, I spent a summer in industry studying and applying these papers to the modeling of a polymerization reactor.) Material in the papers on the single catalyst particle and on tubular and packed bed reactors has permeated most graduate-level courses in chemical reaction engineering and is ideal supplementary reading for students.

At a price of more than $100, the volume unfortunately lies outside the budget of many who would greatly benefit by its presence in their personal libraries. No academic or industrial chemical engineering department should be without at least one copy of this book. For those engaged in or embarking on a career of research that involves the mathematical modeling of chemical engineering systems, the collected wisdom of much of Neal Amundson's incomparable career is well worth the personal investment. □

In Memoriam

LLOYD A. SPIELMAN

Lloyd A. Spielman, 42, Professor of Civil and Chemical Engineering at the University of Delaware, died on March 26 in Newark, DE.