human being can get to 1/2 HP. For slow lifting the power is less.

- The air resistance of the bicycle and man is very complex with pumping legs, but the equivalence to a short cylinder is not a bad assumption, though the drag coefficient may be high.
- At rest a man breathes about 0.007 m^3/min. A few people can get to 0.12 m^3/min, but this appears to be a maximum. The bicyclist in Denver is averaging 0.085 m^3/min, which is 12 times that at rest.
- Some doctors feel that 3/4 pound glucose is the most a body can handle in an hour. This leads to efficiencies of the body as a thermodynamic machine up in the 30% range, or too much glucose will be required, not to mention air. In New York the bicyclist is burning up a little more than one-half pound of glucose in an hour. □

ASEE SUMMER SCHOOL FOR CHE FACULTY

REQUEST FOR INFORMATION

There have been eight ASEE Summer Schools for Chemical Engineering Faculty to date, but complete records only seem to exist for the 1977 and 1972 schools. T.W.F. Russell and S. I. Sandler, ChE Department, University of Delaware, Newark, DE 19711, the directors of the 1982 Summer School are writing a history of the summer schools and badly need any information our readers may possess. They are particularly interested in the following:

- **Date of the summer school, location, and directors.**
- **Program and those presenting it.**
- **Number of participants and number of schools represented.**
- **Budget details.**
- **Any documentation, final reports, correspondence, etc., particularly with regard to the early efforts in 1931 (Univ. of Michigan) and 1939 (Penn State).**

REQUEST FOR FALL ISSUE PAPERS

Each year CHEMICAL ENGINEERING EDUCATION publishes a special Fall issue devoted to graduate education. This issue consists mainly of articles on graduate courses written by professors at various universities, and of advertisements placed by ChE departments describing their graduate programs. Anyone interested in contributing to the editorial content of the Fall 1979 special issue should write to the Editor indicating the subject of the paper and the tentative date the paper can be submitted. This information should be sent to Ray Fahien, Editor, CHEMICAL ENGINEERING EDUCATION, c/o Chemical Engineering Dept., University of Florida, Gainesville, Florida 32611.

ChE book reviews

OPERATIONAL AMPLIFIERS IN CHEMICAL INSTRUMENTATION

By Robert Kalvoda, Ellis Horwood Limited, 1975.
Reviewed by Kenneth R. Jolls
Iowa State University.

Dr. Kalvoda's book provides a relatively brief but sufficiently thorough discussion of the operational amplifier, particularly as its use pertains to electroanalytical instrumentation. For the chemical engineer to whom modern electronics has become important in his experimental work, control studies, or computer automation, the operational amplifier is an invaluable tool. It has become so much the "black box," however, that many of us lose sight of its limitations, its nontypical applications, and the ways in which its functions may be modified through external circuitry. This book attempts to cover these areas as well as the more familiar ones.

The book is organized into eight chapters as noted below:

- **I. The General Scheme of the Measuring Apparatus**
- **II. The Operational Amplifier—an Introduction**
- **III. Basic Operational Amplifier Circuits**
- **IV. Further Circuits Using Operational Amplifiers**
- **V. Important Parameters in Application of Operational Amplifiers**
- **VI. Types of Operational Amplifiers**
- **VII. Applications of Operational Amplifiers in Chemical Instrumentation**
- **VIII. Operational Amplifier Module Kits**

Chapter I describes the usual signal processing scheme encountered in instrumentation. Chapter II provides a brief history of the OA and some of its important macroscopic characteristics. A detailed analysis of the external feedback circuitry used to implement operational amplifier functions is presented in chapter III. The current follower is explained with emphasis being given to the concepts of virtual ground and input impedance. The inverting voltage amplifier naturally follows and is discussed in terms of its transfer function dependence upon resistance ratios and signal frequency. Non-inverting circuits including the simple follower and follower with gain are described in adequate detail, and their higher input resistances are noted. Several configurations of differential amplifiers are discussed as are a number of OA circuits for precise voltage and current sources.

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BOOK REVIEW: Amplifiers

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The all important operational amplifier integrator is explained briefly along with several device parameters that influence the quality of the integration. An excellent discussion of the OA differentiator is given with an example of a practical circuit to control frequency response. Figure 3-25 presents the gain function during either integration or differentiation in a manner that readily characterizes the response of the circuit. The remainder of chapter III treats logarithmic circuits and the operational amplifier comparator.

Somewhat less familiar OA circuits are described in chapter IV. The use of zener diodes to produce limited or otherwise bound circuits is noted followed by a brief description of constant amplitude phase shifting. Operational amplifier active filters for passing or rejecting selected frequency bands are discussed, and commercially available units are listed. The rectification of low level ac signals and its use in phase-selective detection are also treated for OA-based circuits. The chapter concludes with a discussion of function generators and oscillators, sample-and-hold circuits for analog memories, and operational amplifier regulators that offer PID action. I found a surprising lack of figures to support the rather complex ideas introduced in this chapter, and I frequently had to sketch the circuit myself in order to follow the author's reasoning.

Chapter V deals with the extensive and often subtly differentiated list of parameters that characterize modern operational amplifiers. Offset and drift along with circuit models of these effects, circuits to measure them, and circuits to compensate for them are presented in excellent detail. Difference amplifier properties are also noted. Noise that originates both within the operational amplifier and from external sources is discussed and classified as to frequency. Several standard techniques for minimizing the noise problem are suggested. A rather lengthy section on frequency response, dynamic properties and amplifier stability completes the chapter. Some of this material would be tedious for the non-electrical engineer, but certain properties such as unity gain bandwidth, slewing rate, and full power response need to be understood.

Chapter VI lists the specifications of several commercial operational amplifiers (current to 1975) and distinguishes between bipolar and FET-input units. Other specialized devices that are discussed include the chopper-stabilized, electrometric, programmable gain, and the so-called instrumentation amplifiers. Again, a more liberal use of figures would have made the reading go more rapidly.

Chapter VII is devoted to applications mainly in the field of electro-analytical chemistry. It provides an excellent review of the ways in which these interesting and powerful devices have been used to control, detect and measure physicochemical properties in systems that also concern chemical engineers. The applications cited are well referenced to the literature and provide a broad base for further utilization of operational amplifiers in chemical instrumentation.

Chapter VIII discusses some of the commercially available modular OA systems that permit the user to construct his own OA-based instrumentation array. Unfortunately, the Malmstadt-Enke system is no longer available as noted, but to my knowledge, the other American-made systems can still be obtained in a form similar to that described. With the wide availability of both discrete component and integrated circuit operational amplifiers in today's electronics market, many educators and experimentalists are assembling their own modular systems with excellent results.

For the experimentally oriented chemical engineer who deals with chemical instrumentation and who feels the need to understand the applications of operational amplifiers in detail, this book provides excellent resource material, and I certainly recommend it. For the most part its content is well within the grasp of any engineer, scientist or educator with a modest background in basic electronics, and the nearly 200 references to the literature permit considerable study beyond the scope of the book. Since the book is oriented to applications in electrochemistry, the chemical engineer would occasionally have to reapply the same operational amplifier principles to systems more common to his own work.

The translation from the original Czech is generally well done. One occasionally finds a non-idiomatic expression or a term that has been translated too literally. There are very few actual errors and a correspondingly small number of typographical errors. More figures would have helped in the comprehension as well as certain repeated figures that would save the reader from constantly paging back through the text. My overall impression of the book is quite good, and I think the author has done an excellent job. □