# CHEMICAL ENGINEERING PROGRESS SYMPOSIUM SERIES ABSTRACTS

*The Chemical Engineering Progress Symposium Series is composed of papers on specific subjects conveniently bound in individual books, which are published at intervals. The books are 8½ by 11 inches, paper covered, and cost $4.00 to members, $6.00 to nonmembers for "Heat Transfer—Storrs," No. 30, and $3.75 to members, $5.75 to nonmembers for "Advances in Computational and Mathematical Techniques in Chemical Engineering," No. 31. They may be ordered from the Secretary's Office, the American Institute of Chemical Engineers, 25 West 45 Street, New York 36, New York.*

*The A. I. Ch. E. Journal will publish, from time to time, abstracts of the articles appearing in the Symposium Series volumes. Recently published volumes are abstracted below.*

**HEAT TRANSFER—STORRS, Vol. 56, No. 30, 1960.**

**Organization of Heat Exchanger Programs on Digital Computers,** J. J. Taborek. Published reports on heat exchanger computer programs show solutions of only a limited number of the various cases possible. A complete program should include all possible variations among construction types; shell and tube, double pipe, air coolers, plain or finned tubes; various types of heat exchanger processes: no phase change, condensation with desuperheating or subcooling inside or outside tubes on horizontal or vertical condensers, partial condensation, and vaporization; problem formulation: new equipment design for economic optimum or to engineering specifications, and performance evaluation of existing equipment. The difficulties in programing however increase rapidly with greater versatility of the program, especially on computers with limited memory storage. Program completeness was therefore studied from economic aspects. The direct savings on manpower through computer use will be of secondary importance to the benefits resulting from economic optimization of designs and the increased computing speed. The differences in the engineering analysis between the manual calculation methods and the form required for computer programs are pointed out, and the development of equations with general applicability is shown. The program organization is based on a method by which the program is subdivided into executive routines, which perform only nonrepetitive calculations and keep the program constantly under control, and subroutines, which are repetitive calculation groups forming building blocks of the various programs. This system results in great flexibility, saves coding work, and permits eventual changes to be made in the program without disrupting the rest of it. Finally principles of the internal program automation are discussed. **Heat Transfer with Molecular Sieve Adsorbent: I. Effective Thermal Conductivity,** B. D. Phillips, F. W. Leavitt, and C. Y. Yoon. Effective thermal conductivities in beds packed with molecular-sieve pellets have been measured for both stagnant and flow conditions. Several gases have been studied to investigate the effect of gas thermal properties. These data are correlated by a method which takes into account superficial gas mass velocity, gas thermal conductivity, and gas heat capacity. Operating at steady state made it possible to measure effective bed thermal conductivity with adsorbate on the packing. Appreciable quantities of adsorbate were found to have no significant effect on the effective thermal conductivity. The correlation method is found to predict results obtained with adsorbable gases. **Heat Transfer with Molecular Sieve Adsorbent: II. Heat Transfer to a Packed Bed from Finned Tubes,** B. D. Phillips. A method is derived which allows prediction of point-to-point temperatures within packing which is heated by a bundle of finned tubes, once the conductive properties of the packing and the effective heating radius of a finned tube are known. From data collected with single tubes, surrounded with molecular sieve pellets, it was possible to determine the effective heating radius. Data are presented to show the effect of tube temperature and gas mass velocity on the heating rate. **Heat Transfer in Baffled, Jacketed, Agitated Kettles,** Gary Brooks and Goug-Jen Su. The effect of baffles on the kettle-side film coefficient for heat transfer was studied on a 30-gal. Pfaudler type-202 tank, with a six-blade flat-bladed turbine impeller mounted centrally for agitation. Tests were made with 0, 1, 2 and 4 baffles. The fluids used provided data covering the range of Reynolds numbers from 30 to 5 x $10^5$. Tests were of the batch type for both heating and cooling, and data were interpreted by means of a modified Wilson plot. The results show that in the turbulent region the addition of baffles increases the kettle-side film heat transfer coefficient by 37%. The increase was independent of the number of baffles inserted. No differences were observed between baffled and unbaffled tests in the viscous and transition ranges. This investigation presents the first reported data for the effect of baffles on heat transfer coefficients in turbine-agitated systems. **Heat Transfer to a Single Cooling Tube in a Moving Bed Reactor,** D. J. Loudin and K. O. Beatty, Jr. Heat transfer to a single cooling tube placed across the diameter of a moving-bed column was measured during pilot plant reduction of uranium trioxide to uranium dioxide. Thermal resistance on the bed side of the cooling tube is approximately two thirds of over-all resistance between the bed and cooling air in the tube for zero air flow through the bed and is of the order of one fifth of over-all resistance with hot air flowing through the bed. Heat transfer coefficients on the bed side of the tube are severalfold greater than those which would be predicted for air flow past a single tube in the absence of solid particles. The heat transfer rate was not materially affected by the low solids velocities employed. The heat transfer studies were made in a 13½-in. I.D. moving-bed column during countercurrent flow operation. Partially hydrated uranium trioxide pellets ¼-in. in diameter passed downward approximately 2 ft./hr., while hot air passed upward through the pellet bed at zero to about 1,200 lb./hr. Air metered at room temperature was passed through the ½-in. stainless steel cooling tube at 50 to 100 ft./sec., and heat transfer rates were determined from the inlet and outlet temperatures of the metered air stream. **Heat Transfer to Sodium-Potassium Alloy in Pool Boiling.** Neils Madsen and C. F. Bonilla. Film coefficients are presented for sodium-potassium-alloy (44 wt.%) boiling on a horizontal surface. The heat transfer at the boiling surface was calculated by subtracting the heat loss to the surroundings from the electrical input to the heater. Temperatures in the boiling liquid and the vapor space above it were also determined. The best temperature differential for computing the heat transfer coefficients was found to be the difference between the boiling surface temperature and the equilibrium boiling point of the sodium-potassium at the pressure of the vapor

space. A correlating equation was derived statistically for heat velocity as a function of pressure and temperature differential. **The Thermal Conductivity of Several Plastics Measured by an Unsteady State Method,** W. M. Underwood and R. B. McTaggart. A method of measuring the thermal conductivity of solids and very viscous liquids, based on the temperature rise with time of a line source of heat, has been adapted here to measurement of the thermal conductivity of plastics. Simple equipment to be found in most laboratories, is used, and the cost of the element in the sample is negligible. The test, which may be performed in a few minutes at any desired temperature level, is very accurate. Values are given for polystyrene and polyethylene over the temperature range of 40° to 400°F. Values are also given for foamed polystyrene of various densities at room temperature. **Heat Transfer from Fine Wires and Particles by Natural Convection,** T. Tsubouchi and S. Sato. The specimens studied in this paper were fine horizontal wires, including the Wohrastone wires, and fine thermistor particles approximately spherical. The experimental formula for particles not only satisfies the experimental data at low Grashof numbers, but its applicable range may be extended to moderate values of Grashof numbers in laminar natural convection. **Heat Transfer Between Single Particles and Fluids in Relative Forced Convection,** T. Tsubouchi and S. Sato. Results are reported for the cooling of small stationary approximately spherical particles by air in forced convection. Thermistors were used as the particles, a very convenient device, especially in the case of small Reynolds numbers. The general case of separate or simultaneous forced and natural convection at a sphere is given by an equation, in which in particles that are approximately spherical the diameter is replaced by 6 (volume/surface).

**ADVANCES IN COMPUTATIONAL AND MATHEMATICAL TECHNIQUES IN CHEMICAL ENGINEERING, Vol. 56, No. 31, 1960.**

**Undergraduate Training in Chemical Process Dynamics,** D. E. Lamb. The need not only for specialists in process dynamics and process control but also for chemical engineers working in production, design, and process development with an understanding of the unsteady state behavior of chemical process equipment can be expected to increase as the advantages of such training become more apparent. Establishment of undergraduate courses in process dynamics and integration of

unsteady state concepts with existing chemical engineering courses can help to meet this need. **Some Applications of Statistics to Experimentation,** J. S. Hunter. Some of the statistical techniques of design of experiments and analysis that fall under the general heading of response surface methodology are reviewed here, with particular emphasis on the sequential use of these techniques and on the contributions of Dr. G. E. P. Box. A single simple illustrative example is used throughout the paper. **Methods of Handling Nonideal Vapor-Liquid Equilibria in Digital-Computer Distillation Programs,** N. G. O'Brien and R. L. Turner. Techniques are described which permit digital-computer distillation-column routines to handle a large number of the nonideal systems of components encountered in chemical process distillation separations. The treatment of thermal property data for a plate-to-plate heat balance for simple systems is also described. **Application of a General Purpose Analogue Computer in the Design of a Cooler Condenser,** R. G. E. Franks and N. G. O'Brien. The analogue computer offers a different approach to the problem of computing the performance of a cooler condenser than do the manual or digital computer techniques. The specific calculation described in this paper is that of cooling a saturated vapor mixture in the shell side of a horizontal condenser. **Design and Analysis of Gas-Gathering Systems by Digital Computation,** Bill L. Giles. This paper describes general aspects of design and analysis programs, including several developed computing techniques. These include method of system description, method of loop balancing, and method of determining optimal pipe sizes. **Digital-Computer Solution of Gas-Distribution-System-Network Flow Problems,** D. V. Kniebes and G. G. Wilson. This paper discusses numerical methods of solving gas-distribution-system-network flow problems, a digital-computer program for their solution, and the experiences gained in solving actual problems for gas-utility companies. **Evaluation and Design of Pipeline Networks,** Robert J. Hunn, Robert L. McIntire, and Kenneth L. Austin. The techniques described here are applicable to the computation of the distribution of the flow of water or of other fluids in complex piping networks. The computation is approached entirely from the friction-factor viewpoint. **Digital-Computer Applications: A Process Control Example,** R. Curtis Johnson. This paper is intended to illustrate a simple case with emphasis on the various sets of control equations or control relationships. A fictitious system has been selected with properties whose values are suitable for the example. **Process Dynamics and Analogue-Computer Simulation of Shell-and-Tube Heat Exchangers,** Louis H. Fricke, Henry J. Morris, Robert E. Otto, and Theodore J. Williams. The purpose of the program described here was to evaluate the response of a theoretical model with parameters calculated from the physical dimensions and existing heat transfer properties of an actual industrial exchanger and to determine the significant factors which influence the response of the exchanger. **Procedures for Selection of Optimum Conditions,** W. O. Cochran. This article attempts to clarify to a reasonable degree how mathematical optimization techniques and large-scale computers should and should not be used in chemical-process studies. **Some Optimization Problems in Chemical Engineering,** Rutherford Aris, Richard Bellman, and Robert Kalaba. The purpose of this paper is to indicate the applicability of the methods and concepts of dynamic programing to three representative types of problems common in chemical engineering. **Dynamic Programing Formulation of the Catalyst Replacement Problem,** S. M. Roberts. In this paper the author has tried to apply the concepts of dynamic programing to the catalyst replacement problem. It is hoped that through this paper the powerful and flexible methodology of dynamic programing will

be made better known to chemical engineers whose problems abound in multistage decision processes. **Reaction Kinetics Optimization Using Nonlinear Estimation,** T. I. Peterson. The result of this investigation indicate that several mechanisms may be plausible representations for a given set of experimental data. Such ambiguity may possibly be resolved by further experimentation or through independent information.

# Computer Program Abstracts

**Readers of the *A.I.Ch.E. Journal* who are interested in programing for machine computation of chemical engineering problems will find in each issue of *Chemical Engineering Progress* abstracts of programs submitted by companies in the chemical process industries. Collected by the Machine Computation Committee of the A.I.Ch.E., these programs will be published as manuals where sufficient interest is indicated. The following abstracts have appeared this year:**

**CEP (March, 1961), p. 88**

A General Equation Solver for Engineering Computations (068)
Traverse Closure and Curve Data Program (072)

**CEP (April, 1961), p. 88**

Fisher's F-Distribution (071)
Thermodynamic Functions of Monatomic Gases (073)

**CEP (May, 1961), p. 78**

Computer Program for the Construction of a Table of Temperature vs. Resistance for a Platinum Resistance Thermometer (054)
Computer Program for Evaluation of Free Energy of Formation Temperature Functions (074)

## ERRATUM

The captain for Figure 2 appeared under Figure 3 and vice versa for "Extractive Reaction: Batch and Continuous-Flow Chemical Reaction Systems Dilute Case" by Edgar Piret, W. H. Penney, and P. J. Trambouze which appeared on page 394 of the September, 1960, issue of the *A.I.Ch.E. Journal.*

# BOOKS

**Transport Phenomena,** R. B. Bird, W. E. Stewart, and E. N. Lightfoot, John Wiley and Sons, Inc., New York (1960). 780 pages. $11.50.

In the opinion of the reviewer this book is probably one of the most important texts to appear in the field of chemical engineering in many years. Indeed there is little doubt that the consideration of transport phenomena as a distinct engineering subject can and should have a great impact on engineering in general, far beyond its immediate usefulness and application to chemical engineering.

The authors have endeavored to develop from fundamental principles the topics of momentum, energy, and mass transport in a rigorous manner and then, through the use of many problems, to point out the applications of these topics to subjects of engineering interest. Diligent pursuit of the material included in the text leads to a good idea of the meaning of engineering science and the importance of this approach, particularly to those who may be convinced that the term is only a combination of two words sitting in somewhat uneasy proximity to one another.

The text is concerned with molecular and turbulent transport processes, and encompasses both the rigorous developments allowable for molecular transport and the approximations or empiricisms necessary