(*Continued from page 824*)

Phase equilibria in polymer solutions, Heil, J. F., and J. M. Prausnitz, **A.I.Ch.E. Journal, 12,** No. 4, p. 678 (July, 1966).

Key Words: A. Thermodynamics-8, Phase Equilibria-8, Phase Diagrams-8, 9, Solubility-8, 9, 2, Polymers-9, Polymer Solutions-9, Ternary Systems-9, Polystyrene-9, Solvent Mixtures-5, Acetone-Toluene-5, Acetone-Benzene-5, Methanol-Benzene-5, Methanol-Ethyl Acetate-5, Acetone-Methylcyclohexane-5, Calculating-8, 4, Predicting-8,4, Vapor Pressures-1, Gibbs Energy of Mixing-2, Segment-Interaction Equation-10, 8, Equation-10, 8.

Abstract: A new semiempirical equation, called the segment-interaction equation, is presented for the Gibbs energy of mixing for solutions of polymers in single and mixed solvents. The equation contains two adjustable parameters per binary mixture and can readily be extended to multicomponent systems without additional parameters. Parameters are determined from binary vapor pressure data. A graphical method based on the new equation is given for predicting solubility limits in ternary systems containing one polymer and a mixed solvent. The method is demonstrated by comparisons of predicted solubility behavior with experimental data taken on systems of polystyrene and the following mixed solvents: acetone-toluene, acetone-benzene, methanol-benzene, methanol-ethyl acetate, and acetone-methylcyclohexane.

Reduction of single particles and packed beds of hematite with carbon monoxide, Osman, M. A., F. S. Manning, and W. O. Philbrook, **A.I.Ch.E. Journal, 12,** No. 4, p. 685 (July, 1966).

Key Words: A. Reduction-8, 9, 4, Fractional Reduction-8, 9, 4, Reaction-8, 9, 4, Kinetics-8, 7, 2, Rate-8, 7, 2, Hematite-1, 9, Vermilion Ore-1, 9, Ferric Oxide-1, 9, Single Particles-1, Packed Beds-1, Iron-2, Carbon Dioxide-2, Temperature-6, Concentration-6, Composition-6, Porosity-6, Calculating-8, Mass Transfer Coefficients-2, Diffusion Coefficients-2, Rate Constants-2.

Abstract: Sintered spheres of reagent grade hematite and particles of vermillion ore are reduced by carbon monoxide over the temperature range 820° to 920°C. The early stages of reduction are correlated by a series combination of the individual resistances due to boundary-layer transport, transport through the reduced iron shell, and interfacial chemical reaction. Packed beds of vermillion ore particles are also reduced in the same temperature range. Barner's and Spitzer's predictions of fractional reduction are compared with data acquired in this investigation.

Reaction of chlorine and uranium tetrachloride in the fused lithium chloride-potassium chloride eutectic, Olander, Donald R., and J. L. Camahort, **A.I.Ch.E. Journal, 12,** No. 4, p. 693 (July, 1966).

Key Words: A. Rate-8, 7, Reaction-9, 8, Chlorination-9, 8, Uranium Tetrachloride-1, Chlorine-1, Gas-1, Uranium Hexachloride-2, 9, Fused Salt-5, Lithium Chloride-5, Potassium Chloride-5, Mixture-5, Eutectic-0, Wetted-Rod Contactor-10, Calculating-8, Concentration-2, Gas Phase Resistance-2, 6, Liquid Resistance-2, 6, Diffusion-6, Yield-7.

Abstract: The rates of the reaction of chlorine gas with uranium tetrachloride dissolved in the lithium chloride-potassium chloride eutectic have been studied in a wetted-rod contactor. The reaction was studied at temperatures from 400° to 700°C, uranium tetrachloride concentrations of 1 to 3 wt. %, and chlorine partial pressures of 0.25 to 1 atm. Both the effect of the rate of reaction at the gas-liquid interface and the effect of uranium (IV) ion diffusion in the liquid phase on the production of uranium hexachloride are considered.

Similarity solutions for non-Newtonian fluids, Lee S. Y., and W. F. Ames, **A.I.Ch.E. Journal, 12,** No. 4, p. 700 (July, 1966).

Key Words: A. Deriving-8, Equations-2, 10, Nusselt Number-2, Similarity-0, Boundary Layer-0, Similarity Solutions-10, 8, Group Theory-10, Transformation Methods-10, Solutions-4, 8, Describing-4, 8, Flow-9, 8, Goldstein Flow-9, Falkner-Skan Flow-9, Wedge Flow-9, 8, Fluids-9, Non-Newtonian Fluids-9, Eyring Viscous Fluids-9, Momentum Transfer-9, 8.

Abstract: An investigation of boundary-layer equations for non-Newtonian fluids is reported. Similarity variables and equations for various flows are obtained by using transformation group methods. Transformation forms for Goldstein types of flow, Eyring viscous flows, and nonconstant heat conductivity flows are given. A numerical solution is obtained for forced convection of power law fluids about a right angle wedge with an isothermal surface. From the numerical results an approximate expression is obtained for the local Nusselt number.

Free tear sheets of the information retrieval entries in this issue may be obtained by writing to the New York office.

(*Continued on page 826*)

The Continuous Maximum Principle, L. T. Fan, John Wiley and Sons, New York (1966). 411 pages, $16.00.

This is a book which will find its greatest use as an introduction to the maximum principle. As Professor Fan states: "there is a strong emphasis on the application of the theory to specific problems, and detailed solutions are presented so that the reader can see how the maximum principle algorithms are used." Depending on their degree of background knowledge, certain readers will thus find this book too simple for their use, while others will find that it serves as an excellent introduction to the ideas of the maximum principle. The primary endeavour of this review is to point out some of the strong features of the book and at the same time indicate certain shortcomings in the depth of coverage.

The book first presents the basic theorem of the maximum principle in its simplest form and then proceeds to illustrate same with examples in optimal control and industrial and aerospace systems. The main emphasis here is on the setting up and detailed solution of many examples. This is followed by more complex developments, including an interesting combined use of the maximum principle and dynamic programming for optimizing a mixture of continuous and discrete (staged) systems and the application to highly nonsequential systems such as those with recycle (feedback) and various composite structures. Finally, a comparison is made between the development of the maximum principle and those involving variational techniques.

Each of these areas is clearly written and well-documented in terms of examples of interest to chemical engineers. In fact, the examples are worked out to the point where almost each step is explicitly presented. As an illustration, the chapter on optimal control, which is thirty-nine pages long, contains ten examples covering thirty pages of the chapter. Both analytic and numerical solutions are used in the book, with the numerical solutions evolving from cases where nonlinear chemical reaction is a part of the system.

As a result this book should find a wide acceptance as an introductory text for seniors or first-year graduate students in chemical engineering. Combined with the text by Aris on dynamic programming, it should prove

(*Continued from page 825*)

Entrainment of air into a liquid spray, Briffa, Francis E. J., and Norman Dombrowski, **A.I.Ch.E. Journal, 12,** No. 4, p. 708 (July, 1966).

Key Words: A. Entrainment-8, Air-1, Spray-5, 9, Isooctane-5, 9, Tetralin-5, 9, Flat Spray-5, Deriving-8, Equations-2, 10, Correlating-4, 8, Measuring-4, 8, Drop Size-9, 7, Air Velocity-9, 6, Trajectory-9, Flow Pattern-9, 8, Photography-10.

Abstract: An investigation into the flow pattern existing in and around a flat spray is reported; particular attention is paid to the region of disintegration of the liquid sheet in this report. The mass of air entrained into the spray, the decay of air velocity along the spray axis, and the spread of the drops in the plane normal to that of the sheet, have been related to the operating conditions by equations theoretically derived and experimentally confirmed. Similarities between the characteristics of air entrainment into liquid sprays and into gas jets are noted.

Surface catalysis of the hydrogen-oxygen reaction on platinum at low temperatures, Leder, Frederic, and John B. Butt, **A.I.Ch.E. Journal, 12,** No. 4, p. 718 (July, 1966).

Key Words: A. Catalysis-8, Reaction-8, 9, Hydrogen-1, 9, Oxygen-1, Water-2, 9, 6, Catalyst-10, Platinum-10, 9, Alumina-5, Fixed Bed-9, Temperature-6, Pressure-6, Concentration-6, 2, Residence Time-6, Rate-7, 8, Kinetics-7, 8, Calculating-8, Activation Energy-2.

Abstract: The reaction between hydrogen and oxygen with a dilute platinum catalyst is investigated at low temperatures. The effect of product water on the reaction rate and the effect of hydrogen partial pressure (in the presence of a large excess of oxygen) are each considered. Activation energy for the reaction at 100°C. is also determined.

The relaxation of concentration polarization in a reverse osmis desalination system, Tien, Chi, and William N. Gill, **A.I.Ch.E. Journal, 12,** No. 4, p. 722 (July, 1966).

Key Words: A. Mathematical Analysis-8, Calculation-8, Concentration-2, 7, Distribution-2, 7, Salt-9, 3, Desalination-9, 8, 4, Purification-9, 8, 4, Seawater-1, Brine-1, Water-2, Reverse Osmosis-10, 8, 9, Membrane Process-10, 8, 9, Diffusion-6, Polarization Relaxation-6, Impermeable Sections-6, Membranes-9, Rate-7, Effectiveness-7, Diffusion Equation-10.

Abstract: An analysis of diffusional effects in a system consisting of impermeable relaxation sections placed alternately between semipermeable membrane sections is presented. The system under consideration uses the membrane process in the desalination of seawater. The analysis employed exploits a relation deduced by Lighthill to avoid the necessity of using orthogonal function expansions which converge slowly in the diffusion entrance region which is studied here.

Film boiling of liquid nitrogen from porous surfaces with vapor suction: experimental extensions, Pai, V. K., and S. G. Bankoff, **A.I.Ch.E. Journal, 12,** No. 4, p. 727 (July, 1966).

Key Words: A. Heat Transfer-8, Boiling-8, Film Boiling-10, 8, 9, 4, Nitrogen-1, Feasibility-8, Effectiveness-8, 7, Vapor Suction-9, 10, Flat Heating Elements-9, 10, Tubular Heating Elements-9, 10, 6, Porous-0, Flow Control Elements-9, 4, Asbestos Paper-9, 6, Heat Fluxes-7, Heat Transfer Coefficients-7.

Abstract: Film boiling of liquid nitrogen with vapor suction is studied on both flat and tubular porous heating elements at heat fluxes as high as 80,000 B.t.u./(hr.)(sq. ft.). Two types of flow control elements are used: porous stainless steel plate separated from the heating element by a layer of Fiberglass cloth, and thin, glass-bonded asbestos paper. Heat transfer coefficients and heat fluxes for this mode of boiling heat transfer are compared with those for nucleate boiling. An approximate theoretical model for a single liquid tongue breaking through the heating section at the critical flow rate is also presented.

Free tear sheets of the information retrieval entries in this issue may be obtained by writing to the New York office.

(*Continued on page 827*)

to be an excellent teaching guide in a course on optimization or control.

At the same time it is important to realize the limitations of the analysis presented in this book. First, there is very little motivation or depth in the presentation of Pontryagin's theorem. Thus the reader is given the theorem and the algorithm with a minimum of associated discussion on the details of the derivation. It is the mechanics of the use which are emphasized and this can be very dangerous in the hands of a novice. As a fine-grained, but not necessarily trivial, point the title to the book should probably have been the minimum principle rather than the maximum principle. This is because Professor Fan has used the boundary condition formulation which is the negative of that used by Pontryagin and his collaborators. As a result, minimization of the Hamiltonian function occurs instead of maximization. Without realizing that this change has been made the reader may encounter certain difficulties in the outside literature.

Second, the simplicity of many of the examples may leave the reader with the impression that the maximum principle can handle all types of problems with relative ease. This is not true but all more advanced techniques and analysis are merely mentioned in reference form. As an illustration of this point, on pages 321-22, the system equations and the corresponding adjoint equations are developed for a specific example; the problem is then left with the statement "one must solve equations 249 through 263 simultaneously" to achieve the optimal answer. That it is a tremendous feat goes without saying but the novice to the area may not appreciate the difficulties associated with such a comment. Furthermore, the ten examples in the optimal control chapter are all linear; this would tend to leave the reader with the mistaken impression that all optimal control problems are as simple as those shown.

Finally, this reviewer feels that the nomenclature used may cause many difficulties for the reader. This is because the nomenclature makes excessive use of superscripts and subscripts. It would have been much easier and cleaner to use standard matrix-vector notation throughout, thereby eliminating the need for super- and subscripts.

In summary, this book has many strong points from an application point of view and certain shortcomings in terms of its depth of coverage. As long as these shortcomings are kept in mind the book should prove to be an excellent and useful text.

LEON LAPIDUS
PRINCETON UNIVERSITY