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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 as follows: "Computer Techniques in Chemical Engineering," \$3.00 to members, \$4.00 to nonmembers; "Nuclear Engineering Part V," \$3.50 to members, \$4.50 to nonmembers; "Adsorption, Dialysis, and Ion Exchange," \$3.50 to members, \$4.50 to nonmembers. They may be ordered from the Secretary's Office, the American Institute of Chemical Engineers, 25 West 45 Street, New York 36, New York.

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COMPUTER TECHNIQUES IN CHEMICAL ENGINEERING, Vol. 55, No. 21, 1959

Machine Computations of K-Values, EDWARD GORDON, M. J. GOODWILL, AND J. W. PAYLOR. For computations involving equilibrium between vapor and liquid phases, the oil and natural gas industries find it necessary to obtain much of their phase-equilibrium data from graphical K-value correlations. One such accurate correlation has been converted into relatively compact equations suitable for use with digital computers. **Solution of a Multicomponent-Distillation Problem With Two Feeds or a Side Stream,** R. J. HENGSTEBECK. Multicomponent distillation problems involving two feed streams or a side stream can be solved by a graphical method developed for simpler towers. The section between the feeds of a two-feed tower and the trays near the feeds require special treatment. A tower with a side stream becomes two simpler towers. The splits of the light components can be approximated. **Evaluation of Benedict-Webb-Rubin Equation for Prediction of Phase Equilibrium of Light Hydrocarbon Mixtures at Low Temperatures,** A. ROY PRICE, T. W. LELAND, AND RIKI KOBAYASHI. An analysis of the Benedict-Webb-Rubin equation of state for light hydrocarbons at low temperatures and high pressures has been made with a medium-speed digital computer on the basis of original data for

the methane-ethane-propane system. Pairs of plots employing molal average boiling point as composition parameters represent smoothed experimental data for each component. The correlational properties of these plots are confirmed by checks of the K values of methane, ethane, and propane with those from other experimental sources. **Present and Prospective Use of Computers in Management Control,** ROBERT H. GREGORY. Data-processing systems attempt to meet managerial requirements concerning past history and future prospects by developing both data—the mass of facts concerning a business—and information—the small number of facts that are useful for decision making. **Development and Application of a General-Purpose Analogue Computer Circuit to Steady State Multicomponent-Distillation Calculations,** N. G. O'BRIEN AND R. G. E. FRANKS. The problem studied was separation of acetylene from ethylene by extractive distillation. The numerical values computed for one set of operating conditions by manual, analogue, and digital computation are compared. Electrical analogue circuits capable of handling plate-to-plate calculations where the vapor composition is known are given. The liquid composition on a plate containing a large amount of nonvolatile solvent is computed. **The Use of a Computing System in a Large Chemical Company,** F. A. LANDEE. The preparation by hand and in

the original machine language of programs for an electrical digital computer is a long, expensive, and error-prone process. This paper describes a rather complete system devised at The Dow Chemical Company for use with an intermediate-sized computer to reduce the difficulty of the programming problem. **Optimum Design of Ejectors Using Digital Computers,** L. A. DEFRADE AND A. E. HOERL. An earlier one-dimensional analysis of single-stage jet ejectors is extended by accounting for the effects of dissimilarities in molecular weights between the motive and suction gases. The numerical solution of the resulting nonlinear simultaneous equations on digital computers is discussed, and a dimensionless design chart for jet ejectors in chemical processes is presented. **Prerequisite for Computer Applications,** H. A. HASHBARGER AND N. L. SAMPLE. Monsanto's experience with the IBM 702-EDPM is described, and its utilization in management control is presented, together with advantages and benefits which have been achieved, difficulties that have been encountered, and prerequisites for successful utilization. Translating existing company control techniques into programs that can be handled by the computer is discussed. **Fractionator Design with Automatic Computing Equipment, Part I,** ROBERT L. MCINTIRE. A step-by-step method of fractionator design directed specifically toward application to

automatic digital computing equipment is presented. The procedure is used to predict the number of ideal equilibrium steps required to make a given separation of a multicomponent feed. Examples of machine solutions are given to demonstrate this method of solving process-design and operating problems. **Fractionator Design, Part II**, R. O. SHELTON AND R. L. MCINTIRE. A step-by-step fractionator-design method developed for application to automatic computers is presented. This system of equations is used to calculate the separation of a multicomponent feed which is obtained with fixed operating conditions in a given fractionator. Heat, material, and equilibrium balances are used throughout. The convergence equations given require no manual intervention once the process is started on a computer. **Automatic Computer Procedure for Calculating Plates Required for Nonideal Ternary Continuous Distillation**, ARTHUR ROSE, RICHARD E. STILLMAN, THEODORE J. WILLIAMS, AND HARRISON C. CARLSON. This paper describes an automatic-computer trial-and-error procedure for calculating reflux ratio, total plates, and feed-plate location required for meeting specification requirements in continuous distillation of a ternary mixture with activity coefficients fitted by three-suffix equations in volume fractions. It is the general approach for a nonideal situation that is the basis for the discussion in this paper. **An Integrated System for the Automatic Solution of Distillation Problems**, J. S. BONNER. An automatic computation system for the solution of any problem must meet several basic requirements, such as precision, speed, generality, and simplicity of application. This paper describes a system which meets all these requirements.

NUCLEAR ENGINEERING—PART V,

Vol. 55, No. 22, 1959

Engineering Hot-Channel Factors, B. W. LETOURNEAU AND R. E. GRIMBLE. Engineering hot-channel factors have been established to account for small dimensional deviations from the nominal design of reactor fuel elements. Common deviations are described, together with methods of estimating the effect on channel enthalpy rise, film temperature difference, and maximum heat flux.

Examples are given for parallel-plate type of fuel elements separated by rectangular coolant channels. **An In-Pile Study of Organics as Nuclear Reactor Coolants**, MALCOLM MCEWEN AND EDWARD W. WIEDERHOLD. In a study of the feasibility of using organic chemicals as nuclear reactor coolant-moderators, a test loop was operated in conjunction with the reactor at Brookhaven to determine for these organics the specific radiolytic-decomposition rate, gas-generation rate, induced-radioactivity levels, and effect of decomposition products on the operating characteristics of the system and on the engineering properties of each material. **The Inside-Out Reactor**, MILAN OSREDKAR AND RICHARD STEPHENSON. A reactor design is described which offers the possibility of obtaining a given thermal flux at a

power less than that of a conventional reactor such as the MTR. **Use Of a Nuclear Reactor as a Process Heat Source**, R. W. RITZMANN. Possible methods of using a nuclear reactor as the endothermic-chemical-reaction heat source in a coal-gasification plant are discussed. The economics are discussed, and charts showing the effects of steam temperature and heat recovery on the threshold economics are presented. The cost of heat produced by a nuclear reactor is compared with the cost of heat supplied by the conventional method of burning coal with oxygen. **Continuous Dissolution of Uranium-Aluminum Fuels in a Trickle-Type Column Dissolver**, J. C. BRESEE, D. L. FOSTER, AND E. O. NURMI. A continuous column dissolver may be operated with critically safe dimensions; hence this type of dissolver may have an unlimited charge of metal per unit with no theoretical upper limit to the capacity. With the advantage that a continuous dissolver may better serve a continuous solvent-extraction process than a batch dissolver, the continuous column dissolver is potentially the most satisfactory type for short fuel elements or sections of elements. **Design of Plutonium Processing Plants**, B. F. JUDSON. This paper presents a design philosophy for plutonium processing plants based upon the experience gained in the operation of a semiworks facility at Hanford Atomic Products Operation. Prime concepts include the use of contamination barriers made of sealed hoods and directionalized air flow, partial separation of operating and maintenance functions in the physical layout, inclusion of multicomponent processing systems in single large hoods, and the considerations necessary for critical mass control. **Radioactivity Levels and Temperature Variations of the Columbia River**, ROYAL E. ROSTENBACH. The Columbia River was a prime factor in the selection of the Hanford site for the AEC's water-cooled nuclear reactors. Besides cooling the reactors, the river also serves to dispose of radioactive waste. River water passes through the reactors and large retention basins and is then discharged to the river as a warm radioactive effluent under carefully controlled conditions. This report considers temperature and radioactivity levels of the river. **Studies On X Rays and Bremsstrahlen**, L. E. BROWNELL AND E. W. COLEMAN. Although secondary radiations may be predicted accurately for very simple situations, such methods are of little value in real situations. The complexity of the problem is apparent if one considers that the production and absorption of electrons and of photons are interdependent processes. This paper discusses briefly some of the factors considered in developing bremsstrahlen sources for medical radiography. **Application of the Packed Column to the Redox Process**, E. R. IRISH. A brief description is presented of the Redox process for plutonium and uranium separation and decontamination from fission products contained in irradiated uranium fuel elements. Performance characteristics determined for packed solvent-extraction columns during development work are discussed. Instru-

mentation for control and observation of performance is described briefly. **Electrolytic Recycle Method for the Treatment of Radioactive Nitric Acid Waste**, H. W. ALTER, D. L. BARNEY, A. C. SCHAFER, AND F. J. WITT. The bulk of high-level, radioactive waste will consist of solvent extraction raffinate. Most of this will be nitric acid containing over 95% of the fission products from the separation process and small amounts of nitrate salts. The first objective in waste treatment is volume reduction of the waste to yield the mixed fission products in a small, high-specific activity package without the simultaneous production of large volumes of low-level waste. **Industry's Role in University Programs of Nuclear Engineering**, D. W. MCLENNAN. In training tomorrow's engineers, today's specific problem becomes secondary to the fields of knowledge and the processes of analysis which this problem and others are likely to demand.

This concept tells how industry can best cooperate with the colleges to their advantage and its own, particularly in the long range sense. **The Subcritical Assembly in Engineering Teaching**, W. F. FAGEN AND JOSEPH WEIL. The advent of the subcritical assembly has provided university instructors with a versatile laboratory tool which can be used for studying the basic factors involved in reactor design and operation without the hazards produced by criticality. At the same time measurements can be made within the lattice, and the behavior of the neutrons in environments associated with reactors can be analyzed. In addition, neutrons can readily be detected and measured. Design predictions also can be compared with actual practical measurements. **Radiation Source Fabrication and Handling**, EUGENE LAMB. Radiation sources containing greater quantities of separated fission products than are now available will be produced in the Fission Products Pilot Plant at Oak Ridge.

It is expected that much of the plant output will be used in gamma irradiators of intermediate or pilot plant size. Therefore, integrated planning will be necessary from the design of the source unit to its installation in the irradiator. Certain limitations are placed on the source unit by the fabricator's plant, the intended use of the source, the characteristics of the fission products in the source, and the method of shipment. **Design and Construction Criteria for In-Pile Experimental Chemical Reactors**, D. J. DANIELS, M. C. SCHROEDER, D. D. FOLEY, AND R. B. FILBERT, JR. Use of nuclear radiation in carrying out chemical reactions is now being extensively explored by chemists and chemical engineers. Of the various radiation sources the nuclear reactor is by far the most powerful in terms of intensity of penetrating radiation available and may be the most likely source of nuclear radiations for chemical processing.

A number of the specific problems encountered in the design and construction of chemical processing loops were not evident at the outset, and one of the purposes of this discussion is, therefore, to alert others venturing into the area. **Report on Process Steam Reactors**, E. L. HELLER AND D. O. HUBBARD. The chemical industries

require an uninterrupted, reliable, and constant source of heat for their continuously operating processes. In many plants, load factors of 90 to 95% of demand are the rule rather than the exception. Those conditions are ideal for nuclear reactors.

On the basis of recent experience, it is safe to assume that the potential market is 50 to 100 process steam-generator units a year. **Nuclear Considerations in Design of High-Temperature-Process Heat Reactors**, J. T. ROBERTS. Designers of high-temperature-process heat reactors must be careful not to rely uncritically on nuclear generalizations based on low-temperature thermal reactors. Differences are reflected in differences in critical size and mass and in control problems associated with temperature coefficient of reactivity and degree of fuel burn-up attainable before processing. **Design of a Plant for Recovery of Uranium by Liquid Ion Exchange (Solvent Extraction)**, KATHLEEN BLACK AND JOSEPH KOSLOV. A process description for the recovery of uranium from sulfuric acid leach solutions by solvent extraction, designed to process 600 tons of ore daily, is presented. **Indirect Cycle Nuclear Reactor System to Furnish Process Heat**, R. CARSON DALZELL AND JAMES P. MCGEE. Use of nuclear fission for chemical process heat offers the special advantage of high temperature, limited only by materials of construction. The process heat may be supplied economically at elevated pressures, since no compression of combustion air is required. The major problems are the design of high-temperature fuel elements, construction of an exchanger to transfer heat to process streams in the range of 2,500°F., and development of compressors capable of recycling helium at 1,000°F. and above. **Direct Utilization of Fission Energy for Radiation Processing**, WARD S. DIETHORN, PAUL SCHALL, JR., AND G. D. CALKINS. Radiation-induced degradation, polymerization, and synthesis of both organic and inorganic compounds have been reported. High chemical yields in some of these systems suggest the possibility of utilizing radiation sources for the commercial production of chemicals.

If fission recoils could be utilized in a reactor, it would be a highly efficient radiation processing source. The purpose of this paper is to discuss a reactor application of this type. **Experimental Determination of Dose Distribution in the Proposed Fir Gamma Irradiator**, B. MANOWITZ, D. M. RICHMAN, L. GALANTER, AND O. A. KUHL. This paper presents an experimental program to determine the depth-dose distribution in food packages for several gamma irradiator geometries and to examine the nature of aqueous, indium-salt solutions. The experimental results of the irradiator experiments were compared to theoretical calculations of depth-dose distributions and reactor power required for one particular irradiator geometry. **Engineering Continuous Filtration to the Uranium Ore-Processing Flow Sheet**, C. F. CORNELL, R. C. EMMETT, AND D. A. DAHLSTROM. Rapid development of uranium-ore milling has required the solution

of several difficult and critical liquid-solids separations. Filtration has been given a large place in the flow sheet in finding these solutions. Filtration theory, test procedures, methods of correlation, and filter construction had to be developed. **High-Operating-Temperature Reactor Design**, JOSEPH DEFELICE. The design presented affords a method of immediate entry into the field of high-temperature nuclear reactors for chemical processing. The reactor described is, in essence, a test reactor for the development of high-temperature fuel elements. **Process Applications and Construction Materials for a High-Temperature Nuclear Reactor for Chemical Processing**, LEON DAVIDSON AND ALFRED A. STRASSER. A preliminary study to explore the design and application of a high-temperature process heat reactor.

With known technology a relatively small demonstration reactor could be built in which an insulated central fuel region, running at high temperature, could be used to develop and demonstrate high-temperature components. **The Effects of Gamma Radiation on Several Polysulfone Reactions**, BRUCE G. BRAY, JOSEPH J. MARTIN, AND LEIGH C. ANDERSON. The advent of the atomic energy program stimulated many research activities to discover uses for the high-energy radiation made available in the fission products of the nuclear reactors. The use of this radiation as a catalyst in chemical reactions has been shown to be very effective in certain cases and may prove to be advantageous on an industrial scale.

ADSORPTION, DIALYSIS, AND ION EXCHANGE, Vol. 55, No. 24, 1959

Similarities in Adsorption, Dialysis, and Ion Exchange, G. P. MONET. If adsorption, dialysis, and ion exchange are grouped together, there are many obvious similarities of a physicochemical and chemical engineering nature. Classification of the three fields into one is expected to facilitate chemical engineering instruction, to stimulate further research, and lead to increased commercial application. **Adsorption Equilibria**, DONALD GRAHAM. The nature and energies of adsorption are reviewed with particular reference to its use in clarification or fractionation. Experimental techniques for obtaining adsorption equilibrium data and analytical methods for their interpretation are reviewed. Factors which should be considered in the selection of an adsorbent for a specific purpose are discussed, and methods for handling solid adsorbents in fluid media are outlined. **Kinetics of Batch Adsorption of Dichlorophenol on Activated Carbon**, S. B. SMITH, A. X. HILTGEN, AND A. J. JUHOLA. The rate of adsorption of 2, 4-dichlorophenol from aqueous solution by granular activated carbons of various sizes and types was followed for 3-hr. periods. The effects of adsorbent structure, particle size, initial adsorbate concentration, temperature, and adsorbent-solution ratio were studied and mathematical treatments tested. A proposed semiempirical treatment permits determination of relative diffusivities within the particles. **Deactivation and Reactiva-**

tion Phenomena During Charcoal Adsorption of Hydrocarbon Gases, R. F. BADDOUR AND R. L. GEDDES. The effect of hydrocarbon pyrolysis gas on the adsorptive capacity of activated petroleum coke was explored in bench-scale experiments with fixed char beds. Deactivation and reactivation phenomena were studied at varying conditions in an effort to gain information useful in commercial design work. **Molecular Sieves**, G. J. GRIESMER, R. A. JONES, AND HARRY LAUTENSACK. Since molecular-sieve adsorbents were introduced, they have been applied by the process industries to the drying and purification of a large variety of gas and liquid streams. This paper deals with the properties and uses of molecular sieves. **Application of Ion Exchange Equilibrium Relationships to Process Design**, NORMAN W. FRISCH AND FRANCIS X. MCGARVEY. Kinetic relationships which describe ion exchange processes have been developed, each relationship depending upon a mass balance, a rate equation, an equilibrium relationship (isotherm), and a set of boundary conditions. In many design applications, expressions based on equilibrium concepts yield important process information. **Kinetic Relationships for Ion Exchange Processes**, THEODORE VERMEULEN AND NEVIN K. HIESTER. Efforts to place ion exchange and related adsorption operations on a sound theoretical basis are reviewed. Graphs and tables are cited which present the results of complex mathematical analysis in readily usable form. Finally, resin utilization and regenerant efficiency important in the economic design of processes for cyclic operation are discussed. **Ion Exchange Kinetics**, R. L. MOISON AND H. A. O'HERN, JR. New data were obtained on ion exchange in deep, fixed-bed equipment. The data for favorable equilibria were correlated by a variation of the "exchange zone" concept of Michaels, and the results revealed that liquid-phase diffusion is controlling with feed concentrations of 0.01 to 0.10 *N*. Heights of transfer units were found to be proportional to the 0.4 power of Reynolds number and the 0.3 power of the ratio of bed depth to particle diameter. **Semi-continuous Countercurrent Apparatus for Contacting Granular Solids and Solution**, C. W. HANCHER AND S. H. JURY. Progress is reported in the field of semicontinuous countercurrent ion exchange at Oak Ridge National Laboratory. Additional operating data are given on a 12-in. diameter pilot-scale slurry contactor operating on low-grade Western uranium ore. Hydraulic data from a 36-in. contactor with new types of pulsing mechanisms are presented to show the decreased effect of wall resistance in the larger contactors.

(Continued from p. 412)

Professor Peters has written a readable book which emphasizes the dual economic and technical basis for plant design. It will be of use to chemical engineering students and practicing engineers not directly concerned with cost estimation.

J. FRIEDLANDER