July through September, 1958

IBM Technical Papers Published in Other Journals

The Acquisition and Utilization of Information in Problem Solving and Thinking, Manfred Kochen** and Eugene H. Galanter,* *Information and Control,* **1,** No. 3, 267-288 (September 1958).

Some of the logical consequences of drawing a distinction between the following two aspects of problem-solving behavior are explored: (a) actions directed toward the acquisition of information to guide future actions toward valuable goals; (b) actions directed toward the utilization of accumulated information to attain a valuable goal. An experimental paradigm accomplishing this separation is described in the case of an environment of periodic sequences of binary events. A general way of describing behavioral strategies is developed in terms of: (a) a plan for when to acquire information, to guess an outcome, or to guess at the solution; and (b) a program for how to compute guesses from the information accumulated. The structure of the binary environmental sequences, the structure of these behavioral strategies, and the relations between them are analyzed, and certain strategies which maximize value are suggested. Computing machine interpretations of certain specific strategies for a restricted kind of experiment are displayed, and predictions from these are compared with experimental data from pilot studies performed with human subjects.

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**Work supported by Ford Foundation post-doctoral Research Fellowship at Harvard University, 1955-56.

Algebraic Topological Methods for the Synthesis of Switching Systems. I, J. Paul Roth, *Transactions of the American Mathematical Society,* **88,** No. 2, 301-326 (July 1958).

An algebraic topological formulation for the problem of synthesizing switching systems is given in this paper. The principal problem considered in this paper is that of finding an algorithm for computing minimum two-stage and-or circuits. This problem is formulated topologically and several algorithms directed toward this goal are given. This may be considered as a generalization of a logical problem due to Quine. Two algorithms are given for this problem in Part II of this paper (to appear in the *Proceedings of the International Symposium on the Theory of Switching,* Harvard University, Cambridge, Mass., April 2, 1957). Part III, which has been submitted to the *IBM Journal,* treats a more general problem.

Applicability of the Knudsen Effusion Method to the Study of Decomposition Reactions. The Decomposition of Magnesium Hydroxide, E. Kay and N. W. Gregory,* *Journal of Physical Chemistry,* **62,** 1079-1083 (September, 1958).

Expected equilibrium water pressures over $Mg(OH)_2$ and MgO and a condensation coefficient of unity are observed in effusion experiments at 28° only in the initial stages of the decomposition. As the reaction progresses, pressures within the cell drop to immeasurably low values. At higher temperatures a constant steady-state effusion pressure has been observed between 5 and 55 percent decomposition when the cell is kept continuously *in vacuo.* Under these conditions, the system shows a pseudo-equilibrium behavior; P_s shows a systematic variation with cell orifice area; however, extrapolation to zero orifice area gives an apparent equilibrium pressure only a ten-thousandth that of the expected value, a condensation coefficient of 10^{-3}, and an apparent H^0, 58 percent larger than the thermodynamic value. A possible kinetic explanation is discussed. It is concluded that the effusion method can give very misleading results when applied to the determination of equilibrium characteristics of decomposition reactions involving substances of very low volatility.

*Chemistry Department, University of Washington.

The Automatic Creation of Literature Abstracts (Auto-Abstracts); H. P. Luhn, *1958 IRE National Convention Record (Part 10),* 20-27 (1958).

Excerpts of technical papers and magazine articles that serve the purposes of conventional abstracts have been created entirely by automatic means. In the process described, the complete text of an article in machine-readable form is scanned by an IBM 704 data processor and analyzed in accordance with a standard program. Statistical information derived on word frequency and distribution is used by the machine to compute a relative measure of significance, first for individual words and then for sentences. Sentences scoring highest in significance are extracted and printed out to become the "Auto-Abstract."

Automatic Reading and Sorting of Intermixed Random-Size Checks, J. A. Weidenhammer, *Machine Design,* **30,** No. 17, 114-116 (August 21, 1958).

The design criteria and development problems of the IBM 635 Sorter-Reader are described in detail. This machine was designed for sorting and reading various sized bank checks which are coded with printed bits of magnetic ink. As a reading machine, it may serve as data input to the IBM 650 RAMAC. The design problems of paper feeding, sorting speeds greater than 650 checks per minute, accurate alignment, magnetic sensing, and efficient stacking are discussed, together with their solutions.

Calculation of Flux Patterns in Ferrite Multipath Structures, S. A. Abbas and D. L. Critchlow, *1958 IRE National Convention Record (Part 4),* 263-267 (1958).

Methods are described for the prediction of the final flux patterns resulting from driving multipath ferrite cores by a step of mmf. It is shown that there exist three regions of constant incremental permeability within a core, based on an idealized B-H loop for the material. Laplace's equation is solved, taking into account the potentials due to the current, surfaces of distribution of magnetic polarity at the physical boundaries of the core, and polarities induced at the boundaries separating the different regions of constant incremental permeabilities. Various drive-winding configurations are considered. The results of the mathematical analysis are approximate but can be further refined.

Development of Ultra-Low-Loss Quartz Ceramic Dielectric Insulations, Barlane R. Eichbaum, *Insulations,* 72-75 (September 1958).

A new type of dense ceramic insulation has been developed which has better ultra-low-loss properties than any presently used high-frequency insulation. This insulation is composed of crystalline-phase quartz in several low-loss glass phases. The methods of fabrication are discussed.

Effect of Plastic Deformation on the γ-Ray Coloration of NaCl Crystals,* A. S. Nowick, *Physical Review,* **111,** No. 1, 16-25 (July 1, 1958).

Measurements are made at room temperature of the growth of the F-band in NaCl crystals, under gamma irradiation in a Co^{60} source of constant intensity. Crystals of different origins, heat treatments, and states of deformation are examined. While deformation has only a relatively small effect on the colorability in the early stage of F-band growth, the effect on the later stage is quite striking. The annealed crystals appear to saturate sharply at a value close to 10^{17} F-centers/cm^3, except for small linear increase with time, while the deformed crystals continue to show a high growth rate in the later stage of irradiation. Upon optical bleaching, the deformed crystals show R-bands, while undeformed crystals irradiated for the same time show no absorption maxima in the visible range. These and other observations confirm the concept advanced earlier that the first stage is due to vacancies and vacancy clusters present in the crystal prior to irradiation (which are determined by the impurity content of the crystal) while the second stage involves the generation of new vacancies at dislocations.

*Experiments conducted at the Brookhaven National Laboratory.

Ferroresonant Switching Circuits, W. E. Proebster, *Proceedings of the Nonlinear Magnetics and Magnetic Amplifiers Conference,* 434-443 (August 1958).

The object of this paper is to show some of the reasons for the application of ferroresonance to some specific problems only, and why a broader use has so far been impeded. Ways of overcoming the present restrictions are discussed.

Fiber Materials, T. D. Callinan, Chapter III, pp. 143-182 in *Modern Materials,* edited by H. H. Hausner, Academic Press Inc., New York, 1958.

The field of fiber materials is surveyed critically. The major advances in the field have been in the production and utilization of inorganic fibers. The properties of both commercially available and experimentally prepared fibers are given.

Fluorescence Spectra, Term Assignments, and Crystal Field Splitting of Rare Earth Activated Phosphors, S. P. Keller, *The Journal of Chemical Physics,* **29,** No. 1, 180-187 (July, 1958).

The visible fluorescent emissions, excited by 280-mμ radiation, of SrS phosphors, singly activated with rare earth ions, have been determined. These spectra are correlated with atomic term signature designations and with spectra of rare-earth salt compounds. Crystal field splittings of certain energy levels are observed.

Glass and Ceramic Fibers, T. D. Callinan, *Product Engineering,* **29,** No. 27, 70-2 (July 7, 1958).

The properties and uses of a wide variety of inorganic fibers are reviewed. Glass fibers have been made into highly efficient filter papers, and ceramic fibers have been converted into yarns and cloths of high thermal stability.

High Current Switching Times for a PNP Drift Transistor, A. Mitchell and L. Lapidus, *1958 IRE Convention Record (Part 3),* 57-67 (1958).

A one-dimensional model is proposed for predicting the high current turn-on and turn-off times of a PNP drift transistor. The system of equations describing this model is highly nonlinear and does not admit of an analytical solution. Numerical calculations on the IBM 704 are discussed with consideration to stability and convergence of the equations. Results are presented for drift transistors currently in usage. The effect of the various physical parameters such as the donor gradient, the intrinsic resistivity and base width are discussed.

Hot Probe Measures Germanium Diffusion Depth, M. Beliveau, *Electronics,* **31,** No. 39, 106, 108-109 (September 26, 1958).

In work that involves the diffusion of metals into germanium, it is important to measure the depth of diffusion accurately. The "hot probe" apparatus described here permits direct depth measurements to be taken with only a few minutes' time for sample preparation. It uses the thermoelectric effect in semiconductors to detect the change in impurity type and concentration. With this method, it is not necessary to measure both angle and length. Thus a multiplication of error is avoided, and accuracies within a few millionths of an inch are attainable. The operation, construction, and instrumentation of the apparatus are described in detail.

Lead Powder Connects Superconducting Film, J. A. Kurtz, *Electronics,* **31,** 92-94 (July 4, 1958).

Two methods are described for making superconducting connections between tin films and solder-coated copper wires. In the first method a cryotron gate, consisting of a tin film on insulated wire, and the solder-coated wire are placed in opposite ends of a hollow tapered plug, which is then filled with lead powder and compressed by a hand crimping tool. In the second method, the wires to be joined are placed in a slotted plastic support having end cavities into which the lead powder is poured. A punch then compresses the powder at 5000 psi. The technique provides connections with critical currents as high as 1 amp.

Logic by Ordered Flux Changes in Multipath Ferrite Cores, N. F. Lockhart, *1958 IRE Convention Record (Part 4),* 268-278 (1958).

A technique for performing logical switching functions with multipath cores is presented. In this method the magnetic state of a multipath core is made to respond in a predictable way to either the number or combination of inputs applied to it. Circuits for indicating specific functional relationships between the inputs are then realized simply through examination of the magnetic state of the core. Circuits for performing some binary and ternary logic including binary full addition are illustrated.

Magnetic Inks for Electronic Sensing, L. F. Miller and C. B. Blake,* *American Ink Maker,* **36,** No. 8, 32-34 (August, 1958).

Printing inks, in combination with complex electronic equipment, are finding new uses for automatic sorting of various printed materials. The theory of how magnetic inks act and how they operate with electronic equipment is discussed, along with the major problems of formulation and application. The present status and possible future applications of magnetic inks are described, particularly from the point of view of the printer and ink maker.

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Magnetic Susceptibility of Copper-Nickel and Silver-Palladium Alloys at Low Temperatures, E. W. Pugh and F. M. Ryan,* *Physical Review,* **111,** No. 4, 1038-1042 (August 15, 1958).

The magnetic susceptibilities of copper-nickel alloys with up to 39 atomic percent nickel and silver-palladium alloys with up to 10 atomic percent palladium have been measured by the Gouy method at temperatures between 295° and 2.1°K. Measurements are reported on samples with an impurity content of less than 10 parts per million and on samples with greater impurity content. The susceptibility is nearly temperature-independent for all the silver-palladium alloys and for the copper-nickel alloys with up to 27% nickel. Higher nickel concentrations give rise to a 1/T susceptibility term which is too large to be accounted for by impurity content. The simple band model of Mott adequately describes the susceptibility of the silver-palladium alloys but fails to predict the large temperature-independent paramagnetic contribution of nickel in copper. Exchange energies calculated by the Stoner collective-electron method for the copper-nickel alloys, using specific heat and susceptibility data, are somewhat unsatisfactory and suggest the presence of another mechanism.

*Carnegie Institute of Technology, Pittsburgh, Pa.

A Mathematical Formulation of Influence Distributions in Decision-Making Groups;* M. Kochen, *Journal of the Society of Industrial Applied Mathematics,* **6,** No. 3, 199-208 (September, 1958).

Let $b \varepsilon B$ be some proposal which must either be accepted (by majority) or rejected by N people. Let a_{ij} be the probability that the i^{th} voter votes for a proposal liked only by the j^{th} voter and disliked by all others. The quantity

$$\sigma^2 = \frac{1}{N} \sum_{i=1}^{N} \left[\frac{1}{CN-1} \sum_{j=1}^{N} (a_{ji} - a_{ij}) \right]$$

is minimum (O) when the voters are decomposed into cliques within which each member votes for exactly one other member's proposal. It is maximum $\left(\frac{1}{3} \frac{N+1}{N-1} \right)$ if and only if the voters form a hierarchy. The relation between σ^2 and the probability that a bill which is preferred by a majority is selected, or that a bill which is not preferred by a majority is rejected, is investigated.

*This study was made at Princeton University during 1955 under a Ford Foundation research grant.

Means for Attaining Vacua without the Use of Pump Fluids, I. Ames, R. L. Christensen, and J. Teale, *The Review of Scientific Instruments,* **29,** 736-737 (August, 1958). (Published as a Note.)

A new method is described for producing vacua with minimum contamination in moderate-sized systems. Pressure is reduced from atmospheric to about 1 micron within a few seconds by the use of a "finger" cooled by liquid helium. Subsequently, higher vacua may be obtained by ion-getter pumping. After outgassing and several hours of ion-getter pumping, the system pressure dropped to about 10^{-10} mm Hg.

The Molecular Key to Dielectric Properties—A Capsule Physical Chemistry for the Design Engineer, T. D. Callinan and A. E. Javitz,* *Electrical Manufacturing,* **62,** No. 1, 73-92 (1958).

The properties of dielectric materials are examined in terms of their fundamental physico-chemical constants. The physical and chemical properties of dielectric gases, liquids and solids and their ultimate performance in operating equipment are discussed and the basic principles common to such materials are interpreted functionally.

*Special Features Editor, *Electrical Manufacturing.*

On the Commutativity of Operators in Stochastic Models for Learning, M. Kochen, *The Annals of Mathematical Statistics,* **29,** No. 3, 930-933 (September, 1958).

The probability p of one of two possible responses in a learning experiment (e.g., a rat in a T-maze) is related* by one of two linear operators to the corresponding probability at the previous trial, depending on whether a reward or punishment followed: $p'=O_ip$, $i=1, 2$. A necessary and sufficient condition for the existence of a continuous function $f(p)$, $O\leq f(p)\leq 1$, such that $T_1T_2f(p)=T_2T_1f(p)$ where $f(O_ip)=T_if(p)$ for $i=1,2$, all p, $O\leq p\leq 1$, is that $f(p)$ be periodic with period equal to $(O_1O_2-O_2O_1)p$. Extensions of this result and implications for the statistical estimation of learning parameters from experimental data are discussed.

*R. R. Bush and F. Mosteller, *Stochastic Models for Learning,* John Wiley and Sons, New York, N. Y., 1955.

On the Effect of Fractional X-Irradiation of NaCl Crystals on F-Center Density, W. E. Bron and A. S. Nowick, *Physical Review,* **111,** No. 1, 26-27 (July 1, 1958).

An attempt is made to verify an effect reported by Lin whereby the F-center density in an alkali halide crystal irradiated over only part of its cross section is proportional to the fraction of the crystal exposed to the x-ray beam. These experiments fail to verify Lin's result, and in fact show that, within experimental error, the F-center density produced in a crystal exposed to a given intensity of x-rays for a given time is independent of the fraction of the crystal irradiated.

Optical Transmission and Photoconductive and Photovoltaic Effects in Activated and Unactivated Single Crystals of ZnS, G. Cheroff and S. P. Keller, *Physical Review,* **111,** No. 1, 98-102 (July 1, 1958).

Certain physical properties of single crystals of ZnS activated with Mn, Cu, and Al have been determined. The optical studies involve transmission spectra. Photovoltages much larger than the energy gap have been measured. Reversals in the sign of the voltage have been measured as a function of the wavelength of incident light. The photovoltages and photocurrents have been determined as functions of wavelength and of intensity of incident light. A description is presented in which the characteristics of the crystals are treated as simple circuit elements.

Reactions of the Group VB Pentoxides. VIII. Thermal, Density and X-Ray Studies of the Systems $KNbO_3$-$NaNbO_3$ and $KTaO_3$-$KNbO_3$, A. Reisman* and E. Banks,** *Journal of the American Chemical Society,* **80,** 1877 (1958).

The heterogeneous equilibria in the system $KNbO_3$-$NaNbO_3$ have been investigated using differential thermal analysis, density and X-ray techniques. The system was found to exhibit continuous solid solutions in all phases, and an explanation is offered to account for absence of expected miscibility gap behavior. Certain ambiguities in previous work have been clarified, and on the basis of the results a discontinuous transition from antiferroelectric to ferroelectric states is postulated, consistent with a theory of "interaction isomorphism." Previously determined unit cell volume variations in the mixed phases have been verified using refined powder-density measuring techniques. In order to compare two solid solutions, one of which would be expected to be more ideal than the other, a density phase diagram of the $KTaO_3$-$KNbO_3$ system has been constructed. In addition, the phase transformations of this system have been traced with DTA until they approach second order.

*Second part of a thesis submitted to Graduate School, Polytechnic Institute of Brooklyn, in partial fulfillment of requirements for degree of Doctor of Philosophy.

**Department of Chemistry, Polytechnic Institute of Brooklyn.

Reactions of the Group VB Pentoxides with Alkali Oxides and Carbonates. IX. A DTA Study of Alkali Metal Carbonates, A. Reisman, *Journal of the American Chemical Society,* **80,** 3558 (1958).

The thermal behavior of alkali metal carbonates has been investigated using differential thermal analysis. In the absence of decomposition products, the freezing points of Li_2CO_3, Na_2CO_3, K_2CO_3, Rb_2CO_3 and Cs_2CO_3 were established at $720\pm1°$, $854\pm1°$, $901\pm1°$, $873\pm1°$ and $792\pm1°$, respectively. Heat anomalies were observed in Li_2CO_3 at 410°, in K_2CO_3 at 422° and in Rb_2CO_3 at 303°. Unless the analyses were performed in a CO_2 atmosphere, additional heat effects occurred in Li_2CO_3 at 350° and in K_2CO_3 at 367° and 253°. The data obtained for K_2CO_3, in conjunction with other information, negate the published results for the solid system Na_2CO_3-K_2CO_3. The present studies provide a means for examining the binary systems alkali oxide-alkali carbonate.

Semi-Automatic Circuit Component Tester, F. C. Brammer, *Electrical Design News,* **III,** No. 8, 12-13 (August, 1958).

The necessity of evaluating the quality of the components after assembly in the thousands of printed wiring boards used in the manufacture of a high-speed digital computer has demanded the design of test equipment of unusual versatility in the testing of the several hundred different types of subassemblies involved.

The components are tested for conformity to specification by a go-no-go method on the basis that a component test is more valid than a functional test for this application.

The use of IBM punched cards to program the test eliminates extensive readjustments of the equipment in changing the testing from one type of subassembly to another.

Ten-Megapulse Transistorized Pulse Circuits for Computer Application, W. N. Carroll and R. A. Cooper, *Semiconductor Products,* **1,** No. 4, 26-30 (July-August, 1958).

Described are a group of ten-megapulse transistorized computer circuits which combine the simplicity of direct-coupled transistor logic and the speed of more complex circuitry.

These transformer coupled circuits operate in a parallel-organized pulse computer utilizing circuit techniques that minimize component count and the use of delay lines.

The Use of the IBM 704 in the Simulation of Speech Recognition Systems, G. L. Shultz, *December 1957 Proceedings of the Eastern Joint Computer Conference,* 214-218 (1958).

The first step in mechanical speech recognition involves the analysis of a large number of speech sounds to determine the characteristics by which these sounds may best be discriminated. To accomplish this analysis special advantage is taken of techniques made possible by the advent of the large-scale digital computer. This paper describes the equipment required to both facilitate editing samples of sounds for analysis and convert these sounds to digital form suitable as computer inputs. A system of programs is presented and the feasibility of the computer as a research tool is illustrated.

Variational Calculations of the 2^3S State of Helium, J. Traub* and H. M. Foley,** *Physical Review,* **III,** 1098-1108 (August 15, 1958).

With a 12-parameter, Hylleraas-type wave function containing only positive powers, a new calculation has been carried out for the 2^3S state of helium by the Ritz variational principle. The energy was minimized by a descent process. A nonrelativistic energy of -1.0876088 Hylleraas units was reached as compared with the best previously published value of -1.0876015 Hylleraas units from a 6-parameter function. When mass-polarization and $\alpha^2 R_y$ corrections are included, the 12-parameter function gives an ionization potential 2.52 cm^{-1} less than the experimental value of 38,454.64 cm^{-1}. The electron density at the nucleus is also calculated and compared with the experimental hyperfine spectrum value. All numerical work was carried out on an IBM 650 computer.

The authors have just completed an 18-parameter calculation of the energy of the 2^3P state of helium. The wave function was used to calculate fine-structure splitting. A paper giving the results will appear in the near future.

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Xerography, R. M. Schaffert, *Supplement to the Encyclopedia of Chemistry,* Reinhold Publishing Co., New York, N. Y., pp. 317-318 (September, 1958).

A brief description of the origin and development of the xerographic printing process is given, followed by a listing of the sequence of process steps. Preparation of the photosensitive surface is discussed, and a number of photoconductive materials used in xerographic plates are listed. Techniques for sensitizing the plates are briefly reviewed. A variety of developers are discussed. Applications of the process to X-rays and electron optics are mentioned.