April through June, 1958

IBM Technical Papers Published in Other Journals*

Advanced Maintenance Techniques for Digital Computers, *C. J. Hesner, Proceedings of the Electronic Industries Association Conference on Maintainability of Electronic Equipment,* University of Pennsylvania (May 27-28, 1958).

Maintenance on large-scale computing systems has reached a degree of complexity where trial-and-error methods must be abandoned. To cope with this problem, the SAGE Computing System has made extensive use of two sophisticated techniques. These are Diagnostic Programs and Marginal Checking.

The development of diagnostic programs involved considerable study on "worst patterns" for storage devices and critical rates of information flow. Reduced running times for programs was also an important factor. Examples of major achievements in these areas are summarized.

Marginal Checking is primarily a tool for error detection and prediction of future malfunctions but offers other useful by-products. Types of applications and significant results are discussed.

Algorithm for Analyzing Logical Statements to Produce a Truth Function Table, Harold Wolpe, *Communications of the Association for Computing Machinery,* **1,** No. 3, 4-13 (March, 1958).†

A method is set forth for the scanning and decomposition of statements made in the Boolean Algebra and subsequent analysis to create machine language program sections. The procedure is designed to produce a minimum number of instructions and is quite analogous to the scan and breakdown of normal algebraic statements in the FORTRAN system for the IBM 704.

†For the period January through March, 1958.

The Application of Transistors to Computers, R. A. Henle and J. L. Walsh, *Proceedings of the IRE,* **46,** No. 6, 1240-1254 (June, 1958).

This paper is a survey of some of the transistor switching techniques now in use, mainly the direct-coupled types. It includes a brief survey of the more important d-c and a-c transistor switching characteristics. It discusses the advantages and disadvantages of representative circuits in the broad resistance-coupled class, and describes the Direct-Coupled Transistor Logic circuits and the current-switching approach.

Attenuation of Gamma Rays from an Infinite Plane Source, M. G. Chasanov and M. Shatzkes, *Nucleonics,* **16,** No. 6, 6 (June, 1958).

A nomograph is presented to estimate attenuation of gamma rays from an infinite plane source. The buildups factor, B, is approximated by the expression $(1+b)$ where b is the product of the linear absorption coefficient μ and the shield thickness t. This approximation is applicable to gamma rays with energies up to 3 Mev. The nomograph is for elements other than lead. An expression is given for the attenuation factor for lead.

*The July issue of the *IBM Journal* included on page 255 an abstract by Slonczewski and Weiss. A footnote, indicating that Professor Weiss is at Rutgers University, was inadvertently omitted.

Automatic Implementation of Computer Logic, E. F. Morris and T. E. Wohr, *Communications of the Association for Computing Machinery,* **1,** No. 5, 14-20 (May, 1958).

A method is described for the use of a computer to help design circuitry for its successor. Specific circuits are synthesized, by the computer program, from an available stock of hardware to meet the necessary operating conditions and speeds. Hardware characteristics are stored in tables so that when the optimum circuit is realized there are actual components with these discrete values available.

Chirality of Tensors and Parity-Nonconserving Interactions, Yasutaka Tanikawa** and Satosi Watanabe, *The Physical Review,* **110,** No. 1, 289-290 (April 1, 1958). (Letter to the Editor)

It is shown that there necessarily exist two independent chirality operators, X, Y, in tensor calculus, and that any Lagrangian has to be invariant under the combined transformation $X \cdot Y \cdot P$, where P is the parity operator. The requirement that any interaction Lagrangian should be invariant under one of these three and noninvariant under each of the remaining two seems to delimit the possible types to a reasonable number of varieties as necessitated by experiments.

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Defense of the Strain-Energy Approach for Small Solute Atoms, A. S. Nowick, *The Physics and Chemistry of Solids,* **5,** 147 (1958). (Letter to the Editor)

This note discusses a paper by Oriani†† on the use of an elastic model which evaluates the energy of formation of primary metallic solid solutions as a strain energy. A critical analysis is made of Oriani's conclusion that the model is not consistent for the case of solute atoms that are smaller than the solvent atoms. This note points out that Oriani's argument fails to take into account that a macroscopic theory such as the elastic model must, to be complete, recognize the existence of some kind of a surface-energy term.

††R. A. Oriani, *Journal of Physics and Chemistry of Solids,* **2,** 327 (1957).

The Effects of Structural Part Design on Tooling for Sintered Metals Fabrication, Frank J. DeMaine, *ASTE Collected Papers,* **98,** 1958 (June, 1958).

Certain part design considerations for sintered metals which

are imposed by the tooling system are outlined. Other variables associated with the sintered metal process, and their influence on the product designer's judgment, are pointed out. Illustrations are given of tooling simplification methods which modify adverse compacting conditions before and during compacting. Case studies of parts and tool design problems from the Endicott Sintered Metallurgical Laboratory are introduced. Factors such as size, radial projections, re-entrant grooves, recesses, threads, reverse tapers, et cetera, are considered in the light of product design limitations. Powder-metallurgy considerations such as sintering, repressing (sometimes referred to as "coining" or "sizing"), various powder alloys and strength characteristics within various density ranges, are discussed for certain mechanical applications. Complexity of various shapes in relation to magnitude of part size are reviewed. Abrasive effects of powder friction on tool materials are examined with the objective of obtaining tolerances compatible with the powder-metal process. Size changes which occur during sintering are discussed for a variety of sintering ranges, alloys and densities. Prerequisites for designing workable parts are described, stressing constructive collaboration between the metallurgist, product designer, tool designer, and tool fabricator.

Efficient Precision Current Regulator for Low-Voltage Magnets, Richard L. Garwin, *The Review of Scientific Instruments,* **29,** No. 3, 223-224 (March, 1958).

A simple, inexpensive current regulator has been built using power transistors and a chopper amplifier to regulate magnet currents to $<0.001\%$. Thus far, the regulator has been used to 20 amp and 40 v, and at $\sim$100 amp and $\sim$200 v. With minor modifications, it will give very much better regulation.

Electronic Data Processing Machines Simplify Instrument Calibration Scheduling, W. A. Lawrence, *Industrial Quality Control Magazine,* **14,** No. 11, 32-36 (May, 1958).

Electronic data processing machine methods applied to periodic scheduling of instrument calibration provide: complete work scheduling; automatic individual work assignment; a minimum of clerical work by technicians; accurate maintenance records; compilation of reports for departmental operations analysis; monthly inventory; and a minimum of clerical help in the handling of approximately 5000 pieces of test equipment.

Error Checking for Five-Channel Telegraphic Tape, R. A. Barbeau, *Communications and Electronics,* **36,** 190-193 (May, 1958).

This report describes a complete, practical, error-detection system for paper tape. The system is aimed primarily at compatibility with existing commercial communications facilities. Conventional error handling in accounting systems is time-consuming and costly, because error detection is normally done at a point later than tape conversion. The checking system described here allows for error detection by unit record during the conversion process. Considerable time is saved because only the records in error are reprocessed or retransmitted.

The paper discusses the systems problems, including the areas where errors occur, and the design goals selected as being particularly important. It then describes in detail the following items: preparation of the checkable tape, error deletion, checking code, automatic cycles, redundancy checking, reliability checks, error detection during conversion, and unit record control.

Isotopic Mass Ratios, Magnetic Moments and the Sign of the Electric Dipole Moment in Carbon Monoxide, A. H. Nethercot, Jr., B. Rosenblum,* and C. H. Townes,† *Physical Review,* **109,** No. 2, 400 (January 15, 1958).††

Precision measurements of the $J=1\leftarrow 0$ rotational frequencies and the molecular magnetic moments for various isotopic species of carbon monoxide have been made in order to determine isotopic mass ratios. A correction amounting to several hundred micromass units and evaluated from the magnetic moment has been applied for the fact that the electrons are not spherically distributed about their respective nuclei. It is also shown that the rapidly precessing electronic angular momentum causes a "wobbling" motion of the nuclei which in turn produces a stretching of the molecule ("wobble stretching") inversely proportional to the reduced mass of the molecule, but independent of J. This stretching cannot be accurately evaluated from theory and therefore appears to be the ultimate limitation on microwave determinations of mass ratios. This correction amounts to about 20 micro-mass units and is evaluated by the use of the nuclear reaction value for the C^{14}/C^{12} mass ratio. The final mass ratios agree very closely with the nuclear reaction values.

The sign of the electric dipole moment was determined from the relative magnetic moments of the several isotopic species and corresponds in the charge distribution, $C^{-}O^{+}$. This appears to be the first measurement of the sign of the electric dipole moment in any molecule.

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Ordering Kinetics in Long-Range Ordered Cu_3Au, R. Feder,* M. Mooney* and A. S. Nowick,† *Acta Metallurgica,* **6,** 266 (April, 1958).

The kinetics of the change of order in a partly long-range ordered Cu_3Au alloy, when the temperature is varied below the critical temperature, are studied in the range 210°-290°C by means of precision lattice-parameter measurements. These data, and the results of Weisberg and Quimby for the range of temperature above 290°C, are analyzed in terms of the second-order kinetic equations predicted from the theory presented in a previous paper. The results show that the theory is obeyed remarkably well, in particular that the rate constant, α, which appears in the kinetic equations, varies exponentially with the reciprocal absolute temperature up to 320°C. The plot of log α vs. T^{-1} gives an activation energy of 2.03 eV and a frequency factor of $3.6 \times 10^{14}\,\mathrm{sec}^{-1}$. In addition, the variation of ordering energy with the long-range order parameter is estimated. It is found that the energy to produce a wrong Cu-Au pair in the otherwise perfect alloy is in the vicinity of 0.4-0.5 eV. This value is in good agreement with that obtained from calorimetric measurements, when the latter are corrected for the residual short-range order present above the critical temperature.

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A Machine Method for Square-Root Computation, R. W. Bemer, *Communications of the Association for Computing Machinery,* **1,** No. 1, 6-7 (January, 1958).††

This paper describes a variation of Newton's method, which is particularly suited to computers with operations that have variable execution times. For various numbers of digits of accuracy, tables are given for the coefficients of linear first approximations such that convergence to the desired accuracy occurs in 2 iterations, causing a fixed and predetermined execution time.

††For the period January through March, 1958.

Paramagnetic Resonance Absorption in Mn-Activated Hexagonal ZnS, S. P. Keller, I. L. Gelles, and W. V. Smith, *Physical Review,* **110,** No. 4, 850-855 (May 15, 1958).

The absorption spectrum of divalent Mn incorporated into hexagonal ZnS has been determined. The anisotropic behavior of the absorption has been measured, yielding the crystalline field parameters $D=113\pm2$ and $F=-8.1\pm1$ oersteds. The g value and hyperfine splitting were observed to be isotropic, with values respectively of 2.0016 ± 0.0001 and of -70 ± 1 oersteds.

Production of Beams of Polarized Protons by the Acceleration of Protons Derived from Polarized Hydrogen Molecules, R. L. Garwin, *The Review of Scientific Instruments,* **29,** No. 5, 374-376 (May, 1958).

A conventional Stern-Gerlach separation of hydrogen molecules is proposed for supplying of a radio-frequency or PIG ion source of standard type to produce microampere beams of polarized protons for acceleration in electrostatic accelerators, cyclotrons, et cetera. The long nuclear relaxation time of molecular hydrogen gas allows the accumulation of polarized protons (as molecules) for the production of microampere average beams by means of a pulsed-ion source. The polarized protons after acceleration have the energy- and angular-spread characteristics of the machine with which they were accelerated. There is no apparent reason why polarized H^- may not be produced in the same strong-field rf ion source, accelerated in a weak field to preserve polarization and stripped in a tandem machine, all without significant depolarization.

Rate Processes and Low-Temperature Electrical Conduction in n-Type Germanium, Seymour H. Koenig, *The Physical Review,* **110,** No. 4, 986-988 (May 15, 1958). (Letter to the Editor)

Data are given for the variation of dc and pulse current density n-type germanium with applied electric field in the range 4.55° to 8.33°K, showing a sharp rise in current at a critical "breakdown" field. Data are also given for the variation of time constant for response to a small step voltage vs. the dc bias current for lattice temperatures of 5.0° to 10°K. The data show that both the steady-state and transient behavior may be quantitatively understood by assuming that the electron "temperature" follows changes in electric field in $\lesssim 10^{-9}$ sec and that the carrier density at any time is then determined by a rate equation involving thermal generation, impact ionization and the corresponding inverse processes which have values depending on the electron "temperature" appropriate to the particular electric field and on lattice temperature. Incidental to this is the prediction that the "breakdown" field should then decrease when more donor impurities are added at constant values of N_A, as long as the donor density is low enough so that neutral impurity scattering is not significant in determining the mobility.

Recombination of Thermal Electrons in n-Type Germanium below 10°K, Seymour H. Koenig, *The Physical Review,* **110,** No. 4, 988-990 (May 15, 1958). (Letter to the Editor)

The rate of recombination of B_T of an electron with an ionized donor, averaged over a thermal distribution for the electron, has been measured in n-type germanium as a function of lattice temperature in the range 4° to 10°K. The experimental details show how results of B_T for thermal electrons were obtained and indicate how these techniques can be extended to obtain the dependence of B_T on electron temperature. The experimental cross section is in qualitative agreement with the theory of Lax* for this temperature range. Recombination on this model involves capture in an excited state as the result of an appropriate, but improbable, energy-losing collision, followed either by a cascade of transitions to the ground state or by an "immediate" ejection of the electron (by absorption of a phonon) into the conduction band with no net contribution to the recombination rate.

*M. Lax, *Bulletin of American Physical Society,* **Ser. II,** No. 1, 128 (1956).

A Simple Treatment of Ordering Kinetics, A. S. Nowick* and L. R. Weisberg,† *Acta Metallurgica,* **6,** 266 (April, 1958).

The differential equation for the kinetics of ordering, derived by Dienes from chemical rate theory, is simplified, by making suitable approximations, into a second-order differential equation whose solutions are hyperbolic functions. It is shown that these functions adequately describe the data for changes in long-range order of Cu_3Au. It is further shown that the rate constant, α, which appears in these equations is given to a good approximation by an Arrhenius-type equation in which the frequency factor and activation energy have simple interpretations.

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Study of Order in Annealed and Irradiated Alpha Brass by Lattice Parameter Measurements, R. Feder,* A. S. Nowick, and D. B. Rosenblatt,* *Journal of Applied Physics,* **29,** 984-988 (June, 1958).

The increase in short-range order in alpha brass (25% and 30% Zn) produced by thermal treatment or neutron irradiation is accompanied by a measurable decrease in lattice parameter (up to 0.02%). The equilibrium values of the lattice parameter decrease markedly with annealing temperature in the lower range of the measurements, i.e., in the vicinity of 125°C. The activation energies calculated from the kinetics of the lattice parameter changes are 40.7 kcal/mole for the 25% Zn alloy, and 39.5 kcal/mole for the 30% Zn alloy, in agreement with results of anelastic measurements and electrical resistivity studies. From thermodynamic data it is estimated that a decrease in lattice parameter of 0.01% corresponds to an increase of about 0.05 in the Bethe short-range order parameter.

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A Subroutine Method for Calculating Logarithms, R. W. Bemer, *Communications of the Association for Computing Machinery,* **1,** No. 5, 5-7 (May, 1958).

A new method is described and suitable tables given for the computation of logarithms on either decimal or binary computers. The principle lies in the multiplication of the argument by successive multipliers from a table until the modified argument lies between 1 and $1+\Delta$, where Δ is sufficiently small so that the Taylor's series expansion for log $(1+x)$ can be reduced to a minimum number of terms by Tchebysheff relaxation. The true logarithm is the evaluation of the polynomial approximation minus the logarithms of the various multipliers, which are also carried in the table. This method is best used on computers with variable execution times, where multiplications by very few digits or bits are essentially as fast as addition.

Synthetic Sampling—A Way to Predict Circuit Reliability and to Automate Design, L. Hellerman and M. P. Racite, *National Convention Transactions, Twelfth Annual Convention of the American Society for Quality Control,* 357-382 (May 26-28, 1958).

A new approach to the problem of designing reliability into an electronic circuit is the method of synthetic sampling. It is superior to the commonly used "worst-case" design philosophy, which is characterized by the requirement that the circuit operate reliably when the components are at specified adverse limits. The following shortcomings of the worst-case philosophy are considered:

1. It makes no distinction between the probability of mean and extreme outputs.
2. If a circuit can fail in more than one way, no distinction is made between the probabilities of failure from the different causes.
3. It provides no measure of reliability.

Synthetic sampling does not have these weaknesses. It automatically weighs each output with its probability, and it gives the reliability of the circuit based on the actual component distributions. The method is illustrated by application to a typical transistor switching circuit.

Variable-Width Tables with Binary-Search Facility, Mark Halpern, *Communications of the Association for Computing Machinery,* **1,** No. 2, 1-3 (February, 1958).*

Table forming and searching operations are among the most vital to efficient internal operation of computer programs. Specifications are given for a family of subroutines, independent of computer type, which automatically perform these functions for the programmer.

*For the period January through March, 1958.