

Technical Papers by IBM Authors Published Recently in Other Journals

Acoustic-Mode Scattering Mobility of Holes in Diamond-Type Semiconductors, Martin Tiersten,* *Journal of the Physics and Chemistry of Solids* **25**, 1151-1168 (November, 1964).

The mobility of holes scattered by acoustic phonons in a diamond-type semiconductor, and specifically in germanium, has been calculated using matrix elements calculated, in a previous paper, as a function of the three applicable deformation potentials. The matrix elements, and hence the scattering times and the mean free paths, were represented by expansions in Cubic Harmonics. No "spherical symmetry" approximations were made and the calculation provides a critique, on the basis of the rate of convergence of the expansions, of such approximations. The experimental values $a = 2.0$ eV, $b = -2.1$ eV, and $d = -7.0$ eV were used for the deformation potentials in germanium, and the acoustic-mode drift mobility was calculated to be 3.13×10^4 cm²/volt-sec at 100°K. The available experimental value is 3.38×10^4 .

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Analysis of a One-Tunnel-Diode Bistable Circuit with a Counting Property, T. W. Collins, *Solid State Design* **5**, No. 12, 27-31 (December, 1964).

This paper is concerned with the analysis of a one-tunnel-diode bistable circuit, pulsed with unidirectional input pulses. It contributes the use of piecewise linear analysis to explain the switching action of the circuit and the derivation of design equations which establish certain conditions—the correct value of external inductance, the correct bias arrangement, the correct amplitude and duration of the input pulse and the maximum repetition rate—for correct operation of the circuit. Finally, experimental results are given to verify the analysis.

Analysis of a Proposed Bistable Injection Laser, G. J. Lasher, *Solid State Electronics* **7**, No. 10, 707-716 (October, 1964).

The operation of a proposed bistable injection laser is analyzed. The device consists of a Fabry-Perot injection laser whose plated p -contact is divided into two electrically isolated portions by a slit parallel to the light-reflecting sides of the crystal. An injection current is passed through one contact. The other is biased so that a negligible injection current flows through the junction beneath it, which then acts as a nonlinear absorber of light. Under proper conditions, the laser will have two states: in one, it emits coherent light and in the other, only spontaneous light, both being stable for the same injection current. Switching between states is possible with electrical pulses or incident light. The

analysis is done for liquid helium temperatures and for the recombining electrons lying in an exponential conduction band tail, and for liquid nitrogen temperature and parabolic valence and conduction bands. In both cases, the analysis predicts bistable operation for certain conditions and favors a ratio of absorbing contact length to emitting contact length greater than unity.

A Comment on "Some Structure-Property Relationships in Thin Magnetic Films," E. I. Alessandrini, J. F. Freedman and K. Y. Ahn, *Journal of Applied Physics* **35**, 3051-3052 (October, 1964).

Structure data presented in the paper "Some Structure-Property Relationships in Thin Magnetic Films" by K. Y. Ahn, G. S. Ansell, C. J. Barton and W. R. Beam, *J. Appl. Phys.* **35**, 1187 (1964) were analyzed. It was shown that the calculated values for the extra reflections attributed to long-range ordering on annealing permalloy films at temperatures below 300°C were not in agreement with the parameter values for the normal face-centered cubic reflections of the same structure. Experimental results were presented to show long-range ordering in permalloy films and the results obtained by K. Y. Ahn, et al. were attributed to impurities in their films.

A Comparison of Alternative Estimators for Simultaneous Equations, Gregory C. Chow, *Econometrica* **32**, No. 4, 532-553 (October, 1964).

A natural generalization of least squares is proposed to estimate parameters in simultaneous linear equations. Full-information maximum likelihood is shown to be identical with this generalization. The extent to which other estimators deviate from the generalization is discussed. A paradox of Strotz is resolved, and application of canonical correlation theory to structural equations is indicated.

Computer-Aided Kinematic Analysis of General Planar Mechanisms, E. W. Rosencrans, *Proceedings of the ASME Mechanisms Conference* **64**, No. 31, 1-8 (October, 1964).

A method is presented for obtaining the kinematic analysis of a general planar mechanism utilizing a computer. The mechanism consists of a combination of basic kinematic elements such as links, sliders, gears, belts and pulleys, cams, clutches, and so on. The input specifications to the computer that define the kinematic elements and describe the assembly procedure are outlined. A four-bar mechanism is used as an example to prove program feasibility. Numerical and graphical results are presented.

A Computer-Oriented Mechanical Design System, L. F. Knappe, *Proceedings of the ASME Mechanisms Conference* 64, No. 30, 1-9 (October, 1964).

This paper is a report on the development of an engineer-computer mechanical design system called COMMEND. The initial system is restricted to the design of planar or equivalent planar mechanisms and implemented on presently available computer equipment. The paper discusses the problems encountered in utilizing a computer in the mechanical design process and the system approach taken for this project. Design system programs are discussed along with examples. Anticipated benefits of the design system are also reviewed.

Data Processing in Cardiovascular Physiology with Particular Reference to Roentgen Videodensitometry,† E. H. Wood,* R. E. Sturm** and J. J. Sanders, *Mayo Clinic Proceedings* 39, No. 11, 849-865 (November, 1964).

This presentation (1) describes briefly why and how the Physiology Laboratory of the Mayo Clinic became involved in electronic data processing and related computer techniques, (2) describes some of the equipment used in this data-collecting and analysis system, which is still being evolved, and (3) by means of a specific example, namely the roentgen videodensitometer project, gives some idea of how the system works and perhaps some insight into (a) the very powerful tools these devices constitute and (b) their tremendous potential application both in investigative projects and also in practical diagnostic techniques for, among other things, detecting and assessing the magnitude of hemodynamic abnormalities.

† This study was supported in part by Grant NsG-327 from the National Aeronautics and Space Administration, Air Force Contract AF 33 (657)-8899, and by Research Grant H-3532 from the National Institutes of Health.

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The Decomposition of Stochastic Automata, G. C. Bacon, *Information and Control* 7, No. 3, 320-339 (September, 1964).

Finite-state stochastic sequential systems, which are interconnections of two or more component systems, exhibit a special structural property in their transition matrices as a consequence of the statistical independence of the next states of the component systems, given the present states and the input to the interconnection. Along with the concept of a "lumpable" stochastic matrix, this structural property is of central importance to the decomposition theory presented. These ideas allow a generalization to the stochastic case of the definitions used by Hartmanis in his study of the decomposition of conventional switching circuits. With these definitions we are able to prove decomposition theorems for stochastic automata which reduce to those of Hartmanis in the deterministic case.

Degradation of Planar Junctions During Reoxidation, F. Barson, W. J. Armstrong, and M. E. Mutter, *Journal of the Electrochemical Society* 3, No. 11, 1263-1266 (November, 1964).

Planar junctions in silicon can be degraded electrically by the growth of an oxide on the surface, particularly if the oxidation is carried out at low temperatures and at rapid rates. It is suggested here that the mechanism of degrada-

tion involves the formation of shallow dislocation loops due to dopant pile-up at the surface as the oxide grows, followed by the precipitation of fast-diffusing impurities about these defects. High-temperature oxidation, especially at low growth rates, minimizes this problem.

Design and Analysis of Mechanical Components with Computers, M. A. Howard, *Proceedings of the ASME Mechanisms Conference* 64, No. 29, 1-7 (October, 1964).

A computer program concept is described that enables the engineer-designer to utilize a computer in the performance of repetitive design and analysis calculations for mechanical components. The components included were selected on the frequency of their occurrence as design problems and the amount of reiterative calculations and decisions normally required for a design solution. The program logic is designed to accept component functional parameters and/or optional physical size parameters or operating conditions to provide information for part drawing specifications, quality assurance information and analysis data for evaluating the design. The programs, used separately or as subprograms in a more complex computer-aided design systems, provide design flexibility to accept the majority of the problems that arise for a particular component.

The Determination of the Components of a Tensor Characterizing a Crystal, Paul Erdős, *Helvetica Physica Acta* 37, No. 4/5, 493-504 (1964).

A method is given which permits the explicit determination of the components of a tensor describing the physical properties of a crystal in terms of a minimum number of constants. The application to the theory of the deformation potential of charge carriers in solids is indicated.

Discussion on the paper by D. A. Sawyer and L. E. Grinter entitled "Minimum Weight Plastic Design of Continuous Frames," Jacques Heyman* and William Prager, *Journal of the Engineering Mechanics Division—Proceedings of the American Society of Civil Engineers* 90, No. EM 5, 459-461 (October, 1964).

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Dynamics of New Product Campaigns, H. D. Mills, *Journal of Marketing* 28, No. 4, 60-63 (October, 1964). Introducing a new consumer product on a nationwide basis is much like playing a game of stud poker. Consumer reaction early in the campaign, when sufficiently well understood, can provide vital clues in accelerating or cutting off product promotion as required for maximum impact to corporate objectives. The major fact of life for new consumer products in our competitive economy is that most of them fail. Yet, every single one of these new products is originally launched with much enthusiasm and seemingly good reason. Indeed, the greater the enthusiasm and the higher the hopes, the more difficult it is to recognize a failure. First, there is a trade retailing pipeline to fill; second, a consumer trial period; and eventually, some combined trade-consumer level of acceptance emerges. The early trade

shipments and consumer sales may tell little about the final outcome. A million units sold means something quite different if a million consumers have tried once, or if half that many have tried and repeated.

Electron-Spin Resonance of Neutral Hydrogen Atoms in SrF_2 and BaF_2 , Benjamin Welber, *The Physical Review* **136**, A1408-A1412 (November 30, 1964).

The electron-spin resonance spectra of SrF_2 and BaF_2 , each containing neutral hydrogen atoms in interstitial sites, is investigated. In all cases, the electron-proton contact hyperfine interaction is resolved. Also resolved are the smaller superhyperfine interactions with the nuclei of the eight neighboring F^- ions. It is found that the magnitude of these interactions is very sensitive to the host lattice. In particular, the superhyperfine interaction decreases by about a factor of two as one proceeds from smallest to largest lattice parameter. It is also found that the difference between the electron-proton interaction parameter B and the corresponding quantity for the free atom is positive, and decreases from 39.9 ± 0.1 Mc/sec for CaF_2 to about 4.1 ± 0.1 Mc/sec for BaF_2 , at room temperature. Forbidden transitions corresponding to simultaneous flips of the electron and an associated fluorine nucleus were also observed, and the intensity of these is discussed in terms of the effective magnetic fields acting on the F^- sites.

Ergodic and Mixing Properties of Chebyshev Polynomials, R. L. Adler and T. J. Rivlin, *Proceedings of the American Mathematical Society* **15**, No. 3, 794-796 (1964).

The Chebyshev polynomials can be considered as many-to-one mappings of the interval $[-1, 1]$ onto itself. This paper shows that with an appropriate measure put on this interval they become a strongly mixing measure preserving sequence of transformations and that, consequently, each individual mapping is strongly mixing and hence ergodic.

Evaluation of Semiconductors Through Angle Sectioning and Junction Delineation, J. J. Gajda, *Semiconductor Products and Solid State Technology* **7**, No. 11, 17-21 (November, 1964).

With increasing microminiaturization of semiconductor devices, new techniques of microsectioning have become necessary. A technique has been developed to angle-section most types of semiconductor devices. Angle sectioning permits deeper probing into the metallurgical aspects of these devices by increasing the magnification factor. The technique is presently used on SLT components that have failed at different stages of manufacture and has applications in the general field of metallurgy also.

Exciton Absorption and Emission in InP ,† W. J. Turner, W. E. Reese, and G. D. Pettit, *Physical Review* **136**, A1467-A1470 (November 30, 1964).

Sharp peaks due to exciton formation have been observed in the intrinsic optical-absorption-coefficient data for undoped indium phosphide at 6, 20 and 77°K. At 298°K, the absorption data do not show a peak, because of thermal broadening. Low-temperature photoluminescence data obtained on the same InP used for absorption data exhibited

an exciton emission peak at the same energy as the absorption peak and confirm the earlier identification of the emission line due to Turner and Pettit. At 6 and 77°K, the exciton peak energies are 1.416 and 1.409 eV, respectively. From the absorption data, the exciton binding energy at both temperatures is 0.0040 eV. The temperature dependence of the gap in the linear region above 100°K is -2.9×10^{-4} eV/°K, in sharp disagreement with the earlier value of Oswald.

† The work of W.E.R. and G.D.P. was supported as part of Project Defender under the joint sponsorship of the Advanced Research Projects Agency, the U. S. Office of Naval Research, and the U. S. Department of Defense.

An Executive System Implemented as a Finite-State Automaton, Roy E. Heistand, *Communications of the Association for Computing Machinery* **7**, No. 11, 669-667 (November, 1964).

The 473L Command and Control System used by the Air Force permits many operators to access large data files through the use of a computer. The man-machine interface is satisfied by several communication consoles from which operators may enter queries and view replies. A data link permits remote stations to send messages, status reports and inventories directly to the computer. The information received over the online data link is used to update the data files which are stored on disk.

The 473L Programming System is divided into an Executive Control Program and five components with different processing priorities. These priorities permit the system to be most sensitive to the console inputs and permit the operators at all the consoles to time-share the central processor. The Executive Control Program provides for the orderly transitions of control among the programming system components. The major emphasis of the paper is on the technique of using the definition of a finite-state automaton for organizing the Executive Control Program.

Eye Movement Patterns as a Function of Previous Tachistoscopic Practice, A. Schaffer and J. D. Gould, *Perceptual and Motor Skills* **19**, No. 3, 701-702 (December, 1964).

Eye movement patterns during a scanning task were compared for Ss with over 100 hr practice in tachistoscopic experiments and Ss with no such practice. The task consisted of scanning numeric matrices to determine the frequency of appearance (0 to 7) of a predesignated digit. The tachistoscopically practiced group scanned more quickly and made significantly fewer fixations per matrix, but made significantly more errors. Both groups showed significant variation in scan time as a function of the particular digit scanned for and as a function of frequency of appearance of the digit being scanned for.

A Formal Description of System/360, A. D. Falkoff, K. E. Iverson and E. H. Sussenguth, *IBM Systems Journal* **3**, No. 3 198-262 (1964).

All System/360 functional characteristics having programming significance are completely and concisely described. The description, which is formal rather than verbal, is accomplished by a set of programs, interacting through common variables used in conjunction with auxiliary tables.

The language used in the programs involves operators and

notation selected from mathematics and logic, together with additional operators and conventions defined to facilitate system description. Although the formal description is complete and self-contained, text is provided as an aid to initial study. Examples to illustrate the application of the formal description are given in an appendix.

FORTRAN, J. W. Backus and W. P. Heising, *IEEE Transactions on Electronic Computers* **EC-13**, No. 4, 382-385 (August, 1964).

The fundamental concepts of FORTRAN, the most widely used high-level, scientific programming language, are set forth and the significant characteristics are described in historical order from inception of FORTRAN in 1954 to the present time. The basic problem of how to get high quality programming from an easy-to-write high-level language is emphasized.

FORTRAN vs Basic FORTRAN, W. P. Heising, *Communications of the Association for Computing Machinery* **7**, No. 10, 590-625 (October, 1964).

This paper gives working drafts of two levels of FORTRAN (Basic FORTRAN as a subset of full FORTRAN). These documents were prepared by the American Standards Association Subcommittee X3.4.3-FORTRAN.

Eine Gabelschaltung für Nanosekundenimpulse zur Herabsetzung der Schreibstörung in einem Magnetschichtspeicher (A nanosecond pulse balancing circuit for bit noise reduction in a thin film memory), Dieter Seitzer, *Archiv der Elektrischen Übertragung* **18**, No. 10, 577-584 (October, 1964).

The write-noise voltage appearing in the readout channel of a word-organized magnetic film memory limits the shortest cycle time of the memory. A circuit is described which substantially protects the readout amplifier from the write-noise voltage and which itself has a recovery time of 20 nsec. It contains a balanced setup of tunnel diodes which limit the write-noise voltage in a nonlinear manner and amplify the readout signal as active elements. This makes possible the use of a common bit sense line.

Measurements show a bit-noise rejection ratio of more than 35 dB even with 10% asymmetry of the write-noise voltage. When operated in connection with a memory model up to 20 Mc/sec repetition frequency is obtained for write/read and up to 74 Mc/sec for nondestructive readout alone.

A General Expression for Electrostatic Induction and its Application to Semiconductor Devices, J. B. Gunn, *Solid State Electronics* **7**, 739-742 (October, 1964).

A new formula is deduced, under rather general conditions, for the charges induced upon a system of conductors by the motion of a small charge nearby. The conditions are found under which the result can be simplified to yield various previously derived formulas applicable to the problem of collector transit times in semiconductor devices.

Generation and Use of Mechanical Step Transients in Dynamic Measurement, E. C. H. Becker and H. D. Conway,* *British Journal of Applied Physics* **15**, No. 10, 1225-1231 (October, 1964).

An obstacle to the analysis and synthesis of dynamically loaded structures is the difficulty of measuring the lumped mechanical circuit constants over a sufficiently wide frequency band. This article describes a technique for measuring the wide frequency band mechanical impedances of small structures utilizing a Hopkinson pressure bar. One of the difficulties in using a Hopkinson pressure bar is to obtain absolutely plane contact between the plane ends of the impacting bars. Effective means of achieving this are described.

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A High Frequency Multiple Signal Conductor Transmission Line, R. C. Paulsen and W. K. Springfield, *Electrical Design News, Packaging Reference Issue* **9**, 78 (October, 1964).

The application of a multiple signal conductor transmission line for use in modern high speed miniaturized computers is discussed. Electrical and mechanical requirements are outlined. Design aspects showing analytical and experimental results with analog techniques on round and flat wire configurations are reviewed. Noise coupling, characteristic impedance, loss and propagation delays versus frequency, and termination aspects are considered.

The IBM Hypertape System, B. E. Cunningham, *AFIPS Conference Proceedings, Fall Joint Computer Conference* **26**, 423-434 (1964).

The Hypertape System consists of the IBM 7640 Tape Control Unit and the IBM 7340 Tape Drive. The 7640 has two channels which time share a single read and a single write section, and each can control up to ten 7340's. The 7340 description will include such features as: tapes fully enclosed in a cartridge, automatic cartridge loading, programmable file protect, and cartridge operations. The 7640 is attached to the computer channel through the Simplex I/O Interface (33 lines). Four commands (Read, Write, Control, and Sense) initiate the operations available on the interface. The 7340 writes ten bits across tape (8 information and 2 check bits). Phase-encoding recording and the two check bits allow correction of all single errors and most double errors. The 7640 has extensive servicing facilities for off-line testing in CE Mode. Also, diagnostic programs can utilize some of these facilities on line if the 7640 is operated in the Diagnostic Mode, rather than the normal Ready Mode.

A modified version of the Hypertape System, for use as I/O with the new IBM System/360, is also described briefly.

IBM System/360 Engineering, P. Fagg, J. L. Brown, J. A. Hipp, D. T. Doody, J. W. Fairclough and J. Greene, *AFIPS Conference Proceedings, Fall Joint Computer Conference* **26**, 205-231 (1964).

The design philosophy of the IBM System/360 represents a unique system approach to computing. This paper describes the engineering considerations that influenced the development of this system. A brief description of the IBM System/360 models and the reasons for the various key

decisions made in implementing them in a particular manner are also discussed.

Emphasis is given to describing some of the more novel features of the System/360 such as the microcoding techniques utilized for control logic and for emulating certain other IBM systems (for example 1401), as well as the logical organizations utilized to achieve high speeds.

Incorporation of Zinc in Vapor Grown Gallium Arsenide, V. J. Silvestri and F. Fang, *Journal of the Electrochemical Society* **111**, No. 10, 1164-1167 (October, 1964).

A vertical sealed tube configuration has been used to deposit epitaxially Zn-doped GaAs on Te-doped substrates. The vapor grown junctions were characterized through capacitance measurements. Linearly graded, nonuniform, and abrupt impurity profiles were observed. The nature of these junctions is shown to correlate with the zinc dopant concentrations present in the vapor. The distribution of zinc between the vapor phase of solid GaAs was determined for the junction growth conditions, and this distribution was found to follow Henry's law for the range investigated. The results of these investigations indicate that autodoping phenomena are involved in producing the variety of junctions observed.

Internal Strain in Elastically Strained Germanium and Silicon, I. Longitudinal Case, Armin Segmüller, *Physik der Kondensierten Materie* **3**, No. 1, 18-28 (1964).

X-ray diffraction of "forbidden" reflections in elastically strained germanium and silicon shows that the four nearest neighbor bonds are not strained according to the strain tensor but rather keep their length almost unchanged because of the occurrence of an internal strain. Consequently the bond angles are changed. From the structure factor of the (600) reflection, this internal strain has been found to be in good quantitative agreement with theoretical calculations.

Kinetic Motion Analysis of Function-Generating Plane-Mechanisms, W. Rehwald, *VDI-Forschungsheft* **30**, No. 503, 36 (1964).

After preliminary considerations with regard to the "kinetic motion analysis," the "transfer functions from zero up to second order" for all important coordinates of four-link mechanisms are derived from the functional dimensions and used for representing the kinematic values. From the kinetic basic equations and the kinetic energy, the dependency on time is given for all geometrical and kinematic values as well as for the mass reduction and the forces reduction. All equations are represented in such a manner that arbitrary plane mechanisms with four swivel joints or with three swivel joints and one sliding joint can be evaluated on program-controlled electronic computers using only one program.

Ligand Effects on the Directed Polymerization of Butadiene by Palladium Salts in Aqueous Media, W. A. Hewett and A. J. Canale,* *Polymer Letters* **2**, 1041 (November, 1964).

It was previously shown that a water solution of PdCl_2 catalyzed the polymerization of butadiene to a low molecular weight polymer with a high 1, 2-microstructure. With a

proper choice of ligands in the palladium system, structural control has now been achieved ranging from 98% 1, 2- to 85% trans-1, 4-polybutadiene.

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Magnetic Properties of Superconducting Films, R. C. Casella and P. B. Miller, *The Physical Review* **136**, A928-A937 (November 16, 1964).

The general Gor'kov equations are solved for a superconducting film in a parallel magnetic field. The method determines the best pairing in the superconducting state without the need for ad hoc assumptions about pairing such as used in other theories. The critical field $H_c(T)$ and energy gap $\Delta(H, T)$ are determined for temperatures near the transition temperature at zero field T_c . The energy gap in the quasi particle excitation spectrum is shown to be approximately equal to the spatial average of the order parameter. For films whose thickness d is less than the coherence length ξ_T the Gor'kov equations are nonlocal and differ from the Ginzburg-Landau (GL) equations. In this range we find $H_c \propto d^{-3/2}$ in agreement with experiment. For films with $d > \xi_T$ the solution of the Gor'kov equations are the same as the GL results, as expected, since this is a local regime. We find that for all d (excepting ultra-thin films) and in the temperature range $(1 - T/T_c) \ll 1$ the field dependence of the energy gap is the same as that given by the GL equations $[\Delta(H)/\Delta(0) = \{1 - (H/H_c)^2\}^{1/2}]$. Thus, nonlocal effects do not change the field dependence of the gap. Most of the experimental data are in accord with this equation. However some recent results for aluminum films show deviations which we interpret as probably being due to the important role played by energy level quantization of single particle states in ultra-thin films. The extension of the method to lower temperatures and higher fields is also discussed.

Method of Control for Re-Entrant Programs, G. P. Bergin, *AFIPS Conference Proceedings, Fall Joint Computer Conference* **26**, 45-55 (1964).

The use of on-line consoles may require routines to permit multiple entrances and executions before prior executions are completed. Routines which permit multiple entrances of this nature are called re-entrant.

This paper defines the major problem involved in utilizing re-entrant routines, and suggests a method of monitor control. Programming conventions needed within the re-entrant routines are also discussed. The proposed method makes use of list structures to keep track of re-entrant routine usage. It is hoped that this scheme can serve as the basis of a computer implementation to determine the actual monitor and routine overhead.

The Method of Estimating Delay in Switching Circuits and the Figure of Merit of a Switching Transistor, K. G. Ashar, *IEEE Transactions on Electron Devices* **ED-11**, No. 11, 497-506 (November, 1964).

A simple method of estimating delay in a switching network is outlined. The simplicity of formulas thus obtained makes them readily applicable for circuit comparisons or device optimization purposes. It is shown that a term involving the product of base resistance and diffusion capacitance forms a major limitation on high speed, voltage-driven circuits. This method is applicable to a general class of switching problems.

A Method of Syntax Specification, Kenneth E. Iverson, *Communications of the Association for Computing Machinery* 7, No. 10, 588-589 (October, 1964).

The addition of four simple conventions to the Backus Normal Form specification of a language provides a mode of description which is more compact and easier to prepare and use than either the standard BNF description or the corresponding syntactical chart. The use of these conventions is illustrated by a one-page specification of ALGOL 60 as revised in 1963.

Multiple Light Scattering by Spherical Dielectric Particles, D. H. Woodward, *Journal of the Optical Society of America* 54, No. 11, 1325-1331 (November, 1964).

A multiple light scattering theory based on the Mie single scattering theory for spherical particles is presented. The theory predicts the magnitude and form of the angular distribution of scattered intensity for high volume concentrations of scattering spheres. The theory applies to all sizes of scattering spheres with any index of refraction and includes the effects of polarization. Experimental data for the multiple scattering for various volume concentrations of monodisperse polystyrene latex particles are compared with calculations of the theory. The results indicate that the theory is a valid general multiple light scattering theory for fairly high concentrations of spherical scattering particles.

Nature of the Crystalline Solid at Elevated Temperatures,† R. Brout,* S. Nettel** and H. Thomas, *Physical Review Letters* 13, No. 15, 474-476 (October 12, 1964).

The self-consistent field theory developed by one of the authors (R.B.) is applied to obtain numerical results of the behavior of a solid at elevated temperatures. Preliminary results are reported for the temperature dependence of the density, which compares well with experiment for solid Ar, and of the atomic distribution function.

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Negative Magnetoresistance in Impurity Conduction,† J. F. Woods and C. Y. Chen, *The Physical Review* 135, A1462-A1466 (August 31, 1964).

Negative magnetoresistance is observed at 4.2°K in Cd-doped, *p*-type GaAs; vapor deposited, *n*-type GaAs; and *P*-doped, *n*-type Ge. In *n*-type GaAs, prepared by Czochralski or horizontal-Bridgman techniques, samples with carrier concentrations less than about 10^{18} show negative magnetoresistance at 4.2°K which goes through a maximum at fields less than 10,000 gauss and becomes positive at high fields. At concentrations greater than 10^{18} there is no clear indication of a maximum at fields up to 20,000 gauss. The ratio of longitudinal to transverse magnetoresistance in the impurity conduction range is a function of temperature and field, but at 1.4°K it exceeds 0.9 both for negative magnetoresistance at low fields and for positive magnetoresistance at high fields.

The overall trends of the data on GaAs and other materials require two competing processes to account for the magnetoresistance behavior. One of these is the effect of the

magnetic field in reducing orbital overlap which has been demonstrated by Sladek and Keyes on *n*-Ge and *n*-InSb. A competing process which could operate in the "hopping" region of impurity conduction might be an increase in the population of a set of states of higher energy and mobility than the ground states due to a reduction in the energy separation between them.

† The work of J.F.W. as supported as part of Project Defender under the joint sponsorship of the Advanced Research Projects Agency, the Office of Naval Research and the Department of Defense.

A New Optical Laser Pump, G. J. Fan, C. B. Smoyer, and J. Nuñez, *Applied Optics* 3, No. 11, 1277-1279 (November, 1964).

In this paper a new efficient laser pump consisting of a tube and two axicons is discussed. The pumping system is simple in fabricating and alignment. Its efficiency is first estimated using geometrical optics and it seems to compare favorably with the well-known elliptical pump. Experimental data are given which are in qualitative agreement with the prediction.

Nonlinear Optimization and Dynamic Control, R. A. Mugele, *Transactions of the American Gas Association*, 64, 115-119 (October, 1964).

This paper describes methods which have been developed for the solution of certain problems encountered by dispatchers in the transmission of natural gas. Some difficulties arise from the nonlinear character of relations among the variables which control the flow. Other difficulties arise from the transient, i.e., dynamic or time-dependent, nature of the flow. The methods described in this paper are designed to resolve these difficulties and provide results which will aid dispatchers in maintaining efficient as well as safe control of natural gas transmission.

A Note on the Nominal Clearance of the Foil Bearing, H. K. Baumeister, *Lubrication Engineering* 20, No. 10, 377-380 (October, 1964).

An investigation has been made of the magnitudes of the errors introduced into the analytical solution for the nominal clearance of the foil bearing by the assumptions that are usually made. From numerical integrations, it has been concluded that the exact method of specifying the clearance and the exact locations of the ends of the bearing are not critical, and that the assumption of various shapes for the foil will result in erroneous nominal clearance values.

On the Criteria for π -Electron Delocalization in Some Cyclic Conjugated Systems, E. M. Evleth, J. A. Berson,* and S. L. Manatt,** *Tetrahedron Letters*, Nos. 41-42, 3087-3094 (October, 1964).

The interpretation in the literature of the NMR data of certain dihydropyridines has been that these material lacked "aromaticity." It was found that the dipole moments of these materials were experimentally and theoretically, from molecular orbital calculations, large. It remains to be seen if a general correlation between dipole moments and NMR data will be discovered.

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On a Generalized M/G/1 Queuing Process in Which the First Customer of Each Busy Period Receives Exceptional Service, Peter D. Welch, *Operations Research* **12**, No. 5, 736-752 (September/October, 1964).

The following generalization of the M/G/1 queue is considered. If a customer arrives when the server is busy, his service time has a distribution function, $G_b(x)$; while if he arrives when the server is idle, his service time has a different distribution function, $G_e(x)$. Results are obtained that characterize the transient and asymptotic distributions of the queue size, waiting time, and waiting-plus-service time. These results are then applied to the special case of a queue with a single service time distribution function, but with additional independent delay times that have one distribution function for the customers arriving when the server is idle and another for the customers arriving when the server is busy.

Operation of the Cryogenic Continuous Film Memory Cell, J. D. Barnard, R. H. Blumberg, and H. L. Caswell, *Proceedings of the IEEE* **52**, No. 10, 1177-1181 (October, 1964).

Problems and requirements associated with using the cryogenic continuous film memory (CCFM) cell in a random access memory with coincident current cell selection are discussed. Pulse measurement techniques are described which provide information on the storage level within the cell and on the basis of several simple assumptions, permit the operating range (drive current tolerance) of the cell in a memory array to be calculated. The influence of nonideal superconducting to normal phase transitions on storage levels is discussed as is the effect of various memory disturb programs on cell operation. The restricted operating limits of the CCFM cell are found to place requirements on cell uniformity which severely tax today's thin film capabilities.

Optical Transfer Properties of Fiber Bundles, René Drougard, *Journal of the Optical Society of America* **54**, No. 6, 907-914 (July, 1964).

The contrast transfer properties of fiber bundles are investigated both theoretically and experimentally.

The point spread function of a static fiber bundle is not spatially invariant, and the system cannot therefore be strictly characterized by an optical transfer function. It is shown both theoretically and experimentally that, in the case of circular fibers of diameter d , the contrast of the image of an object varies with the position of the fiber bundle and lies between two extreme values which become closer together as the spatial frequency decreases. Thus, for sufficiently low frequencies (of the order $1/8 d$), an optical transfer function can be used. The experimental results are in good agreement with the theory.

A randomly vibrating bundle is found to have a spatially invariant point spread function and can, therefore, be characterized by an optical transfer function.

Orientation Dependence of the Evaporation Rate of CdS Single Crystals, G. A. Somorjai* and N. R. Stemple, *Journal of Applied Physics* **35**, No. 11, 3398-3400 (November, 1964).

The vacuum evaporation characteristics of the (0001), (1120), and (1010) crystal faces of CdS single crystals have been measured in the temperature range of 680 to 760°C.

From the temperature dependence of the rate, the activation energy of the surface reaction which controls the vaporization of (0001) and (1120) faces has been determined. Semi-sphere-shaped crystals are used to study the evaporation of all the orientations simultaneously. The (1010) crystal face is unstable under vacuum evaporation conditions. During vaporization the surface area changes drastically; the crystals develop new orientations. The surface areas of the (0001) and (1120) crystal faces do not change throughout the evaporation with the accuracy of the experiments.

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Partial Differential Equations with Periodic Coefficients and Bloch Waves in Crystals,† F. Odeh and J. B. Keller,* *Journal of Mathematical Physics* **5**, No. 11, 1499 (November, 1964).

Bloch waves are special solutions of Schrödinger's equation with a periodic real potential. They are plane waves multiplied by periodic functions. In this paper we prove the existence and completeness of Bloch waves and of the related Kohn-Luttinger waves in unbounded domains for a class of partial differential equations which includes the Schrödinger equation. In addition, we discuss the dependence of these waves and the corresponding eigenvalues on the wave vector of the associated plane wave. The results may be interpreted as the analogs for certain partial differential equations of Floquet's theory for ordinary differential equations or as the determination of the spectral representation of certain periodic Hamiltonian operators.

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The Past, Present and Future of General Simulation Languages, H. S. Krasnow and R. A. Merikallio, *Management Science* **11**, No. 2, 236-267 (November, 1964).

The widespread use of simulation in the design and analysis of complex systems has received a great impetus in the past few years with the advent of various general simulation languages. Simulation models of a wide variety of physical situations can now be developed with these languages. This paper summarizes and compares various characteristics of five major general simulation languages. The historical background from which these languages developed is discussed first. Predictions are also made of the future development of general simulation languages.

The Plant Sulfolipid: A Crystallographic Study, Y. Okaya, *Acta Crystallographica* **17**, No. 10, 1276-1282 (October, 1964).

The molecular configuration of the plant sulfolipid was studied via a three-dimensional structure analysis of the anhydrous rubidium salt of the deacylated sulpholipid acid, $\text{RbC}_{17}\text{H}_{31}\text{O}_8\text{S}$. The crystallographic constants of this compound are: $a = 10.87$, $b = 7.19$, $c = 9.21$ (all ± 0.005 Å), $\beta = 99.7 \pm 0.3^\circ$, space group $P2_1$. The analysis established the sulpholipid as a derivative of 6-sulpho-6-deoxy- α -D-glucopyranosyl-(1-1')-D-glycerol, thus confirming the results of chemical studies. An anomalous enzyme reaction involving β -galactosidase is discussed in terms of the steric configuration.

The molecular ions are connected with each other through

a network of O-H ··· O hydrogen bonds and also through ionic interaction between the rubidium ions and the sulphate groups. All interatomic distances and bond angles exhibit normal values.

Prediction of the Conductivity in some Compound Semiconductors on the Basis of Multiple Valence States, M. R. Lorenz, *Physics Letters* **12**, No. 3, 161-162 (October, 1964).

There is considerable evidence to suggest that the existence of multiple valence states in the element M of the compound M_nN_m , influences the position of the solid stability region and hence the conductivity type. This leads to a simple rule: If M is in its lowest valence state, the material will be *p*-type, while if M is in its highest valence state, it will be *n*-type. A list of some thirty representative compounds and their usual electrical conductivity type is given which appears to substantiate the rule.

A Proposal for Input of Hand-Drawn Information to a Digital System, P. W. Woo, *IEEE Transactions on Electronic Computers* **EC-13**, No. 5, 609-611 (October, 1964).

Much progress has been made in speeding up communications between input-output digital equipment and the central processing unit. Faster and faster card readers, printers and tape drives have been developed to match the vastly increased internal processing speeds of modern digital computers. In contrast, direct man-machine communication still lags far behind machine-machine data exchange. Much work is being done to ease this communications bottleneck in such areas as character recognition and voice recognition, which are but two of the more well-known examples.

This paper deals with a system designed to facilitate the exchange of information between man and machine. More specifically, the system is designed to convert freehand graphical information on a real-time basis into digital form which can be stored in a computer memory. The stored digital information may be recycled out, reconverted into analog form and displayed by means of a cathode-ray-tube (CRT) projection system. In particular, this display can be projected onto the drawing board to the exact size of the original drawing so that the designer can see what he has drawn, assuming that the pen uses no visible ink and leaves no visible trace otherwise.

Putting VE to Work in Manufacturing, S. Taub, *The Tool and Manufacturing Engineer* **53**, No. 5, 45-47 (November, 1964).

Increased emphasis is being placed on the need for major cost reduction efforts by all who participate in the nation's defense and space exploration efforts. The Manufacturing Engineering organization at the FSD Space Guidance Center endorses the application of Value Engineering to manufacturing tools, equipment and processes as a practical technique for reducing cost and enhancing the Space Guidance Center's competitive position. This article shows how the Manufacturing Engineering organization arrived at the decision to apply value engineering to its areas, and it describes the activity to date.

A Queuing Approach to Logistics Systems,† N. M. Mirasol, *Operations Research* **12**, No. 5, 707-724 (September/October, 1964).

This paper deals with tradeoffs and major interactions among the different activities in logistics systems. Specifically, the problem of "interchangeability" between maintenance and supply, embodied in the question of "subassembly vs piece-part replacement," is considered. The approach presented consists of a novel method of systems representation: A basic model, which is fundamentally a multistage circular queuing system, is developed for each of the units (assemblies, subassemblies, etc) that constitute an equipment system. These elementary systems are then connected together with the pattern of linkage made to correspond to the technological breakdown of the over-all system. An interesting result of this approach is that the important measure of effectiveness for any unit is not only its unavailability (probability of stockout), but also the duration of unavailability. Iterative solutions in the case of linear cost functions, a total cost constraint, and the usual exponential assumptions are also presented.

† Based on the author's doctoral dissertation in Operations Research (Case Institute of Technology, 1963).

Random-Access Stored-Program Machines, an Approach to Programming Languages, C. C. Elgot and A. Robinson,* *Journal of the Association for Computing Machinery* **11**, No. 4, 365-399 (October, 1964).

A new class of machine models as a framework for the rational discussion of programming languages is introduced. In particular, a basis is provided for endowing programming languages with semantics. The notion of Random-Access Stored-Program Machine (RASP) is intended to capture some of the most salient features of the central processing unit of a modern digital computer. An instruction of such a machine is understood as a mapping from states (of the machine) into states. Some classification of instructions is introduced. It is pointed out in several theorems that programs of finitely determined instructions are properly more powerful if address modification is permitted than when it is forbidden, thereby shedding some light on the role of address modification in digital computers. The relation between problem-oriented languages (POL) and machine languages (ML) is briefly considered.

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Rare-Earth Ions in the Alkali Halides I. Emission Spectra of Sm^{2+} -Vacancy Complex, W. E. Bron and W. R. Heller, *The Physical Review* **146**, A1433-A1444 (November 30, 1964).

Measurements have been made of the crystal-field splitting of the 6F_7 energy levels of the $4f^6$ configuration of the Sm^{2+} ion which is dissolved in a number of alkali-halide lattices. Crystal-field term assignments were made from the results of polarized-emission measurements. Observed crystal-field splittings are compared to those predicted from point-charge models. Contributions to the total crystal field are considered to include that due to the presence of a nearest-neighbor cation vacancy as well as that due to displacements, from normal lattice positions, of the nearest-neighbor halide ions and the Sm^{2+} ion. The splitting is shown to arise in part from a displacement of the Sm^{2+} and the cation vacancy toward each other. The extent of the validity of the use of a point-charge model for this case is discussed.

Redundancy Requirements for the Correction of Finite-State Error Patterns (with Application to Recurrent Codes), C. V. Freiman, J. P. Robinson and A. D. Wyner, *Proceedings of the National Electronics Conference* **20**, 687-692 (1964).

A steady state redundancy requirement E_0 is developed for any error correcting code in patterns to be corrected. A method based on Mason's general gain formula is then introduced for the determination of E_0 when the set of error patterns corresponds to the output set of a strongly-connected finite-state machine. This method is used to derive general characteristic equations for burst-error correcting recurrent codes (Types B1, B2, C) and several classes of independent-error correcting recurrent codes (Type A). Minimum redundancies obtained through the numerical solution of these equations are presented graphically for various combinations of recurrent code parameters.

Relation Between Domain-Wall Creeping and the Occurrence of Bloch Lines in Thin Ni-Fe Films, S. Middelhoek, *Physics Letters* **13**, No. 1, 14-15 (November 1, 1964).

This note reports the results of an investigation in which it was found that domain-wall creeping only occurs, when, under the influence of the hard direction ac field, Bloch line motions along the domain walls are observed.

The Ruby Laser as a Brillouin Light Amplifier, R. G. Brewer, *Applied Physics Letters* **5**, No. 7, 127-128 (October 1, 1964).

Stimulated Brillouin light in liquids exhibits a small frequency shift ($\sim 0.2 \text{ cm}^{-1}$) and is strongly scattered in the backward direction. As a result, this light falls within the ruby laser's fluorescence linewidth and retraces the path of the exciting laser beam, entering the laser cavity where it is amplified by a factor of three or more. This enhancement greatly facilitates Brillouin scattering measurements.

Self-Compensation Limited Conductivity in Binary Semiconductors II: $n\text{-ZnTe}$,† R. S. Title, G. Mandel* and F. F. Morehead, *The Physical Review* **136**, A300-A302 (October 5, 1964).

Paramagnetic resonance has been observed in Al-doped ZnTe grown in excess Te vapor. The resonance is due to a hole trapped at a defect consisting of a doubly negatively charged zinc vacancy V_{Zn}^{2-} and an Al^{3+} donor ion on one of the twelve zinc sites nearest the V_{Zn}^{2-} . The hole is trapped at the defect after irradiating the sample at 77°K with light of energy less than that of the band gap. The g tensor is orthorhombic as expected for such a defect. Compensation of donor or acceptor impurities by doubly, as opposed to singly, ionizable defects has been shown to be important in II-VI compounds. The observed resonance shows that compensation of Al donors in ZnTe by doubly charged zinc vacancies does indeed occur. A consequence of the self-compensation of donor impurities in ZnTe is that there is a limit to how n -type the material can be made. Similar attempts to dope ZnTe n -type were carried out with Ga, In,

Br and I. Only insulating crystals were produced, even after subsequent firing in Zn vapor. No analogous resonance signals were observed in these samples, however.

† The research herein reported is part of Project DEFENDER under the joint sponsorship of the Advanced Research Projects Agency, the Office of Naval Research and the Department of Defense.

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Self-Compensation Limited Conductivity in Binary Semiconductors III: Expected Correlations with Fundamental Parameters,† G. Mandel,* F. F. Morehead and P. R. Wagner, *The Physical Review* **136**, A826-A832 (November 2, 1964).

The previously developed calculation of the degree of self-compensation in a binary semiconductor is used to obtain a useful correlation between the degree of self-compensation by singly ionized natural defects and the ratio of the electronic energy gap to certain generally known thermodynamic quantities. The latter quantities are related to the cohesive energy. It is shown, however, that the correlation factor given herein is more meaningful than the previously suggested ratio of the energy gap to the cohesive energy. The results are generalized to include compounds having a composition M_aN_b . One interesting conclusion is the prediction that M atom vacancies will generally dominate interstitial N atoms when $b < a$ and vice versa.

It has previously been shown that the second ionization level of a compensating natural defect can be critical in determining the degree of self-compensation, particularly in the case of the II-VI compounds. A simple model of a singly ionized vacancy is presented which suggests that size considerations should play a major role in determining the second ionization level of such a defect. It is shown that the gross electrical properties of the II-VI compounds can be completely correlated with a single parameter, the ratio of the tetrahedral covalent radii of the elements.

Finally, the overall classification scheme described above is applied to a reasonably large group of compounds. The predicted gross electrical properties of these compounds are found to be in essential agreement with what is known experimentally, with the single exception of $n\text{-SdF}_2$, for which an explanation is offered.

† The research herein reported is part of Project DEFENDER under the joint sponsorship of the Advanced Research Projects Agency, the Office of Naval Research and the Department of Defense.

* Deceased.

A Self-Consistent Theory of Čerenkov and Smith-Purcell Radiation, István Palócz and Arthur A. Oliner,* *Proceedings on Quasi Optics Symposium* **14**, 217-233 (1964).

Previous studies of Čerenkovian effects have taken the excitation, whether a single moving electron or a modulated beam, as prescribed and therefore not subject to change even though radiation is produced. A new theoretical approach is presented here for the analysis of Čerenkov and Smith-Purcell radiation from modulated electron beams which is *self-consistent*, i.e., the effect of the radiation back on the beam is taken into account. In this approach, the beam and the associated structures (dielectric media or periodic gratings) are treated as a unit in an *eigenvalue solution*, so that the requirement of self-consistency is automatically satisfied. In addition, the solution includes the effects of space charge waves on the beam.

Rigorous solutions are obtained for two cases: (a) the Čerenkov radiation for a small-signal modulated sheet elec-

tron beam of finite thickness passing between two semi-infinite dielectric regions, and (b) the Smith-Purcell radiation for a beam similar to that above passing between two parallel planar strip transmission gratings. For the latter case, it was necessary to first calculate the equivalent network for a wave incident on such a grating under multimode conditions. Using a simple but accurate perturbation procedure, numerical results were obtained for various situations.

The eigenvalue approach indicates new effects for both the Čerenkov and the Smith-Purcell radiation. It is shown that the eigenwavenumbers are complex for both phenomena, and that the radiation consists of an infinite set of fast and slow waves. The radiation does not emerge at a single angle only, even in the ideal mono-energetic case. The angular spread is usually less than 1° ; however, neither experimentalists nor theorists have heretofore noted the fine structure of the radiation. The different behaviors of the fast and slow waves are examined, and the slow waves are demonstrated to be growing waves. Among other results, it is shown that an optimum beam thickness exists.

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Sequencing a One State-Variable Machine: A Solvable Case of the Traveling Salesman Problem, P. C. Gilmore and R. E. Gomory, *Operations Research* **12**, No. 5, 655-679, (September/October, 1964).

We consider a machine with a single real variable x that describes its state. Jobs $J_1, \dots, J_N$ are to be sequenced on the machine. Each job requires a starting state A_i and leaves a final stage B_i . This means that J_i can be started only when $x = A_i$ and, at the completion of the job, $x = B_i$. There is a cost, which may represent time or money, etc., for changing the machine state x so that the next job may start. The problem is to find that minimal cost sequence for the N jobs. This problem is a special case of the traveling salesman problem. We give a solution requiring only $O(N^2)$ simple steps. A solution is also provided for the bottleneck form of this traveling salesman problem under special cost assumptions. This solution permits a characterization of those directed graphs of a special class which possess Hamiltonian circuits.

Shubnikov-de Haas Effect and Cyclotron Resonance in a Dilute Bi-Sb Alloy, Yi-Han Kao,* R. D. Brown, III, and R. L. Hartman, *The Physical Review* **136**, A858-A862 (November 2, 1964).

Magnetoresistance oscillations (Shubnikov-de Haas effect) and Azbel-Kaner cyclotron resonance were studied in a dilute Bi-Sb alloy (Sb concentration of 0.96 wt %) at 4.2°K for various orientations of the magnetic field. It was found that the electron cyclotron masses, and the external cross-sectional areas of the electron Fermi surface, decrease to approximately 80 and 62%, respectively, of the corresponding values in pure Bi. The observed changes in cyclotron masses and Shubnikov-de Haas frequencies in the alloys are consistent with the nonparabolic model and the assumption of rigid motion of the conduction band, and the valence band just beneath it, with respect to the hole band. Effective masses at the bottom of the conduction band were calculated. The electron Fermi energy and concentration in the alloy were determined. The band overlap deduced from this result is in agreement with other work.

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Solutions to the Vector Tetrahedron Equation, Milton A. Chace, *Proceedings of the ASME Mechanisms Conference* **64**, No. 23, 1-24 (October, 1964).

A set of nine closed-form solutions are presented to the single, three-dimensional Vector Tetrahedron Equation, sum of vectors equals zero. The set represents all possible combinations of unknown spherical coordinates among the vectors, assuming the coordinates are functionally independent. Optimum use is made of symmetry. The solutions are interpretable and can be evaluated reliably by digital computer in milliseconds. They have successfully been applied to determining the position of many three-dimensional mechanisms.

Spin-Wave Interactions in an Anisotropic Ferromagnet, S. H. Charap,* *The Physical Review* **136**, A1131-A1136 (November 16, 1964).

In the presence of anisotropic interactions the spin-wave dispersion parameter $D(T)$ acquires an $aT^{3/2}$ dependence in addition to the $bT^{5/2}$ dependence due to isotropic exchange. We have used Van Vleck's anisotropic exchange, and the largest effect consistent with the magnetocrystalline anisotropy of a cubic ferromagnet is found to come from the pseudodipolar coupling. While the anisotropy appears only in the second order of perturbation theory, there is a first-order contribution to $D(T)$ which varies as the third power of the magnetization, itself a function of the temperature. Thus $a \approx C(gBH_A^D/k_B T_c)^{1/2}$, where C is the coefficient in the Bloch law, H_A^D is the pseudodipolar contribution to the anisotropy field, and T_c is the Curie temperature. The coefficient a depends upon the direction of spin-wave propagation and averages to zero over a sphere. In a first approximation, then, there is no T^3 term in the magnetization. In an experiment dealing with selected propagation directions, such as spin-wave resonance or inelastic neutron scattering, since $b \approx C/T_c$, an effect important when $T/T_c < (gBH_A^D/k_B T_c)^{1/2}$ is predicted.

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Standards Application Through Education, D. Burrs, *Standards Engineering* **16**, No. 9, 1 (October 9, 1964).

This paper presents a basic approach to application of standards through an educational program within a company. The program suggests a classroom approach to explain the advantages of standardization and make the user aware of the existence of standards documents.

Structural and Magnetic Properties of Sputtered NiFe Films Grown in a dc Discharge Environment, Eric Kay, *Journal of Applied Physics* **35**, No. 10, 2936-2942 (October, 1964).

Experimental evidence is presented which verifies Middelhoek's recent extension of the Néel theory relation of the coercivity with film thickness variations. Under special preparatory conditions "inverted" NiFe films on glass substrates were produced with excellent reproducibility. Partial oxidation leading to antiferromagnetic inclusions was shown to be absent. Resolution of the substrate temperature control problems using metal substrates in the plasma environment enabled us to show that a uniaxial anisotropy can only be induced into sputtered NiFe films over a limited temperature region.

Temperature control during film growth also made possible a direct correlation of film morphology with the magnitude and uniformity of the dispersion of the easy axis of magnetization and the resultant critical field for wall motion H_c . Typical coercivity H_c , anisotropy field strength H_K , and dispersion measurements on 700-Å NiFe films on very smooth 25-cm Ag:Cu-SiO substrates were: $H_c = 1.92 \pm 0.07$ Oe, $H_K = 2.85 \pm 0.03$ Oe, dispersion $= 1.0 \pm 0.0^\circ$. Special problems pertaining to film growth in a plasma environment are discussed. A typical Lorentz micrograph of a sputtered NiFe film deposited directly onto a microscope grid is given.

Structure of a Cryogenic Associative Processor, J. D. Barnard, F. A. Behnke, A. B. Lindquist, and R. R. Seeber, *Proceedings of the IEEE* **52**, No. 10, 1182-1190 (October, 1964).

A 5000-word, 72-bit per word cryogenic associative processor has been designed in considerable detail. In addition to the basic associative features, this processor features sorting, selective writing, marking, nearest value retrieval (next higher or next lower), and range retrieval. The physical and logical structures of the system are described, and the low temperature and room temperature requirements are outlined. The reasons for choosing the outlined configuration are also discussed.

The Structure of System/360: Part I—Outline of the Logical Structure, G. A. Blaauw and F. P. Brooks, Jr., *IBM Systems Journal* **3**, No. 2, 119-135 (1964).

A general introductory description of the logical structure of System/360 is given in preparation for the more detailed analyses occurring in the other parts of the paper. The functional units, the principal registers and formats, and the basic addressing and sequencing principles of the system are indicated.

The Structure of System/360: Part II—System Implementations, W. Y. Stevens, *IBM Systems Journal* **3**, No. 2, 136-143 (1964).

The performance range desired of System/360 is obtained by variations in the storage, processing, control, and channel functions of the several models. The systematic variations in speed, size, and degree of simultaneity that characterize the functional components and elements of each model are discussed.

The Structure of System/360: Part III—Processing Unit Design Considerations, G. M. Amdahl, *IBM Systems Journal* **3**, No. 2, 144-164 (1964).

Considerations underlying the design of the central processing units are discussed. Particular emphasis is placed on addressing, sequencing, and monitor control functions as well as provisions for arithmetic and logical operations.

The Structure of System/360: Part IV—Channel Design Considerations, A. Padegs, *IBM Systems Journal* **3**, No. 2, 165-180 (1964).

The organization of the input/output section and the control of input/output operations in System/360 are described. Emphasis is on the philosophy of control and on the rea-

sons for choosing the particular logical and physical organization. For each machine feature, the types of tasks requiring the facility are outlined and the significance of the solution is shown.

The Structure of System/360: Part V—Multisystem Organization, G. A. Blaauw, *IBM Systems Journal* **3**, No. 2, 181-195 (1964).

Operation of several systems as one multisystem to obtain increased availability, improved cost/performance, or both, is considered. System requirements for various applications are formulated, and the multisystem capabilities of System/360 are discussed in context.

A Study of Fretting on Steel, A. R. Wayson, *Wear* **7**, No. 5, 435-450 (September/October, 1964).

This paper is an investigation of lubricated and unlubricated fretting of hardened steel balls on 24 common carbon and alloy steel platens. For unlubricated conditions, wear rates were obtained and scar profiles are classified into three types: (A) even wear with little or no transfer; (B) heavy transfer to the ball; and (C) buildup on the platen surface occasioned either by plowing or transfer from the ball. For lubricated conditions, two distinct scar configurations were observed and correlated with the shear stress occurring on the surface of contact. Further, for lubricated conditions, relationships involving stresses and material properties were developed to predict conditions for zero wear.

Superconducting Properties of AuPb₃ and AuPb₂, H. L. Caswell, *Solid State Communications* **2**, 323-324 (1964).

The superconducting critical temperature of AuPb₃ and AuPb₂ has been measured as 4.40°K and 3.15°K, respectively. Data available on the superconducting properties of Pb filaments in an Au matrix indicate AuPb₂ is readily formed at room temperature due to rapid diffusion of Au into Pb.

A Survey of Digital Simulation: Digital Analog Simulator Programs, Robert D. Brennan and Robert N. Linebarger, *Simulation* **3**, No. 6, 22-36 (December, 1964).

This is the first of an intended series of articles on digital simulation. Digital simulation abounds in many fields and disciplines—analogue simulators, circuit simulators, chemical process simulators, traffic simulators, systems simulators, business simulators. At this point in time, a general survey of digital simulation is overdue. Its orderly development demands sufficient respite for a critical evaluation of its progress thus far and its goals for the future. Just what is digital simulation?—where does it stand presently and how did it get there?—where does it seem to be going? This series hopes merely to stimulate the technical conversations which will furnish these answers.

This article restricts attention to digital-analog simulator programs—those programs which simulate the elements and organization of analog computers. It is intended to be both tutorial and documentary in its presentation. This topic was selected for the first article because this segment of digital simulation is of most general interest to analog users. In the

opinion of the authors, the transcendence of digital computers for simulation is inevitable, and it is of paramount importance to capture the interest of analog users in order that their vast experience not be lost as simulation enters this new era.

Synthesis of a Communication Network, R. E. Gomory and T. C. Hu, *SIAM Journal* **12**, No. 2, 348-369 (June, 1964).

A communication network is a set of nodes connected by arcs. Every arc has associated with it a non-negative number called the branch capacity, which indicates the maximum amount of flow that can pass through the arc. A communication network must have large enough branch capacities such that all message requirements (which can be regarded as flows of different commodities) can reach their destinations simultaneously. In general, these requirements vary with time. The present paper gives algorithms for min-cost synthesis of a communication network which is able to handle simultaneous flows of all time periods.

† This research was supported in part by the Office of Naval Research under Contract No. Nonr. 3775(00).

System Reliability when Failure Depends on a Parameter That Ages, F. R. Van Wagner, *Industrial Quality Control* **21**, No. 5, 253-258 (November, 1964).

A mathematical model is developed for the failure rate and other reliability measures of a system whose performance depends essentially upon one random parameter whose probability distribution degrades deterministically with time. In general, the model will be too difficult either to build or to solve analytically. Therefore, approximations to it are developed, and the use of digital Monte Carlo simulation as a first step in the solution is discussed.

Tables of Zeros and Gaussian Weights of Certain Associated Laguerre Polynomials and the Related Generalized Hermite Polynomials, T. S. Shao, T. C. Chen, and R. M. Frank, *Mathematics of Computation* **18**, No. 88, 598-616 (October, 1964).

Generalized Hermite polynomials $H_k^\lambda(\xi)$ which are orthogonal in $(-\infty, +\infty)$ with respect to the weight function $\xi^{2\lambda+1} e^{-\xi^2}$ have been defined in terms of associated Laguerre polynomials $L_n^\alpha(x)$. The use of both types of polynomials in quantum physics and in approximation theory are indicated. Tables for the zeros and Gaussian weights with

$\alpha = -0.5 \text{ (1.0) } 3.5$

$\lambda = 0 \text{ (1.0) } 10.0,$

$n = 4, 8, 16, 32,$

$k = 8, 16, 32, 64,$

computed using the cubically convergent Hofsommer process on the IBM 7030 (STRETCH) computer, are presented.

Techniques for the Diagnosis of Switching Circuit Failures, J. M. Galey, R. E. Norby and J. P. Roth, *IEEE Transactions on Communications and Electronics* **83**, No. 74, 509-514 (September, 1964).

In 2.12 minutes, an IBM 7090 program found four input tests (for an 8-input parity check circuit) whose outcome determines whether any one of 102 possible failures occurred. For any single-output combinational circuit, with

no more than 35 input variables, the program computes the set of all inputs detecting a given failure. These sets, one for each failure, are then processed to find a small subset of tests which detect any failure. The underlying method is extended to the diagnosis of circuits with feedback.

Theories of Elasticity with Couple-Stress, R. A. Toupin, *Archives for Rational Mechanics and Analysis* **17**, No. 2, 85-112 (1964).

This is an expository article in which theories of elasticity for which the usual stress principle fails are reviewed, compared, and extended. Applications are discussed.

Thermodynamic Analyses of Open Tube Germanium Disproportionation Reactions, A. Reisman and S. A. Alyanaky, *Journal of the Electrochemical Society* **111**, No. 10, 1154-1164 (October, 1964).

In order to define conditions most suitable for iodine transport of pure or gallium-doped germanium, the equilibria that obtain when these elements, singly or together, are mixed with iodine or hydrogen iodine in the presence of hydrogen and/or inert gases, were analyzed using computer techniques. It was found that Ge in the presence of an inert carrier gas should transport via a hot to cold process at all iodine pressures studied.

These results are markedly perturbed when H_2 is substituted for the inert gas due to the establishment of a competing equilibrium whose enthalpic change is opposite in sign to that of the equilibrium responsible for semiconductor transport. The effects of the competing equilibrium in turn may be modified by using a mixture of H_2 and He. Under certain sets of conditions, in fact, temperature insensitive regions develop which appear to be suitable as semiconductor source and seed sites.

The results for the gallium-iodine equilibrium are to a good first approximation independent of the nature of the carrier gas and indicate that hot to cold transport is to be expected over a wide range of iodine concentrations. Analyses of the three phase equilibrium in Ge-Ga-halogen systems show them to also be independent of the nature of the carrier gas.

Thin Silicon Film Growth on Polycrystalline Alumina Ceramic, V. Y. Doo, *Journal of the Electrochemical Society* **111**, No. 10, 1196-1198 (October, 1964).

Thin silicon films on polycrystalline alumina ceramic grown by conventional reduction of silicon halide at elevated temperature has previously resulted in polycrystalline deposits. The grain size of silicon was approximately that of the alumina substrate ($\sim 1 \mu$ diameter). It has been found that prolonged high temperature annealing of a pregrown layer on the alumina leads to limited grain growth. Growth from a molten silicon film under suitable conditions has resulted in silicon grain sizes as large as $500 \mu \times 3000 \mu$. The silicon crystals appeared to have little strain.

A Transparent Electrometer Probe, Lester F. Shew, *Photographic Science and Engineering* **8**, No. 5, 282-289 (September/October, 1964).

A transparent electrometer probe has been developed for monitoring the instantaneous surface potential of xerographic plate materials during illumination. It can be used for qualitative evaluation and quantitative measurement of

photoinduced discharge characteristics under dynamic conditions, and for recording charge acceptance, dark charge decay, and residual potential of such media as well.

Design analysis, construction details, and operation of the transparent electrometer probe are described. Performance has indicated that the response of the system is sufficiently fast and the output is very stable with negligible drift for photoinduced discharge measurement. Test data are presented and discussed.

Two-Photon Processes in Complex Atoms, J. D. Axe, *The Physical Review* 136, A42-A45 (October 5, 1964).

The off diagonal matrix elements of the polarizability operator when operating with an I^N configuration of a complex atom can be approximately written in simple tensor operator form. The resulting expressions are discussed in terms of two-photon absorption and the recently observed electronic Raman effect in the trivalent rare earth ions.

The Use of Conventional Microwave Channels for the Transmission of Data at Megabaud Signaling Rates, D. H. Rumble, *Proceedings of the Eighth International Convention on Military Electronics*, 311-314 (1964).

Signal formation techniques are employed to encode base-band digital data for transmission over conventional microwave channels. Experimental work at signaling rates up to 1.5 bits of information per cycle of channel bandwidth (which is of the order of 10^7 bits per second) has shown that the data can be recovered with acceptable freedom from error.

Zerstörungsfreies Lesen und Schreiben mit gekoppelten Magnetschichten im 20-ns-Bereich unter Ausnutzung von Wirbelstromeffekten (Non-destructive read-out and write-in with coupled magnetic films in the 20 nsec range using the effects of eddy currents), W. Jutzi, *Elektronische Rechenanlagen* 6, No. 5, 228-238 (October, 1964).

A new memory cell is described allowing nondestructive read and write operations at very high speeds and with relatively small drive currents. The cell consists of two

NiFe films on a metal substrate. Between the films of one cell there is a copper foil. The torques generated by eddy currents in the copper foil and the nearby groundplate determine the stability of the non-destructive read operation. The interaction of the magnetic films with the conducting surroundings is measured and discussed in detail during the read and write operation. Disturb measurements indicate a high stability of the new cell and the possibility of accomplishing a packing density of 2 bit/mm².

Letters

Comparison of Markov and Least Squares Missile Position and Velocity Estimates, R. R. Hunziker, *AIAA Journal* 2, No. 11, 2024-2026 (November, 1964).

"Flash" Evaporator for Thin Film Deposition,† W. R. Beam and T. Takahashi,* *Review of Scientific Instruments* 35, 1623-1624 (November, 1964).

† Work performed, under IBM support, at Rensselaer Polytechnic Institute.

* Toshiba Central Research Laboratory, Japan.

A Novel Photoisomerization Reaction of Cyclic Ketones, S. Cremer and R. Srinivasan, *Journal of the American Chemical Society* 86, No. 19, 4197 (October 5, 1964).

The Phenylation of Pyridine Metal Complexes, R. J. Gitter and A. W. Godfrey,* *Journal American Chemical Society* 86, No. 21, 4724 (November 5, 1964).

* University of Connecticut.

Der Uebergang vom Metall zum Halbleiter unter hohem Druck im reinen Wismut-Einkristall (The Transition from Metal to Semiconductor under High Pressure in a Pure Bismuth Single Crystal), R. Jaggi, *Die Naturwissenschaften* 51, No. 19, 459 (1964).