IBM Technical Papers Published Recently in Other Journals

Adam—A Problem Oriented Symbol Processor, A. P. Mullery, R. F. Schauer and R. Rice, *Proceedings of 1963 Spring Joint Computer Conference* **23,** 367-380 (May 20, 1963).

A study of problem solving with a digital computer has revealed characteristics of data that are essentially ignored or suppressed in conventional systems. In an attempt to increase the capability and flexibility of digital systems, a new, high level language utilizing these data characteristics has been defined. A machine organization which implements this language as a machine language and yet imposes no restrictions on the use of the language has been proposed. This paper describes such a processor having the following characteristics: complete symbolic addressing on variable field length data; list and string operations; high- to low-order numeric processing; dynamic storage allocation; and automatic input-output.

Adiabatic Magnetization of Antiferromagnets,* R. J. Joenk, *Supplement, Journal of Applied Physics* **34,** 1097-1098 (April, 1963).

Spin wave theory was used to determine the magnetic field dependence of the thermodynamic properties of cubic or uniaxial antiferromagnets at temperatures well below the Néel point. These properties were found to be exponentially increasing functions of applied field for values of H_0 less than the critical spin-flopping field. This field dependence suggests that if spin wave effects are dominant an antiferromagnet can be cooled by adiabatic magnetization in contradistinction to the paramagnetic case of cooling by demagnetization. (The phenomenon of antiferromagnetic cooling by isentropic magnetization was recognized many years ago.) Both lattice and nuclear effects can alter the situation in a real material and were included in this investigation. The dependence of adiabatic magnetization cooling on the physical quantities characterizing the antiferromagnet is discussed and theoretical temperature changes for several uniaxial antiferromagnets are given.

* Work performed at the University of Pittsburgh and supported by AFOSR Contract AF49(638)-323.

Analysis of Linear Distributed Systems with Random Parameters and Inputs, F. Tung and P. K. C. Wang, *Journal of Franklin Institute* **273,** No. 5, 381-391 (May, 1963).

This paper is concerned with the statistical analysis of distributed parameter systems with random parameters and excitations and, specifically, with analysis of a restricted class of distributed systems, namely, first order linear systems. The mathematical description of linear distributed-parameter processes is discussed briefly from the "state" point of view, and then the manner in which random variables enter into distributed processes is outlined. The remaining portion of the paper is devoted to the statistical analysis of first-order systems with random parameters and forcing functions. Particular attention is given to the determination of first-order probability density functions, first and second moments of the system output variables. Conditions for stability in the mean-square sense are derived for first-order linear systems having one parameter with Gaussian distribution.

Analytical Self-Consistent Field Functions for Positive Ions: I, Isoelectronic Series with 2 to 10 Electrons, E. Clementi, *Journal of Chemical Physics* **38,** 996 (February 15, 1963).

Analytical self-consistent field (SCF) functions for the neutral atoms and positive ions isoelectronic series of 2 to 10 electrons up to $Z = 36$ are presented. These computations deal with the lowest electronic configuration ground states and excited states. The basis set of Slater-type orbitals (STO) is fully optimized with respect to the orbital exponent, and considerable effort was given to obtain a short expansion. A maximum of nine STO's were considered sufficient for the largest expansion. The total energies of each isoelectronic series are collected in simple series expansions in power of Z. For the 444 computed SCF functions here reported, only the most important features are discussed.

Analytical Self-Consistent Field Functions for Positive Ions: II, Isoelectronic Series with 11 to 18 Electrons, E. Clementi, *Journal of Chemical Physics* **38,** 1001 (February 15, 1963).

Analytical self-consistent field (SCF) functions for the neutral atoms and positive ions isoelectronic series of 11 to 18 electrons with $Z = 11$ to $Z = 36$ are presented. These computations include the ground state and the excited states for the lowest configurations. As in previous reported work, the basis set of Slater-type orbitals is fully optimized in the orbital exponents, and considerable effort is spent in ensuring accurate and short expansions. The computational results are discussed only in the most important aspects. The total energies for each isoelectronic series are condensed in a power series of Z. These empirical power expansions show a regular dependency on the number of electrons and give an accurate fitting of the several hundreds of states computed. The relation between the ionization potentials and orbital energy is discussed. The experimental excitation energies are compared with the computed. The problem of the "goodness" of the SCF functions is briefly examined in relation to the one-electron operator expectation values.

The Anisotropy of the Conductivity of *n*-Germanium at High Electric Fields,* M. I. Nathan, *Physical Review* **130,** 2201-2204 (June 15, 1963).

Current density vs electric field has been measured up to 10,000 v/cm in *n*-type germanium at 77° and 297°K for the field in the [100], [110] and [111] crystallographic directions. At 77°K for 1000 v/cm the drift velocity in the [100] directions is 60% greater than in the [111] direction. By 10,000 v/cm, this difference (the longitudinal anisotropy) has decreased from its maximum value at 1000 v/cm to 15%. The [110] curve lies between the other two. This anisotropy can be explained in terms of the effective mass anisotropy and population changes of the conduction band valleys oriented differently with respect to the field. The drift velocity of a single valley and the change of inter-valley scattering rate as a function of field are deduced. The latter increases by a factor of 30 over the range of applied field. At 297°K negligible anisotropy is found.

* A preliminary account of this work was presented at the 1960 APS Meeting, *Bull. of Am. Phys. Soc.* **5,** 194 (1960).

Anisotropy of Gadolinium Iron Garnet, B. A. Calhoun and M. J. Freiser, *Journal of Applied Physics* **34,** 1140-1145 (April, 1963).

The "one-ion" theory of origin and anisotropy has been tested by comparing the calculated value of the gadolinium contribution to the anisotropy of GdIG at 0°K with experimental measurements. Crystal field, dipolar, and dipole-crystal field effects are included in the calculation. The median of the values obtained using the crystal field parameters for Gd^{3+} in four diamagnetic garnets agrees within 3% with the result of torque measurements on a pure GdIG crystal. The experimental value, -21.9×10^4 ergs/cc, is approximately 10% lower than previous values for the anisotropy of GdIG. The good agreement between the calculated and experimental anisotropies provides quantitative confirmation of the theory used in the calculations.

Anomalous Thermal Expansion and Magnetostriction of Single Crystals of Dysprosium, A. E. Clark,* R. M. Bozorth and B. F. DeSavage,* *Physics Letters* **5,** No. 2, 100 (June 15, 1963).

Thermal expansion and magnetostriction are measured in the ferromagnetic region of temperature (< 85°K), the region of spiral magnetic structure (85 to 178°), and the paramagnetic region (> 178°). Both expansion and magnetostriction are abnormally large, the latter giving a strain of about 6×10^{-3}. There are sharp discontinuities in length in the principal crystal directions when the material becomes spontaneously magnetized on cooling below 85°K.

* U. S. Naval Ordnance Laboratory, Silver Spring, Maryland.

An Approach to the Internal Rotation Problem,* M. Karplus and Robert G. Parr,† *Journal of Chemical Physics* **38,** 1547-52 (April 1, 1963).

A method is described for a direct calculation of the barrier to internal rotation in ethane and ethanelike molecules. The approach suggested should identify the physical origin of the barrier, provided a satisfactory account would be forthcoming from exact Hartree-Fock calculations of the energies of the staggered and eclipsed forms in the Born-Oppenheimer approximation.

A simple model is considered in which the electronic distribution is taken to be cylindrically symmetric about the central bond. It is demonstrated that this model predicts energy differences between staggered and eclipsed forms, composed solely of nuclear-nuclear repulsion energy, that are consistently about 5/3 of the experimental energy barriers. A slight expansion of the wavefunction in the eclipsed configuration is shown to be required by the virial theorem, but this does not appreciably change the predicted magnitude of the barrier.

It is proposed that the model can be refined by a calculation of the electronic energies of the actual staggered and eclipsed forms of ethane relative to that for the cylindrical distribution. By means of second-order Hartree-Fock perturbation theory, it is shown that the energy differences are a simple sum of contributions from the nine occupied molecular orbitals. The individual contributions can be calculated by the solution of certain differential equations or their variational equivalent. To simplify the treatment further, an approximate set of uncoupled differential equations is suggested for finding the perturbed functions from estimates for the charge densities of the cylindrical-model orbitals.

* This work has been aided by research grants to Carnegie Institute of Technology from the National Science Foundation and the Petroleum Research Fund of the American Chemical Society.
† Department of Chemistry, Carnegie Institute of Technology, Pittsburgh.

Atomic Screening Constants from SCF Functions, E. Clementi and D. L. Raimondi, *Journal of Chemical Physics* **38,** No. 1, 2686-2689 (June, 1963).

The Self-Consistent Field function for atoms with 2 to 36 electrons are computed with a minimal basis set of Slater-type orbitals. The orbital exponent of the atomic orbitals are optimized so as to ensure the energy minimum. The analysis of the optimized orbital exponents allows us to obtain simple and accurate rules for the 1*s*, 2*s*, 3*s*, 4*s*, 2*p*, 3*p*, 4*p*, and 3*d* electronic screening constants. These rules are compared with those proposed by Slater and reveal the need of accounting for the screening due to the outside electrons. The analysis of the screening constants (and orbital exponents) is extended to the excited states of the ground state configuration and to the positive ions.

Automized X-Ray Line Profile Analysis, H. Keller and A. Segmüller, *The Review of Scientific Instruments* **34,** No. 6, 684-688 (June, 1963).

X-ray line profiles are measured fully automatically by means of a preprogrammed step scan. The intensity data are taken by means of the fixed count method and punched into paper tape by an electronic clock. The evaluation of the intensity data and the Fourier analysis of the line profiles is performed on an IBM 1620 computer.

Channel Capacity of a Realizable Passive Two-Port Network, T. B. Horgan, *Journal of the Franklin Institute* **275,** No. 6, 473-480 (June, 1963).

The general lumped linear finite passive bilateral two-port network is analyzed to determine its channel capacity. The noise mechanism is assumed to be the colored gaussian noise associated with the real parts of pertinent impedances (Nyquist noise). It is shown that a single-independent network characterization suffices to determine both the channel capacity and the optimum spectrum for the source to achieve this upper bound. Consideration is given to the optimum match of source spectrum to the network, and to the optimum match of source internal resistance to the network.

Circuit Design and Parameters in Thin-Film Technology,* F. F. Jenny, *International Journal, Electronics Reliability and Micro-miniaturization* **2,** 19-26 (First Quarter, 1963).

Procedures are described for obtaining complex logic functions by integrating, at the panel level, many thin-film circuits of one type with the multilayered film interconnections between them. Familiar design techniques for lumped parameter networks are utilized although disturbed parameter network designs are used when applicable.

* The work reported in this paper was performed, in part, under U. S. Army Signal Corps Contract DA 36-039-SC-87246.

A Computer-Integrated System for Centralized Information Dissemination, Storage, and Retrieval, R. J. Tritschler, *ASLIB Proceedings* **14,** 473-503 (December, 1962).

This paper describes a system for recording and arranging library data in a technical information center. The achievement of system objectives is discussed from the theoretical and practical viewpoints. Also discussed are the acquisition of input material, abstracting and indexing, preparatory processing, machine programs, automatic information dissemination, and customer-initiated retrieval.

Converter Digitizes Low Level Signals for Control Computers, H. L. Funk, T. J. Harrison and J. Jursik, *Automatic Control* **18,** 21-23 (March, 1963).

An analog-to-digital converter developed for use in process control systems directly digitizes low-level transducer signals for entry into a control computer. It features good common-mode signal rejection with a sampling rate compatible with the general requirements of industrial process control. General converter operation and pertinent circuit details are briefly described.

Correlation Energy for Atomic Systems, Enrico Clementi, *Journal of Chemical Physics* **38,** No. 9, 2248-2256 (May, 1963).

Correlation energy for the ground state isoelectronic series of the second-row atoms of the periodic table is estimated. In this estimate the relativistic energies for the closed and the open shells, and the Hartree-Fock energies are taken from calculations recently performed. As expected, the second-row correlation energy parallels, in general, the characteristics of the first-row correlation energy. The principal contribution to the correlation energy is due to pairing of electrons in a given orbital. The inter-shell correlation is smaller than the intra-shell correlation (but not negligible) and the $3s$-$3s$ electron correlation is linear in Z.

Correlation of EPR and Electro-Optical Measurements in ZnS, F. F. Morehead and R. S. Title, *Journal of Physics and Chemistry of Solids* **24,** 719 (June, 1963).

A recent publication by one of the authors described an optically stimulated EPR spectrum in ZnS doped with various amounts of Al. On the basis of the experimentally observed decrease in the optical energy required to excite the EPR spectrum, which was due to Al^{++}, with increasing aluminum, a model was proposed. The model involved two major assumptions: (1) increasing association of aluminum and zinc vacancies with increasing aluminum concentration and (2) a direct, optically induced transfer of charge between these two centers. The present work describes measurements of luminescence and dc photoconductivity in these same powder samples which are in disagreement with this model. A second model involving a doubly ionizable center attributable to copper naturally present in the samples and indirect optical transfer of charge from this center to the Al^{+++} via the conduction band is proposed which is in agreement with all the available data.

Covalency and the Paramagnetic Resonance of Mn^{++} In CdSe, Reuben S. Title, *Physical Review* **130,** 17 (April 1, 1963).

The paramagnetic resonance spectrum of divalent manganese has been measured in a single crystal of CdSe (C_{6v}^4) at 77°K. The parameters are $g = 2.003 \pm 0.001$, $A = -62.7 \pm 0.5 \times 10^{-4}$ cm^{-1}, $D = 15.2 \pm 0.5 \times 10^{-4}$ cm^{-1}, $\alpha = 14.3 \pm 1.0 \times 10^{-4}$ cm^{-1}, $F = -2.0 \pm 1.0 \times 10^{-4}$ cm^{-1}. The α and F values were separated by making measurements in directions other than parallel and perpendicular to the c-axis of the crystal. It is to be noted that in this hexagonal crystal the effect of the cubic field parameter α is comparable to that of the axial field parameter D. The large value of α is attributed to covalency effects. A comparison of the measured α value with α values found for Mn^{++} in other wurtzite and zincblende crystals shows that there is a correlation between the magnitude of the α value and the amount of covalency. A similar correlation between the value of D and the amount of covalency is also found and accounts for the low value of D in CdSe.

A Criterion for Exciton Binding in Dense Electron-Hole Systems: Application to Line Narrowing Observed in GaAs, R. C. Casella, *Journal of Applied Physics* **34,** 1703-1706 (June, 1963).

When classical statistics apply, exciton binding is expected to cease when the concentration increases to the point that the Debye shielding length becomes less than the exciton radius which obtains in the absence of shielding. The statement is made more accurate by employment of Hulthen and Laurikainen's variational solutions of the Schrödinger equation for a particle electrostatically bound to an exponentially shielded charge. The result is applied to recent experiments with GaAs injection lasers. It is concluded that excitons (either free or bound to impurities) do not play a role in the recombination process at high current levels. A similar criterion for binding is derived for low temperatures and applied to proposed experiments to observe line narrowing due to a Bose-Einstein condensation of excitons in CdS and CdSe. Finally, it is concluded that heavy holes do not contribute effectively to the shielding when their thermal (or Fermi) velocity is considerably less than the orbital velocity of the bound electron which obtains in the absence of shielding.

Critical Fields of Thin Superconducting Films: II, Mean Free Path Effects in Indium-Tin Alloy Films, A. M. Toxen and M. J. Burns, *Physical Review* **130,** 1808-1815 (June, 1963).

In a previous paper, a theoretical model was presented from which the critical magnetic fields of thin superconducting films could be calculated. The model was worked out for the nonlocal model of Pippard, but only thickness effects were discussed in detail and compared to experimental data on pure indium films. In this paper, mean free path effects as well as thickness effects are discussed, and the results are

found to be in good agreement with critical field measurements on thin alloy films of indium containing 0 — 4.6 At. % tin, if one assumes that $\xi_0 \lambda_L^2$ is equal to 1.62×10^9 (A)^3 at 0.9 T_c, ξ_0 is equal to 2600 A, and ρl is approximately 2.0×10^{-11} Ω — cm^2. For these values of ξ_0 and ρl, the coherence length, ξ, has been calculated for each film from measurements of resistivity and thickness, and is found to vary from 2600 A at 0 At. % Sn to 1000 A at 4.6 At. % Sn. Also, the question of whether size effects in thin films are equivalent to mean free path effects is discussed in detail. It is concluded that size effects are not equivalent to mean free path effects, or more precisely, boundary scattering is not equivalent to scattering by randomly distributed defects. In fact, it is demonstrated that whereas the London or "local" limit obtains in the presence of high concentrations of randomly distributed defects, the Pippard or "nonlocal" limit obtains in very thin films, where boundary scattering predominates.

A Dember Effect Study of Shifts in the Stoichiometry of ZnS, F. F. Morehead, *Journal of the Electrochemical Society,* **110,** 285-288 (April, 1963).

An attempt was made to follow the changes in vacancy concentration in ZnS resulting from variations of temperature and sulfur pressure. The sign and amplitude of the Dember effect pulse is sensitive to such vacancy changes in ZnS, showing *p*-type currents where a sufficient excess of cation vacancies is present and *n*-type currents for material which either is compensated or contains an excess of anion vacancies. The *p*-type current increases at constant temperatures roughly as the square root of the sulfur pressure; it decreases with temperature for a constant sulfur pressure so as to indicate a reaction energy of 0.6 ev per zinc vacancy formed. The *n*-type current measured in material fired in sealed quartz capsules with no added sulfur increases with the firing temperature, yielding an activation energy of 1.1 ev for each pair of vacancies formed. Firing the "pure" ZnS in a running vacuum at 900°C, on the other hand, yields *p*-type material, indicating that the formation of an isolated Zn vacancy is energetically considerably more favorable than the formation of an isolated S vacancy. This conclusion is further substantiated by examination of the reaction energies mentioned above.

Dépendance entre l'épaisseur des couches magnétiques minces et le champ coercitif de déplacement des parois (Dependence between the thickness of the thin magnetic films and the wall motion coercive force), S. Middelhoek, *Journal de Physique* **24,** No. 3, 173-175 (March, 1963).

Experimental measurements of the thickness dependence of the wall motion coercive force in thin magnetic films are not in agreement with the so-called 4/3-power law of Néel. It will be shown that this 4/3-power law of Néel is only valid for Bloch walls in thick films under the assumption that the magnitude of the thickness variations of the film is independent of the thickness. Using the same assumption one finds that the wall motion coercive force of Néel walls is independent of the thickness of the film.

Developing an Experience Register for Engineers, R. A. Dunlop, *IEEE Transactions on Engineering Management* **EM-10,** No. 1, 6-14 (March, 1963).

Using specific descriptive phrases about experiences, it is possible to classify a group of people into categories. The fewer the number of these experiences used in the classification, the less likely an individual's "personality" will be preserved. The greater the number of items involved, the greater the information processing-problem. In this paper a technique is developed for handling one segment of personnel information—experience. The technique is to describe a person through information related to his work experience. The study covers the development of an experience matrix and shows that such information can be reasonably classified in this form. Two factor analyses were carried out. The direct factor analysis developed factors of combinations of work experience which have a reasonable degree of independence. The inverse factor analysis because of the complex method of interpretation was less satisfactory.

Digital Circuit Techniques for Speech Analysis, G. L. Clapper, *IEEE Transactions on Communications and Electronics* **66,** 296-304 (May, 1963).

The fundamentals of voice production and hearing are briefly reviewed with respect to the nature of the complex speech waveform. Some early speech devices are noted and current work in the field of computer simulation is considered. A general description of an experimental Word Code Generator is given. This device produces a compressed digital code from the spoken word as a function of frequency, intensity, and time. Individual sound patterns are coded as a function of the changes in the word itself. The code is produced as the word is spoken and is displayed in matrix form for immediate analysis. Readout to a card punch or other storage media is easily accomplished. The operation of the system is described with special reference to the circuit configurations and techniques developed for the Word Code Generator. The advantages and disadvantages of the digital representation of speech events are discussed with reference to storage economy, information transfer, and pattern recognition. It is concluded that digital techniques for speech analysis should find usage in speech therapy, speech recognition, and speech synthesis.

Discrete Tracks for Saturation Magnetic Recording, L. F. Shew, *IEEE Transactions on Broadcast and Television Receivers* **BTR-9,** 56-62 (May, 1963).

Discrete-track recording is a magnetic-recording method which employs a single-gap head and a discrete-track medium to increase the head-repositioning tolerance in saturation digital recording. A head with a conventional ring structure may be used. The recording medium consists of discrete magnetic tracks separated by nonmagnetic lands. Width of the magnetic tracks depends largely on the desired track density and maximum tolerable head-repositioning error. Test results indicate excellent track performance; consequently, satisfactory and reliable operation can be expected under actual machine conditions. Major advantages of discrete-track recording are economy, reliability, and increased head-repositioning tolerances.

Dissociation Energy Computations in Diatomic Molecules: An Example, Enrico Clementi, *Journal of Chemical Physics* **38,** No. 11, 2780-2782 (June, 1963).

A method to compute the dissociation energy in diatomic molecules is given. An example, the L:F molecule, is discussed in detail.

Divalent Rare Earth Spectra Selection Rules and Spectroscopy of $SrCl_2:Sm^{+2}$,* J. D. Axe and P. P. Sorokin, *Physical Review* **130,** 945-952 (May 1, 1963).

Selection rules for radiative and nonradiative transitions of divalent rare earth ions in alkaline-earth halide lattices are discussed. Absorption and fluorescence spectra of $SrCl_2:Sm^{+2}$ are given, providing illustrations of the above-mentioned rules.

* This research has been supported jointly by IBM and the U. S. Army Research Office, Durham, North Carolina.

Domain Walls in Thin Ni-Fe Films, S. Middelhoek, *Journal of Applied Physics* **34,** No. 4 (Part 2), 1054-1059 (April, 1963).

The energies of Bloch and Néel walls are calculated as functions of the film thickness and the angle through which the magnetization turns in the wall. It appears that in addition to the well-known Bloch-Néel wall transition as a function of the film thickness, Bloch-Néel wall and cross tie-Néel wall transitions occur when the angle through which the magnetization rotates is changed by an external field. The new calculations together with a review of previous work give a comprehensive picture of the domain walls in thin Ni-Fe films.

Energy-Gap Function in the Theory of Superconductivity, James C. Swihart, *Physical Review* **131,** 73-78 (July, 1963).

The relation between the form of the energy-gap function $\Delta(\epsilon)$ and experimental results for the superconductors with stronger coupling, Pb and Hg, is discussed. It is shown that the critical field curve is affected rather strongly by the form of $\Delta(\epsilon)$ near the Fermi surface, but that the form of $\Delta(\epsilon)$ at distances of a Debye energy or more has little effect. The positive deviation of the critical field from a parabolic indicates that Δ is flat or slightly increasing on moving away from the Fermi surface. Solutions of the BCS integral equation are given for the Bogoliubov, Bardeen-Pines, and Eliashberg interactions. When a screened Coulomb interaction is included, all of these solutions have the necessary form at the Debye energy to explain the anomalous tunneling behavior of Pb. The critical field data eliminates both the Bogoliubov and Bardeen-Pines interactions, and favors the Eliashberg interaction. However, the Pb and Hg critical fields can not be reproduced with these solutions since the ratio $\Delta(0)/kT_c$ is much too small.

Equilibrium Concentration of Lattice Vacancies in Lead and Lead Alloys, F. M. d'Heurle, R. Feder and A. S. Nowick, *Journal of the Physical Society of Japan* **18,** Supplement II, 184-189 (1963).

The equilibrium concentration of vacancies near the melting point of pure lead and of a number of dilute lead solid solutions has been measured. The method involves comparison of macroscopic thermal expansion with the microscopic expansion obtained from precision X-ray lattice parameter measurements. The results on dilute binary solid solutions of lead with In, Tl, Sn, and Bi show no detectable vacancy concentration, corresponding to a mole fraction $\leqq 5 \times 10^{-5}$. On the other hand, the data for pure lead indicates a vacancy concentration of 20×10^{-5} at the melting point. The explanation for these surprising results is not apparent.

Estimation of the Shape and Scale Parameters of the Weibull Distribution, M. V. Menon, *Technometrics* **5,** No. 2, 175-182 (May, 1963).

Estimates $\hat{c}$ and $\hat{b}$ are proposed for the shape parameter c and the scale parameter b of the Weibull distribution on the assumption that the location parameter is known: $\hat{c}$ obtained by first finding an estimate $\hat{d}$ of $1/c$, and then setting $\hat{c} = 1/\hat{d}$. When b is unknown, $\hat{d}$ is a consistent and non-negative estimate of d, with a bias which tends to vanish as the sample size increases and with an asymptotic efficiency of about 55%. When b is known, $\hat{d}$ is an unbiased, non-negative and consistent estimate of d, and its efficiency is approximately 84%. An estimate $\ln\hat{}b$ of $\ln b$ is found. Its asymptotic efficiency is 95%. It is proposed that $\exp(\ln\hat{}b)$ be used to estimate b.

An Experimental and Theoretical Study of Pulse Transmission in Stripline Arrays, D. E. Eastman and H. Chang, *IEEE Winter Meeting (New York, N. Y)* CP63-414 (January, 1963).

Pulse distortion due to skin effects and capacitive coupling and noise effects due to capacitive coupling and coupling between parallel striplines are considered in this work. Skin effect distortion is analyzed and pulse measurements on representative 40-cm striplines are made which generally confirm the analysis. Capacitive cross-coupling alters the velocity of propagation and characteristic impedance, causes pulse distortion, and induces transients in lines orthogonal to the excited line. These effects are analyzed and measurements of capacitively coupled transients are presented which agree with calculated values. Experimental results on coupling between parallel striplines are in agreement with an analysis. Array geometries of interest usually have stripline widths and spacings less than 3 mm, stripline lengths less than 1 meter and impedances less than 60 ohms. The results of this work are generally applicable for risetimes of 1 to 30 nsec for the above range of geometries.

Ein Experiment zur Uberschreitung der Abbeschen Auflösungsgrenze (An experiment to exceed the Abbe resolution limit),* W. Gärtner† and A. Lohmann, *Zeitschrift für Physik* **174,** 18-23 (May, 1963).

It is possible to overcome the Abbe limit of resolution by a factor two. For this, one needs the *a priori* knowledge that the object is not birefringent or dichroic. That is to say, the object acts identically on both of the independent polarization components of the incident light. Then already one polarization component would be enough to form an image as complete as it is permitted by the lens system and by the aperture. The other polarization component would produce an identical image. Hence the capacity of the other polarization component to carry information from the object plane to the image plane is wasted. This waste can be avoided by means of a special set-up containing, for example, two Wollaston prisms. The result is the doubling in resolution without any increase of the aperture. This has been confirmed experimentally both for coherent and incoherent illumination.

* Work performed at Physikalisches Institut der Technischen Hochschule Braunschweig.
† Physikalisches Institut der Technischen Hochschule Braunschweig.

Ferrimagnetic Resonance Linewidth in Dense Polycrystalline Ferrites,* P. E. Seiden and J. G. Grunberg,† *Journal of Applied Physics* **34,** No. 6, 1696-98 (June, 1963).

The linewidth of polycrystalline ferrites has been calculated from the dipole narrowing theory including both anisotropy and porosity effects. It is shown that porosity broadening is successfully accounted for and that porosity is the dominant line broadener even in very dense ferrites. The temperature dependence of the linewidth for samples of yttrium iron garnet and manganese ferrite are in good agreement with the predictions of the theory.

*Part of this work was done under a National Science Foundation Postdoctoral Fellowship at the Institute Fourier of the University of Grenoble, Grenoble, France.
† Centre d'Études Nucleaires de Grenoble, Grenoble, France.

Flame Propagation in Laminar Boundary Layers,* T. Y. Toong,† J. R. Kelly,† and W. S. Wu, *Ninth Symposium (International) on Combustion,* Academic Press, N. Y. and London, pp. 59-64 (April, 1963).

This paper presents the results of an experimental program aimed at providing a critical test of the equilibrium theory of flame stabilization in boundary layers previously proposed by the senior author. Using schlieren photography and a particle-track technique, the characteristics of a two-dimensional flame stabilized on a cylindrical rod and propagating into a laminar boundary layer adjacent to a flat plate are investigated.

The results presented include the velocity distribution of the unburned mixture in the free stream, the velocity profile in the boundary layer, and the experimental burning-velocity profiles for three different plate temperatures. The latter profiles are compared with the adiabatic profiles computed on the basis of a previous theoretical analysis, and the effect of quenching due to the presence of the flat plate is discussed.

It is shown that the burning-velocity profiles are indeed affected by the growth of the thermal boundary layer when the flat plate is heated, and that these profiles assume shapes postulated in the theoretical study of the mechanism of flame stabilization. Quantitatively, the flame-holding characteristics of a smooth surface predicted by the use of these measured profiles agree with reported experimental results.

*Work performed at Massachusetts Institute of Technology.
† Massachusetts Institute of Technology.

Further Study on Flame Stabilization in a Boundary Layer: A Mechanism of Flame Oscillations,* W. S. Wu and T.Y. Toong,† *Ninth Symposium (International) on Combustion,* Academic Press, N. Y. and London, 49-58 (April, 1963).

A mechanism of flame oscillation is proposed in an attempt to explain the often-sought flame oscillation phenomena in a boundary layer and also to bring together with a unified theory the two distinct types of flame stabilization in a boundary layer, i.e., the steady flame and the oscillating flame.

This proposed hypothesis postulates that the oscillation phenomenon of the flame in a boundary layer is caused by the instability of the boundary layer flow. The adverse pressure gradient immediately upstream of the flame nose in the boundary layer and the heat transfer to the unburned mixture from the solid boundary make the boundary-layer flow highly unstable. This instability, combined with the basic principles of flame stabilization and propagation, sets off the oscillation. A comparison of the experimental conditions with the existing boundary-layer stability theory indicates that the boundary layer in the experiments is in the unstable region. Evidence is provided to support the theory.

* Work performed at Massachusetts Institute of Technology.
† Massachusetts Institute of Technology.

Generation of Laser Axial Mode Difference Frequencies in a Nonlinear Dielectric, K. E. Niebuhr, *Applied Physics Letters* **2,** No. 7, 136-137 (April 1, 1963).

This letter reports the optical generation of a microwave difference frequency in a nonlinear dielectric. A quartz crystal was used as the nonlinear device to mix the axial modes of ruby lasers in a parametric coupling techniques to generate the microwave difference frequencies.

Hard Magnetic Films of Co-Ni-P, G. Bate and D. E. Speliotis, *Journal of Applied Physics* **34,** No. 4 (Part 2), 1073-1074 (April, 1963).

Films of Co-Ni-P having thicknesses from 0.020 to 3μ and showing unusual magnetic properties have been prepared by electrodeposition onto polished brass substrates. The crystallite size was very small (~100A); no crystallographic orientation could be detected. The coercivity, in the range 375-600 oe, increased steeply with thickness from 0.020 to 0.1μ then decreased logarithmically with increasing thickness. The remanence coercivity behaved similarly. The ratio of remanent intensity to saturation intensity was high (~0.70-0.80), the sides of the loop were almost vertical, and yet the films were completely isotropic in the film plane. This combination of properties in films of high coercivity is difficult to explain in terms of existing theories of magnetization reversal. Torque curves were measured and showed a weak sin θ dependence at fields less than the coercivity and a weak sin 2θ dependence at higher fields. Graphs of rotational hysteresis W as a function of applied field had a shape which was, in general, independent of film thickness. The peak occurred at about 600 oe and the maximum anisotropy field was ~6500 oe. Calculation of the rotational hysteresis integral

$$\int_0^\infty \frac{W}{I_s}\left(\frac{1}{H}\right)$$

gave values which ranged from 1.9 for the thin films to 4.8 for the thicker ones. Models for magnetization-reversal processes in these films are discussed.

High-Speed Nondestructive-Read Memory, O. A. Gutwin, H. R. Foglia and J. R. Kiseda, *1963 Proceedings of the Intermag Conference* (International Conference on Nonlinear Magnetics, Washington, D. C.) published by *IEEE,* pp. 6-4-1 to 6-5-4 (April 17-19, 1963).

Since most computer programs utilize a high read-to-write ratio in memory, an improvement in system performance can be realized by the use of a nondestructive-read memory. The minimum time that will be saved by such a memory is the regeneration time associated with rewriting the information normally destroyed in a destructive-read memory. This paper describes a cross sectional model of a 16K-word nondestructive-read memory. This memory is word-organized and uses standard ferrite cores operating in the bias-restored

nondestructive-read mode. The cross sectional model consists of a 1000-word segment that has 16 word lines and 4 digit lines fully populated with cores. The read cycle time is 100 nsec, providing information from the memory at a 10 Mc rate. The write cycle time is 500 nsec, giving an effective read-write cycle time of 250 nsec.

High Voltage Vacuum Feedthrough, Robert D. Knight, *The Review of Scientific Instruments* **34,** 303 (March, 1963).

A device is described which combines a modified commercial tube fitting with a Teflon sleeve to conduct high voltage through the wall of a vacuum system. Its advantages over previously described feedthroughs are based on simplicity of design and construction, demountability, protection against electrical shock provided by external sleeve, and high voltage capability ($>$ 40 kv).

Internal Field, Dispersion, Creeping, and Switching Speed of Coupled Films, H. Chang, A. Yelon and O. Voegeli, *Journal of Applied Physics* **34,** 1209-10, (April, 1963).

Coupled films were made either by sandwiching striplines between two films on different substrates or by multilayer evaporation. The first structure was found to be inadequate in reducing the demagnetizing field because the airgap was appreciable. The switching speed of coupled films was calculated with the Landau-Lifshitz equation, taking into account the magnetostatic coupling energies. Nearly identical rotational switching speeds were found for single and coupled films. The results were verified by measurements. Skew, dispersion and creeping were measured. It was found that coupled films were not susceptible to the word field disturbance from neighboring lines.

Internal Magnetic Fields and the Saturation Magnetization of Iron-Aluminum Alloys, E. A. Friedman and W. J. Nicholson, *Journal of Applied Physics* **34,** No. 4, 1048-1049 (April, 1963).

Internal magnetic fields in several iron-aluminum alloys ranging in composition from 19 to 28 at. % aluminum have been measured in a Mossbauer absorption experiment. In the composition range 22% to 26% aluminum, three distinct internal magnetic fields were observed. At 300°K the magnitudes of these fields are in the ratio 1.00 : 0.88 : 0.72. In a 19% alloy only the two larger fields were observed; in a 28% alloy only the largest and smallest fields were seen. The largest and smallest fields are the previously observed internal magnetic fields at iron atoms having, respectively, 8 and 4 iron nearest neighbors in an Fe_3Al structure. The 0.88 field is attributed to iron atoms surrounded by 5 iron nearest neighbors in an $Fe_{13}Al_3$ structure. Using the known relation between the internal magnetic field and the atomic moment and the supposition that an iron atom with 3 iron nearest neighbors has no aligned moment, saturation magnetization curves of the iron-aluminum systems have been calculated on a statistical basis under various known ordering conditions. In the case of annealed alloys, this calculation yields a saturation magnetization curve which agrees with measurements within experimental accuracy. The measured differences between the saturation magnetization of quenched and annealed alloys are also reproduced in these calculations. In the case of cold-worked alloys, good agreement with experiment is similarly obtained.

Ionic Conductivity and Time-Dependent Polarization in NaCl Crystals,* P. H. Sutter† and A. S. Nowick, *Journal of Applied Physics* **34,** 734-746 (April, 1963).

When a constant electric field is applied to a dielectric, the current density per unit field decreases with time from an "initial conductivity" to a "final (or steady-state) conductivity." A study is made of this time dependent polarization effect for "pure" NaCl crystals in the range from 50°C to 200°C. The validity of Ohm's law and the superposition principle is demonstrated for these crystals; this establishes the linearity of the formal equation which relates polarization, electric field, and their time derivatives. Also studied are the effect of prolonged current flow, the effect of deliberate introduction of an air gap between the crystal and one of its electrodes, and the effects of impurities, deformation, X-ray irradiation, and annealing. It is concluded that the results are not consistent with the well-known space-charge polarization theory of Joffe, according to which the buildup of space charge occurs because of blocking of the current carriers at one or both electrodes. Rather, it is necessary to regard the time dependent polarization as a dielectric relaxation phenomenon. According to this viewpoint, the final conductivity, and not the initial value, represents the true ionic conductivity. Possible relaxation mechanisms are discussed in terms of defect clusters and charged jogs on dislocations.

* Based in part on a dissertation submitted by P. H. Sutter for the degree of Doctor of Philosophy at Yale University.
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Kerr-Effect Readout Uses Gas Laser, R. B. Edwards, *Electronics* **36,** 48-50 (April 5, 1963).

Magnetic disk readout by the Kerr magneto-optical effect, using a neon-helium gas continuous laser for a light source, has been achieved. The continuous gas laser offers a substantial improvement in resolution and in readout signal-to-noise ratio over conventional light sources that have been used with the Kerr effect in the past.

Large Linear Programs, A. J. Hoffman, *1962 Proceedings of IFIP Congress,* pp. 173-176 (North-Holland Publishing Company, Amsterdam, Holland).

This paper is an exposition of principles involved in solving large linear programs. Such programs arise when the columns or rows consist of all possible vectors satisfying some specified rules. Under certain circumstances, the choice of a column or row to enter the basis may become a programming problem over the set of vectors satisfying the rules, and this problem may be capable of easy resolution. Examples of achievements in this direction are given, along with some unifying ideas concerning the solution of small linear programming problems that may arise as optimizing subproblems.

Low-Density-Burst-Correcting Codes, A. D. Wyner,* *IEEE Transactions on Information Theory* **IT-9,** No. 2, 124 (April, 1963).

A class of cyclic codes which connect clusters of up to e errors within a span of b digits (a "low-density-burst" when $b < e$) is presented. These codes are a generalization of Fire codes.

* Now with Bell Telephone Laboratories Inc., Murray Hill, New Jersey.

Magnetic Field Effects on an Abnormal Truncated Glow Discharge and Their Relation to Sputtered Thin Film Growth, Eric Kay, *Journal of Applied Physics* **34,** No. 4, 760-768 (April, 1963).

Superposition of a radially symmetric magnetic quadrupole field onto an abnormal glow discharge operating at E/P of 10^5 produces an additional ionization region in the negative glow which is not observed in the absence of a magnetic field and which increases the ion current density at the cathode by more than an order of magnitude. Preliminary Langmuir probe measurements show the electric field gradient in this region to be small and an average electron energy of only 0.8 ev. Data will be given to show how sputtering ratio measurements in such a system can be correlated to secondary electron emission at the cathode and charge transfer in the Crooks dark space. Ion current density profile measurements across the cathode as well as corresponding cathode erosion and anode deposition profiles are given.

Magnetic Properties of Some Divalent Europium Compounds, T. R. McGuire, B. E. Argyle, M. W. Shafer and J. S. Smart, *Journal of Applied Physics* **34,** 1345-46 (April, 1963).

The compounds of divalent europium form an attractive series for magnetic investigations because the magnetic ions are in S states and the crystal structures are generally simple. Moreover, true ferromagnetism, which is quite unusual in compounds, has been observed in EuO by Matthias, Bozorth, and Van Vleck.

We have prepared samples of EuS, EuSe, EuTe, $EuCO_3$, $EuTiO_3$, $EuZrO_3$, $EuSO_4$, and $EuCl_2$, and studied their magnetic properties in the temperature range 4-300°K. The sulfide, selenide, and telluride all have the same NaCl crystal structure as EuO; we find that the first two also become ferromagnetic at low temperature, while EuTe is paramagnetic, or possible antiferromagnetic, at 4.2°K. The Curie temperatures for EuS and EuSe are about 18° and 7°K, respectively. The saturation moments of EuS and EuSe extrapolated to 0°K correspond to 6.8 and 6.7μ_B per Eu^{++} ion, respectively, in good agreement with the expected value of 7μ_B. None of the other compounds were ferromagnetic at liquid helium temperatures, and all exhibited θ values very near to 0°K. A tentative interpretation of the exchange interactions in the rocksalt compounds is made using a molecular field treatment.

Magneto-Optical Readout from a Magnetized Nonspecular Oxide Surface, E. J. Supernowicz, *Journal of Applied Physics* **34,** No. 4, Pt. 2, 1110-1111 (April, 1963).

This paper describes a magneto-optical method for obtaining visual display and electronic readout of magnetic information recorded on a nonspecular oxide surface. A recorded oxide surface is placed in contact with a specular ferromagnetic surface, an external magnetic field is applied normal to the two surfaces in contact, and the recorded information is read out by means of the Kerr effect through the back of the specular surface. The method is a useful tool for studying the writing process independently of the reading process in investigations of magnetic recording on oxide surfaces. It was observed that, when the external field was applied, the magnetic pattern was either sharpened or caused to spread, depending on the polarity of the field.

Maximum Solid Solubility and Distribution Coefficient of Impurities in Germanium and Silicon, H. Statz, *Physics and Chemistry of Solids* **24,** 699-700 (May, 1963).

A theoretical explanation is given for an empirical relation between the maximum solid solubility of impurities in Ge and Si and the distribution coefficient at the melting point. The present calculation starts from a known expression for the distribution coefficient. The impurity concentrations in the liquid are expressed by the ideal liquidus equation. The maximum solid impurity concentration is then determined by differentiation.

A Model for Processing in the Nervous System, S. M. Khanna and C. R. Noback,* *Transactions of the New York Academy of Sciences* **25,** 516-521 (March, 1963).

The digital computer (IBM 709) has been utilized in an analysis of some parameters derived from the nervous system. Based on observations made during simulation of a cell assembly on a digital computer, a condition for convergent activity is derived. Evidence is presented in the form of available neuroanatomical and neurophysiological data to indicate that the requirements for convergence are presently in accord. The phenomenon of convergence produced in the computer experiments simulates the sharpening effect observed in the nervous system. The artificially produced "sharpening" is produced by "excitation."

* Columbia University, New York.

Moderne Informationsspeicher (Modern Computer Memories), G. Kohn, *Physikalische Blätter* **19,** Heft 6, 256-261 (June, 1963).

Present day memory techniques are compared with respect to their capacity and cycle time capabilities. The operation mode of a thin magnetic film memory is described with regard to a 18432-bit, 100-nanosecond film memory model.

Multi-Commodity Network Flows, T. C. Hu, *Journal of Operations Research* **11,** No. 3, 344-360 (May-June, 1963).

A network is a set of nodes N_i connected by arcs with nonnegative arc capacities b_{ij} which indicates the maximum amount of flow that can pass through the arc from N_i to N_j. Given all b_{ij}, there is a maximum flow from N_i to N_j using all arcs. Under the assumption that $b_{ij} = b_{ji}$, the present paper generalizes the maximum flow, minimum cut theorem of Ford and Fulkerson (*Canadian Journal of Mathematics,* 1956) to the problem of finding the maximum simultaneous flows of two commodities and gives an algorithm similar to the labelling method for constructing the two flows.

Note on the One-Dimensional Gas of Impenetrable Point-Particle Bosons, T. D. Schultz, *Journal of Mathematical Physics* **4,** 666-671 (May, 1963).

A one-dimensional gas of impenetrable point-particle bosoms is considered. An exact expression for the one-particle density matrix is derived in terms of the Fredholm determinant

and resolvent of a certain simple kernel. It is proved that for large r, the density matrix is bounded by const Xr^{-k/n^2}, and that this implies the absence of a generalized Bose-Einstein condensation, contrary to a recent approximate calculation by Girardeau, who first defined such a condensation.

Note on the Rate Equations Governing Charge Transfer Controlled Surface Reactions, G. A. Somorjai and R. R. Haering, *Journal of Physical Chemistry* **67,** 1150 (1963).

The rates of semiconductor surface reactions involving charge transfer have been generally found to depend exponentially on the charge concentration. This has been explained by the boundary layer theory which assumes that the reaction rate is limited by the rate of arrival of electrons (or holes) at the surface of the semiconductor. As the reaction proceeds, a space charge layer is built up at the surface which opposes subsequent electron (or hole) flow. The characteristically exponential rate equation follows since the number of electrons with sufficient energy to overcome the space charge barrier varies as exp $(-W/kT)$. W is the instantaneous barrier height at time t, and depends on the number of electrons which have been transferred to the surface prior to time t.

In the present note we discuss an alternate mechanism whereby a charge transfer limited surface reaction may proceed; namely, quantum mechanical tunneling. We show that the rate equations for the two processes are similar, and we point out the conditions under which tunneling through the barrier, rather than diffusion over the barrier, determines the reaction rate. Furthermore, we discuss how the tunneling process may be experimentally recognized.

Observation of Bond-Bending in Strained Germanium, A. Segmüller, *Physics Letters* **4,** No. 5, 277-278 (May 1, 1963).

In a strained single crystal with diamond structure, only the atomic displacements within each of the two c.f.c. sublattices are uniquely determined by the macroscopic strain, whereas the relative displacement of the two sublattices against each other cannot be specified without a more detailed knowledge of the atomic forces. L. Kleinmann predicted, on the basis of his calculation of the deformation potentials of one of the silicon crystals uniaxially strained along the [111] direction, that in such a crystal the distances of an atom from its four nearest neighbors, apart from a slight isotropic dilation, remain unchanged, and are not strained or bent according to the macroscopic strain. This causes a change in the valence angle between three bonds and the fourth in the direction of the applied strain, or a bond-bending. This bond-bending has been evidenced for germanium by the occurrence of X-ray interferences, which are forbidden for the diamond space group but are allowed for the simple c.f.c. lattice.

On-Board Control of OAO Satellite, C. W. Sturgeon, *Instrument Society of America Journal* **10,** No. 6, 61-64 (June, 1963).

In the Orbiting Astronomical Observatory, processing of commands is required both in and out of line of sight of the ground tracking stations. Consequently, a scheme has been devised for storing commands and executing them at programmed times. The memory used for storing the commands is unique in that after commands have been stored, they are not destroyed by read-out or power removal from the memory. The command processor is capable of processing and distributing the commands and data needed by the spacecraft orientation equipment, the spacecraft stabilization equipment, the experimenters' package carried by the spacecraft (which varies with the particular mission of the craft), and other equipments necessary for spacecraft operation.

On the Polynomial of a Graph, A. J. Hoffman, *American Mathematical Monthly* **70,** No. 1, 30-36 (January, 1963).

A class of problems recently investigated in the theory of graphs and in the design of experiments can be characterized as special instances of finding all graphs G with n vertices such that, for given $a_0, a_1, \cdots, a_k$, we have $a_0p_0(i, j) + \cdots + a_kp_k(i, j) = 1$, where $p_t(i, j)$ is the number of t-step paths from vertex i to vertex j. This paper points out that such a relation can hold if and only if G is regular and connected, suggests some appropriate terminology for considering these questions and, by way of example, studies the graphs with 2^m vertices for which the corresponding coefficients are the same as for the graphs formed by vertices and edges of the m-dimensional cube ($m = 2, 3, 4$). For $m = 2$, 3, the graph must be the cube; for $m = 4$ there is, besides the cube, exactly one other graph.

On Unimodular Matrices, A. J. Hoffman and I. Heller,* *Pacific Journal of Mathematics* **12,** 1321-1327 (1962).

Rectangular matrices with the property that every minor of every order has determinant 0, 1, or -1 are called totally unimodular. Previous papers by Heller and by Hoffman and Kruskal had defined two classes of totally unimodular matrices. It is now shown that these classes are, in fact, identical.

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On the Use of Coset Codes in Asymmetric Channels, C. V. Freiman, *IEEE Transactions on Information Theory* **IT-9,** No. 2, 118 (April, 1963).

Cosets of close-packed single error correcting group codes are considered for use as codes in general memoryless binary channels. It is proved that any coset code always outperforms the equivalent group code unless the channel is perfectly symmetric—in which case the two codes perform equally well. In the course of this proof, an expression is presented for the average probability of a k-tuple error in any binary block code for which the distribution of codeword weights is known. The degree of the coset code's superiority is also investigated and it is shown that it becomes vanishingly small as the block length increases.

Simple parity check codes are then considered and it is shown that, for even block lengths, the odd parity check (coset code) has a lower probability of undetectable error than the even parity check (group code). The price for this improvement is a slightly lower probability of correct transmission.

Optical Detection of Level Crossing in a J = ½ State, A. Gallagher and A. Lurio, *Physical Review Letters* **10,** No. 1, 25 (January 1, 1963).

This letter presents both theoretical and experimental confirmation of a method for observing zero-field level crossings (Hanle effect) in an excited $J = 1/2$ (I arbitrary) state populated by optical excitation from a $J = 1/2$ or $J = 3/2$ ground state. The method requires excitation by circularly polarized light and detection of the circular polarization of the scattered light when both incident and observing directions are perpendicular to the applied magnetic field. The technique is used to measure the lifetime of the thallium $^2S_{1/2}$ excited state.

Physical Behavior of Some Magnetic Materials,* R. M. Bozorth, *Proceedings of the Intermag Conference,* **IEEE,** Washington, April 17, 1963.

After a brief description of the most-used magnetic materials and their development and uses, a discussion is given of the less-known peculiar properties possessed by these materials and other special alloys and compounds. Emphasis was on the physical interpretation of their properties as affected by composition, heat treatment, stress, temperature, etc., making frequent use of domain theory. Materials included square loop materials, superconducting magnetic compounds, rare-earth elements and compounds, spinels, garnets, silicon iron, and others.

* Work performed at the IBM Research Center and at the Naval Ordnance Laboratory, Silver Spring, Maryland.

Piezoresistance and Piezo-Hall-Effect in n-Type Silicon, J. E. Aubrey,* W. Gubler, T. Henningsen† and S. H. Koenig, *Physical Review* **130,** No. 5, 1667-1670 (June 1, 1963).

Preliminary piezoresistance and piezo-Hall-effect measurements have been made on three relatively pure samples of n-type silicon over the temperature range 77-300°K to strains $\sim 1/2\%$. The room-temperature value of the ratio of the saturation resistivity at large stress to the resistivity at zero stress confirms Long's estimate of the relative strength of the "across the zone face" umklapp scattering in intravalley acoustic phonon scattering, rather than a value an order of magnitude larger estimated by Dumke. Additionally, from the dependence of resistivity upon stress at 77°K, the value 8.3 ± 0.3 ev is found for the shear deformation potential tensor component Ξ_μ. The dependence of both resistivity and Hall coefficient on stress at 77°K can be fitted quite well by theoretical expressions, deduced under certain reasonable simplifying assumptions, over the entire range of stress.

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Printed Circuit Motors for High-Speed Incrementing of Inertial and Dissipative Loads, V. C. Martin, *IEEE Transactions on Industrial Electroncs* **IE-10,** No. 1, 28-45 (May, 1963).

As a high-speed incrementer, the printed circuit motor, while less accurate than a detented incrementer, provides unusual flexibility and reliability with relatively simple input controls. This paper presents an analysis of printed circuit motor response to a unit step of input voltage for incrementing purely inertial and dissipative loads. Incrementing is stable and quite accurate if sufficient friction damping is provided. Input power requirements can be accurately predicted in terms of motor and load parameters, increment displacement, and increment time. Average power during an increment varies approximately as J^2, θ^2, $(1/T)^4$. Armature heating dictates maximum input power and incrementing rate. With external cooling and 120 watts average input power, a combined load of 0.009 oz-in-sec^2 moment of inertia, 10.8 oz-in/100 rpm eddy current damping, and 20 oz-in friction damping was incremented at a continuous rate of 150 steps/sec for 5° increments with ±6 per cent accuracy.

Properties of Evaporated Thin Films of SiO,* D. B. York, *Journal of the Electrochemical Society* **110,** No. 4, 271-275 (April, 1963).

The absorption coefficient and transmission of vacuum deposited films of SiO were used as a measure of the reproducibility of the relative composition of the resulting films. The optical properties of the films can be reproduced by controlling the evaporation rate and partial pressure of oxygen. Reproducibility of optical properties does not insure reproducible electrical properties since the surface condition of the electrode material greatly affects the electrical properties.

* A paper originally presented at the Electrochemical Society Conference, Indianapolis, Indiana, April 1961.

Quantum Efficiency of GaAs Injection Lasers, G. Cheroff, F. Stern and S. Triebwasser, *Applied Physics Letters* **2,** 173-174 (May 1, 1963).

Measurements of external quantum efficiency, the number of photons emitted for each carrier crossing the p-n junction, were made for a number of gallium arsenide diodes at 77°K using an integrating chamber. In Fabry-Perot units the light emission is proportional to the current below the threshold for line narrowing, then rises more rapidly but still linearly at higher currents. A simple model is used to relate the differential quantum efficiency above threshold to the internal absorption coefficient α', to the internal quantum efficiency η', and to the length and surface transmissivity of the samples. Results for a series of units of varying length give $\alpha' \approx 56$ cm^{-1} and $\eta' \approx 0.7$. The external quantum efficiency of typical units is $\approx 4\%$ below threshold.

Reversal of Electro-Optical Birefringence in Bentonite Suspensions, M. J. Shah, D. C. Thompson,* and C. M. Hart,† *Journal of Physical Chemistry* **67,** 1170-1178 (June, 1963).

An investigation in the birefringence of various monodisperse bentonite suspensions containing a threefold range of particle sizes (2500-7800 A) is presented. The dimensions of the macromolecules and their degree of dispersion were determined with the aid of an electron microscope. Bire-

fringence measurements were carried out using monochromatic light, applying a pulsed dc field as well as ac and square wave fields to the bentonite dispersions in water-cooled cells with 10- and 40-mm light path lengths. Suspensions of various concentrations and various particle sizes were employed in this study. It was concluded that the negative birefringence exhibited by bentonite in weak fields is brought about by a permanent dipole along the axis of symmetry of the bentonite disk. The permanent dipole orientation is perpendicular to the strong field orientation, which is predominantly governed by the electrical anisotropy of the macromolecule. Experimental results with square wave and ac fields in support of this model are presented.

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Röntgenfeinstruktur-Untersuchungen zur Bestimmung der Kristallitgrösse und des Mittelwertes der Eigenspannungen 2. und 3. Art an dünnen Metallschichten (X-Ray Diffraction on Thin Metal Films), Armin Segmüller, *Zeitschrift für Metallkunde* **54,** Heft 4, 247-251 (1963).

Fourier analysis of the X-ray line profile is a useful method for determining the average crystallite size and rms strain in thin evaporated nickel films, provided that the film is sufficiently thick for measuring the second order of the (111) or (200) reflection. Nickel films evaporated on substrates at temperatures between 200° and 300°C have crystallite sizes comparable with that of cold-worked bulk nickel that may also be recovered below 400°C, whereas the rms strain is lower than in that bulk nickel. During annealing at temperatures above that of the substrate during evaporation, a recrystallization and grain growth takes place even at temperatures which are not sufficient for the recrystallization of cold-worked bulk nickel. After a recrystallization, a preferred orientation of the (100) lattice planes parallel to the film surface is very often observed.

Second Anisotropy Constant in Cubic Ferromagnetic Crystals,* R. J. Joenk, *Physical Review* **130,** 932-938 (May 1, 1963).

The second anisotropy constant, K_2, is evaluated at 0°K for cubic, ferromagnetic crystals using two particle dipole- and quadrupole-like interactions as perturbations on a molecular field Hamiltonian. In second and third order perturbation, the energy denominators are modified to take into account the effect on the molecular field of the exchange interaction of consecutively reversed spins. The expression for $K_2(0)$ is used in conjunction with that for $K_1(0)$ to calculate the values of the pseudodipolar and pseudoquadrupolar coupling constants for iron, cobalt, and nickel. For bcc Fe, $D/J = 0.0793$ and $Q/J = 0.00157$, where $JS = 2.87 \times 10^{-14}$ erg; for fcc Co, $D/J = 0.113$ and $Q/J = 0.000865$, where $JS = 2.0 \times 10^{-14}$ erg; and for fcc Ni, $D/J = -0.0768$ and $Q = 0$, where $JS = 2.5 \times 10^{-14}$ erg, although the application of the model to nickel is not entirely satisfactory. These values are used to predict the size of the third anisotropy constant and the paramagnetic resonance linewidth.

*Work done at the University of Pittsburgh and supported by AFOSR Contract #AF49(638)-323.

Semantic Transfer of the Differential Conditioned Eyelid Response From Words to Objects,* T. F. Hartman, *Journal of Experimental Psychology* **65,** No. 2, 194-200 (1963).

This experiment investigated transfer of the conditioned response (CR) from words to objects possessing characteristics of the words, and evaluated the effects of concurrently verbalizing specific characteristics of the objects. 120 subjects were used. Findings were (a) marked discrimination early in the transfer phase even when the words initially differentially reinforced were unrelated to the objects; (b) more initial CR transfer to the positive object conditional stimulus (CS) for 2 groups with initially relevant words—one group verbalizing a dimension of the objects identical to the words, the other group verbalizing another relevant dimension of the objects; (c) more initial transfer of discrimination only for the group verbalizing the dimension of the objects identical to the words' CS's.

* Work performed at the University of Wisconsin.

A Simple High Sensitivity Microbalance for Use in Ultra-High Vacuum, I. Haller and P. White, *Review of Scientific Instruments* **34,** 677 (1963).

This paper describes a piezoelectric quartz crystal microbalance which utilizes a commercially available crystal and which is bakeable for ultra-high vacuum use. It has been employed in adsorption studies and for measurement of deposition rates in condensation and polymerization processes.

Simulation of a Learning Machine for Playing *Go*, H. Remus, *Information Processing 1962,* pp. 428-432 (North-Holland Publishing Company, Amsterdam, 1963).

The rules of *Go* are formulated in mathematical language so that a program for playing the game can be developed. A precise determination of the best move in a given situation is not possible, however, because of limitations of time and storage. By applying three operators successively—a lexicon, a heuristic computer and a random number generator—that move is selected which, according to present experience, is the most favourable of those permitted.
The lexicon and heuristic computer are built up and continuously improved by the machine itself, using the success or failure of previous moves. (The success of a move is deduced from the rules for the final scoring which are valid for each position.) Thus, the effectiveness of these two operators increases in the course of time analogously to learning processes; i.e., during the initial games the moves will be determined mainly by the random number generator, but subsequently and to an increasing extent, by the weighting table of the heuristic computer, and eventually by the lexicon. With the aid of examples it is shown how far the experience gained will improve the quality of the game in formerly unencountered situations.

Single-Domain Properties in Hexagonal Ferrites,* C. D. Mee and J. C. Jeschke,† *Journal of Applied Physics* **34,** No. 4 (Part 2), 1271-2 (April, 1963).

Barium ferrite platelet-shaped particles have been prepared with a diameter of 0.1 micron, which is an order of magnitude smaller than those obtained by conventional sintering

and regrinding techniques. The preparation technique used has been optimized to produce the complete ferrite with $\sigma^s = 68$ emu/g. Due to the small particle size, extremely high intrinsic coercive forces have been obtained, ($H_c =$ 5350 oe), in good agreement with the value calculated from the Stoner-Wohlfarth (SW) coherent rotating model for single-domain noninteracting particles when shape and crystal anisotropy are both taken into account. Furthermore, the measured hysteresis loop for an unoriented sample agrees well with the theoretical SW loop. Similar hysteretic magnetization properties have been obtained in strontium ferrite. The single-domain nature of these powders is also demonstrated by their temperature dependence of coercive force where little change is obtained over the range −200° to +150°C. An estimate of the relative interaction field magnitude for the small particles of barium ferrite has been obtained by comparing its initial anhysteretic susceptibility with that of an acicular iron oxide powder.

*Work done at the CBS Laboratories, Stamford, Connecticut.
† With CBS Laboratories, Stamford, Connecticut.

Solid State Sensors in Process Control, E. Stern, *Electrical Engineering* **82,** 332-335 (May, 1963).

Solid state devices and techniques employed in process control applications are reviewed with special attention to the sensing requirements of computer-controlled processes. A silicon carbide temperature sensor covering the range from 0-900°C and a silicon carbide strain gauge with high temperature capability are described. The desirability of digital and quasidigital sensing techniques are briefly discussed.

Some Characteristics of Sorting in Computing Systems Using Random Access Storage Devices, G. U. Hubbard, *Communications of the ACM* **6,** No. 5, 248 (May, 1963).

The substantial differences in characteristics of random access storage and tape devices dictate that concepts and objectives of computer program design be considered from the viewpoint of the external file medium used. This is particularly true in the case of sorting. In a tape-oriented system, the major sorting problem is that of minimizing merge time despite the limited orders of merge possible. In contrast, sorting in a random access-oriented system encourages the selection of the optimum order of merge from many possible orders.

The latter problem is discussed in this paper, along with criteria developed for determining the optimum order of merge according to the various properties of random access storage devices. Attention is also given to the problem of key sorting vs record sorting and the possibly serious disadvantage of key sorting on a random access system.

Some Theorems Concerning the Dual of a Commutative Semigroup, M. Petrich, *Duke Mathematical Journal* **30,** No. 1, 25-32 (March, 1963).

Several properties of the dual of a commutative semigroup, S, are established. Necessary and sufficient conditions are given for a complex-valued function, X, to be a semicharacter of S in terms of faces of S and the dual of commutative semigroups which satisfy the cancellation law (and may be groups).

Spin Ordering in the Superconducting State, S. H. Liu, *Journal of Physics and Chemistry of Solids* **24,** 475-477 (1963).

It is argued that the spin ordering in the so-called ferromagnetic superconductors is essentially the same as that in normal dilute magnetic alloys such as manganese in copper. The range of ordering of the localized spins is much smaller than the coherence length.

Spin Resonance Spectra of Substituted Aromatic Ions: Perturbation Model, Thomas H. Brown,* Martin Karplus, and John C. Schug,† *The Journal of Chemical Physics* **38,** No. 7, 1749-1758 (April 1, 1963).

By use of a perturbation approach, the valence-bond method is applied to weakly substituted benzene positive and negative ion radicals. Small changes in the Coulomb integrals are introduced to remove the degeneracy present in the unsubstituted case. The case of D_2 symmetry, which corresponds to para-disubstituted benzene, is treated in detail in terms of a basis set consisting of eighteen valence-bond functions. Previously given formulas are used in obtaining the secular equation, spin densities, and charge densities for these ion-radical systems.

To test the usefulness of the method, spin densities of several of the methyl-benzene negative ions are compared with hyperfine constants determined from the ESR spectra of these ions. The theory accounts qualitatively for all of the experimental results, and in most cases the agreement between the measured and the calculated hyperfine constants is semiquantitative. Still better agreement may come with improved knowledge of the molecular integrals involved and of the degree of mixing of nearly degenerative states. Predictions are made for the spin densities in other methyl-benzene negative ions as well as the yet to be observed positive ions.

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A State Variable Assignment Method for Asynchronous Sequential Switching Circuits,* C. N. Liu, *Journal of the Association for Computing Machinery* **10,** No. 2, 209-216 (April, 1963).

This paper describes a method of state variable assignment for asynchronous sequential switching circuits. The method yields state variable assignments with a view towards minimizing the number of state variables and maximizing the operating speed of the circuit. A systematic procedure is presented. An upper bound on the number of state variables for a general r-state circuit is included. The advantages and limitations of the method are discussed.

* Work performed at University of Illinois, Urbana, Illinois.

Steady Flow of a Slightly Viscoelastic Fluid Between Rotating Spheres, W. E. Langlois, *Quarterly of Applied Mathematics* **XXI,** No. 1, 61-71 (April, 1963).

The creeping motion of a Rivlin-Ericksen fluid between concentric spheres rotating steadily about a common axis with different angular velocities is calculated by perturbing about creeping Newtonian flow. If certain of the parameters are not zero, the disturbance flow exhibits a secondary circulation in the meridional planes, an effect which is present in Newtonian flow only because of fluid inertia.

Stimulated Light Emission from Indium Phosphide, K. Weiser and R. S. Levitt, *Applied Physics Letters* **2,** No. 9, 178 (May, 1963).

The observation of stimulated light emission from indium phosphide diodes is reported. Diodes were prepared by diffusing zinc into *n*-type material, and were prepared in roughly cube shapes with four sides cleaved. Stimulated emission at current densities of 6000 amp/cm² at 77°K and 350 milliamperes at 4.2°K was observed. The stimulated emission occurred at the low energy side of the peak of the spontaneous emission peak.

Streaming Potential in Small Capillaries,* I. B. Oldham, F. J. Young† and J. F. Osterle,† *Journal of Colloid Science* **18,** No. 4, 328-336 (April, 1963).

The zeta-potential is related to the electrokinetic streaming potential in small capillaries by a new theoretical solution. This solution does not rest on any of the following three unsatisfactory assumptions: (1) that the surface conductivity of the walls is negligible; (2) that the capillary radius is large compared with the classical thickness of the double layer; or (3) that the zeta-potential is small in comparison with kT/q, where q is the ionic charge. Previous solutions lead to the conclusion that the zeta-potential decreases markedly in small capillaries. This solution indicates that the zeta-potential is relatively independent of capillary size, a more reasonable conclusion.

* Work performed at Carnegie Institute of Technology, Pittsburgh, Pennsylvania.
† Carnegie Institute of Technology, Pittsburgh, Pennsylvania.

Study of Permeability Ratios for Use in Nondestructive Readout of Ferrite Memory Devices, C. S. Holzinger, *Journal of Applied Physics* **34,** No. 4, Part 2, 1123-1124 (April, 1963).

A study has been made which determines the ultimate one-to-zero ratio which can be realized in the permeability sensing technique of nondestructive readout of binary information from ferrite memory cores. The study is limited to the calculation and measurement of the ratios of incremental permeabilities of various magnetic states for ferrites in which the permeabilities can be attributed to a rotational process. Calculations are based upon a polycrystalline randomly oriented grain ferrite with a negative anisotropy constant. Each individual magnetic moment is considered to be constrained to an easy axis only by the anisotropy field. Measurements of possible ratios between the permeabilities for the following three conditions are shown to agree within experimental error to those predicted by the calculations:

I. Completely demagnetized sample.
II. Measuring field parallel to the direction of the remanence existing after the application of a saturating field.
III. Measuring field orthogonal to the direction of the remanence existing after the application of a saturating field.

The experimental verifications were arrived at by measurements performed on a long, thin extruded ferrite tube. It is concluded that the best one-to-zero ratio can be obtained with materials which have as high an initial permeability as possible and which still depend upon the rotational mode of operation. The highest one-to-zero ratio then possible is equal to 3.26. Furthermore, this ratio is obtained by using two orthogonal remanence states with the measuring field applied parallel to the remanence which is to represent the binary zero.

Synchronous Multibit Pattern Generator, R. A. Liberman, *Instruments and Control Systems* **36,** No. 4, 131-133 (April, 1963).

This article discusses a 511-bit pattern generator that feeds binary data to a modulator. After being transmitted over a communications link, a signal is demodulated and compared with the output of a second pattern generator generating the same pattern and synchronized with the first generator. Generator uses logic modules to develop the various patterns.

A Theoretical Study of the Threshold and Switching Properties of Coupled Films, Hsu Chang, *Proceedings of the International Conference on Nonlinear Magnetics,* Washington, D. C., pp. 6-1-1 to 6-1-7 (April, 1963).

The threshold and switching properties of coupled films are analyzed upon the basis of models of flux reversal by rotation. For a pair of perfectly matched and perfectly aligned homogeneous films these properties are found to be identical to those of single films. The properties of film pairs that are mismatched, misaligned or driven unequally are also studied. The effect of air gap and transmission line properties are discussed. It is concluded that coupled films compare favorably with single films in sense signal, driving current and packing density. The capacity of coupled film arrays is probably limited by signal attenuation and power consumption in the high resistance of the thin stripline required for reducing airgap.

Theory of Carbon NMR Chemical Shifts in Conjugated Molecules, M. Karplus and J. A. Pople,* *Journal of Chemical Physics* **38,** 2803-07 (June 15, 1963).

A molecular orbital theory for carbon-13 chemical shifts in conjugated molecules is formulated. Consideration of the various possible contributions to the shift shows that the local paramagnetic term σ_p^{AA} is expected to dominate. By a detailed LCAO analysis of σ_p^{AA}, its variation with the salient features of the electron environment is determined. It is demonstrated that there is a significant local-charge dependence which agrees in sign and order of magnitude with an experimentally established correlation. In addition, the shielding is shown to be a function of the free valence of the atom under consideration and of the polarity of its sigma bonds. A linearized equation for the carbon-13 chemical shift (with respect to benzene) is presented and compared with the available experimental data.

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Theory of Inert Gas Fluorides, R. K. Nesbet, *Journal of Chemical Physics* **38,** No. 7, 1783-1784 (April, 1963).

XeF_2 and XeF_4 have recently been found to be stable, with XeF distances 2.00 A and 1.93 A, respectively. This note suggests that the principal binding mechanism is identical with the so-called "superexchange" mechanism in antiferromagnetic oxides such as MnO.

Theory of the Phase Transition in a Cylindrical Superconductor, J. C. Swihart, *Journal of Applied Physics* **34,** 851-854 (April, 1963).

The theory of the transition of a macroscopic cylindrical superconductor from the superconducting to the normal

state when induced by an external longitudinal magnetic field is considered. Iterative approximate solutions are found, and it is shown that a second-order solution previously derived by Faber is actually a poorer approximation than the first-order approximation from which it was obtained.

Theory of Quadratic Response Functions, P. J. Price, *The Physical Review* **130,** 1792-1797 (June 1, 1963).

The general quantum theory of quadratic response functions, such as the optical-frequency quadratic polarizability of dielectrics, is developed on the lines of Kubo's density matrix—Green's function theory of linear response functions. Sum rule series are obtained and applied to the quadratic polarizability. A suitable form of Kramers-Kronig relations for quadratic response functions is developed.

Thermal Screening Effects in a Ferromagnet, L. P. Horwitz and D. C. Mattis, *Physical Review Letters* **10,** 511-513 (June, 1963).

It is shown, within the context of the nonlinear spin-wave theory introduced by M. Bloch, that there exists a "Debye length" separating the interactions into a "near zone" and a "far zone," and that although the thermal effects on the interactions in the near zone must be found numerically, the only thermal effect in the far zone is a uniform screening; i.e., all transverse correlations disappear. We have also been able to extend the Dyson form of the series expansion of the magnetization as a function of temperature to the actual case of non-nearest neighbor interactions; it is shown that both the magnitude and sign of the coefficients are functions of the range of the interaction.

Toward a Study of Bidding Processes: Some Constant-Sum Games, J. H. Griesmer and M. Shubik, *Naval Research Logistics Quarterly* **10,** 11-21 (March, 1963).

The study of bidding has presented both economics and psychology with a host of as yet unresolved problems. The lack of understanding of these problems has been manifested in the difficulties confronting policy-makers in the framing of laws to deal with collusive or restrictive practices in bidding under various market mechanisms. On the one hand, a theory of competitive behavior may call for all competitors to charge the same price for the same product, yet the submission of identical bids may, in fact, be a criterion of collusion.

This paper, the first of a series on bidding, gives a general and preliminary discussion of several of the factors entering into the construction of models of the bidding process. Following this discussion, a number of bidding situations, formulated as two-person constant-sum games are examined. A number of open questions, suggested during the investigation of such games, are mentioned.

Succeeding papers will be devoted to the more important cases of bidding models formulated as non-constant-sum games, both for single-shot bids and for sequences of bids.

Travelling-Wave Interaction Between the Optical Modes of a Polar Lattice and a Stream of Change Carriers, J. B. Gunn, *Physics Letters* **1,** 194 (April 1, 1963).

The possibility of amplifying optical lattice modes is considered and approximate formulas are derived.

Triple Correlator of Photoelectric Fluctuations as a Spectroscopic Tool, H. Gamo, *Journal of Applied Physics* **34,** 875-876 (April, 1963).

A triple correlator of fluctuating photocurrents is shown to be able to analyze asymmetrical spectrum profiles of light beams, such as laser beams, without the use of an additional light source. The resolving time of photodetectors, multipliers, and electronic delay lines involved must be shorter than the coherence time of the light beam to be analyzed. The method cannot determine the mean frequency of an incident beam and cannot distinguish between a spectrum profile and its mirror image around the mean frequency.

Ultrasonic Amplification in Bismuth, A. M. Toxen and S. Tansal, *Physical Review Letters* **10,** 481-483 (June, 1963).

Theoretical papers by Dumke and Haering, Hopfield, and Eckstein indicate, that under certain conditions, ultrasonic amplification in bismuth might be obtained similar to that observed in CdS. Preliminary results are reported which indicate that the authors have experimentally observed a substantial increase in the amplitude of sound waves propagated through bismuth in the presence of applied electric and magnetic fields. They have also applied the electric and magnetic fields, with no input signal, and observed a build up of acoustic oscillations, indicating a net acoustic gain in the sample.

Untersuchungen an dünnen Alkalimetallschichten: IX, Eigenschaften vektorabhängig absorbierender Kaliumschichten (Optische Konstanten, zeitliche Änderungen, Aggregatzustand)* (Investigations of thin alkali metal films: IX, Properties of vector-dependent absorbing potassium films (Optical constants, variation with time, thermodynamic state)), D. P. Paris, *Zeitschrift für Physik* **174,** 180-196 (May, 1963).

The optical constants are determined for "yellow" vector-dependent absorbing films consisting of potassium droplets. The time behavior of such films is then investigated over a temperature range from 20° to 60°C, and its activation energy is determined. From that it is concluded that the transport of matter, which is the cause of the time variation, takes place on the surface of the carrier of the film. Furthermore, it is shown that the potassium droplets of a "yellow" film are in a supercooled liquid state at room temperature and that they can be supercooled even further. However, a maximum of 62°C supercooling cannot be exceeded. The ratio of maximum supercooling to absolute melting temperature agrees very well with the results reported for other metals which crystallize in the same crystal system.

* Work performed at Physikalisches Institut der Universität Erlangen.

Vacuum Evaporation of Cadmium Telluride, R. Glang, J. G. Kren and W. J. Patrick, *Journal of the Electrochemical Society* **110,** No. 5, 407-412 (May, 1963).

Structural and electrical properties of CdTe films prepared by vacuum evaporation of the compound were studied. Films 0.1 to 1μ thick were deposited on glass substrates be-

tween 25° and 250°C at ambient pressures below 10^{-6} Torr. The deposition rate was controlled by an ionization rate monitor. Film thickness, uniformity, adhesion, and infrared absorption were determined. X-ray diffraction techniques were used to analyze the structure, grain size, and orientation of the films. These properties were found to be related to the deposition temperature. Film resistivities were greater than 10^7 ohm-cm at all deposition temperatures, even if impurities were added during evaporation. Possible causes for this behavior are discussed.

The Viscosity of Liquid Helium 3,* D. S. Betts,† D. W. Osborne,‡ B. Welber and J. Wilks,† *Philosophical Magazine* **8,** 977-987 (June, 1963).

Measurements have been made of the viscosity of liquid ^{3}He under its saturated vapour pressure in the temperature range 0.14-2.1°K. In the experiments, a polished cylinder of quartz oscillates in the liquid in its fundamental elastic torsional mode, the viscosity being obtained by observing the logarithmic decrement of the system. The resulting values of the viscosity are in agreement with those of Osborne *et al.* (1949) and of Taylor and Dash (1957), but are appreciably higher than those of Zinov'eva (1958). At lower temperatures the present results appear to extrapolate towards values consistent with the coefficients of the absorption of sound observed by Abel et al. (1961), and are not inconsistent with the $1/T^2$ dependence predicted by Landau's theory of a Fermi liquid.

* Work performed at Clarendon Laboratory, Oxford, England.
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Wachstumsformen von einkristallinem, aus der Gasphase abgeschiedenem Silicum und ihre atomistische Deutung (Crystal Shapes of Single Crystalline, Vapor Grown Silicon and their Atomistic Interpretation),* E. Sirtl† and W. Spielmann, *Zeitschrift für angewandte Physik* **15,** H.4, 295-300 (1963).

Silicon grows from the vapor phase in characteristic shapes on a long cylindrical silicon seeds. The interaction between the kinetics of the crystal surface and the kinetics of the gas reaction favors certain crystallographic planes. Results of studies of this interaction and its effects are discussed in detail.

• Work performed at Forschungslaboratorium der Siemens and Halske AG., München.
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Zinc Phosphide Iodide (Zn_3PI_3) and Zinc Arsenide Iodide (Zn_3AsI_3): New Compounds with Disordered Defect Zincblende Structure, Lawrence Suchow, Margaret Berry Witzen and Norman R. Stemple, *Inorganic Chemistry* **2,** 441-444 (June, 1963).

New compounds, Zn_3PI_3 and Zn_3AsI_3, have been synthesized by the reaction of Zn_3P_2 or Zn_3As_2 with ZnI_2 in evacuated sealed quartz tubes at 475°. They have disordered defect zincblende structures (space group F43m) in which three zinc atoms and one vacancy are disordered over four cation sites, and three iodine atoms and one phosphorus (or arsenic) atom are disordered over four anion sites. A high Debye parameter for the zinc atoms is attributed to vibrations in the direction of the vacancies. The lattice constants compare favorably with values calculated from atomic radii. Relationships among this new modification of the zincblende structure and other structures are discussed. The compounds reported are the only ones found in the pseudobinary systems studied; compounds with the antichalcopyrite structure have not been observed. Some chemical and physical properties of the new compounds are given.

Letters to the Editor

Čerenkov Radiation and Leaky Waves, I. Palócz and A. A. Oliner,* *Proceedings of IEEE* **51,** No. 4, 622-623 (April, 1963).

* Polytechnic Institute of Brooklyn.

A Closed Form Solution of the Relativistic Differential Equation for Planetary Motion, H. L. Crowson, *AIAA Journal* **1,** No. 5, 1215-1218 (May, 1963).

Codes Autocorrecteurs de Redondance $m/2 + 1$ (Autocorrector Codes of Redundance $m/2m + 1$), C. M. Melas, *Comptes Rendus* **225,** 1569-1571 (October 1, 1962).

Codes Linéaires pour la Correction d'Erreurs (Linear Codes for Error Correction), C. M. Melas, *Comptes Rendus* **255,** 1491-1493 (September 24, 1962).

The Effect of Temperature on the Properties of GaAs Laser, G. Burns, F. H. Dill and M. I. Nathan, *Proceedings IEEE* **51,** 947 (1963).

Effects of Electrostatic Fields on the Surface Tension of Salt Solutions, E. P. Damm, Jr., *Journal of the Electrochemical Society* **110,** No. 6, 590-591 (June, 1963).

Experiments of Optical Coupling Between GaAs *p-n* **Junction and Heterojunction,** H. N. Yu and F. Fang, *Proceedings of IEEE* **51,** No. 5, 860 (May, 1963).

The Frequency Response of Opto-Transistors, H. N. Yu, *Proceedings of IEEE* **51,** No. 6, 945 (June, 1963).

An Implication of Stochastic Convergence, M. V. Menon, *Annals of the Institute of Statistical Mathematics* **14,** No. 2, 183-184 (1962).

Magnetostriction of Yttrium Iron Garnet, K. Andres* and B. Lüthi, *Journal of Physics and Chemistry of Solids* **24,** 584-586 (1963).

* Institut für kalorische Apparate und Kältetechnik der Eidgenössischen Technischen Hochschule, Zurich, Switzerland.

Mechanism of the Photochemical Formation of Phenanthrene from Cis-Stilbene in the Vapor Phase, R. Srinivasan and J. C. Powers, Jr., *Journal of the American Chemical Society* **85,** 1355 (1963).

Mercury Photosensitized Isomerization of 1, 5-Hexadiene, R. Srinivasan, *Journal of Physical Chemistry* **67,** 1367 (1963).

Spin-Wave Resonance in Films Magnetized Parallel to the Surface, P. Wolf, *Journal of Applied Physics* **34,** No. 4 (Part 2), 1139 (April, 1963).