Technical Papers by IBM Authors Published Recently in Other Journals

Algorithm for Computer Control of a Digital Plotter, J. E. Bresenham, *IBM Systems Journal* **4,** No. 1, 25-30 (1965).

This paper describes an efficient algorithm for drawing circles with incremental display devices such as cathode ray tubes and incremental digital recorders. It considers an abstract discrete geometry as a model for incremental digital plotting and derives a minimum error circular approximation which requires neither multiplication, division, nor trigonometric evaluations.

An Analysis of Floating-Point Addition, D. W. Sweeney, *IBM Systems Journal* **4,** No. 1, 31-42 (1965).

This paper analyzes the addition operation of floating-point systems. The analysis of a million executed floating-point additions is presented as an aid in optimizing design and measuring performance. The frequency of the various shifts for floating-point additions with different radices was derived from the basic data so that designs with various radices may be evaluated.

Analytic Differentiation Using a Syntax-Directed Compiler, Herbert Schorr, *The Computer Journal* **7,** 290-298 (January, 1965).

The syntactic definition of a language used for analytic differentiation is presented in this paper. The definition is given in Backus normal form. A translation is then added to this definition so that the derivative of any algebraic expression written in the language can be obtained by using the syntax-directed compiler developed by E. T. Irons. The mathematically inelegant form of the derivatives obtained leads to changes in the original syntactic definition of the language. The language is simultaneously extended in order to obtain: (1) derivatives of higher order, (2) partial derivatives, (3) the derivatives of implicit functions, and (4) the derivatives of any number of functions at the same time.

The output of the compiler is the solution of the original problem and not an intermediate-language program to be assembled and executed. This, it is felt, represents a new use of compilers. Also, using Backus normal form rather than assembly language facilitates the programming, checking out and changing of programs. The principle of extending the syntax of any language in order to obtain a more efficient translation is discussed.

Anti-Static Capacitive Ledge Prevents Card Jams, D. G. Shaw, *Electromechanical Design* **9,** No. 3, 60-62 (March, 1965).

The author describes how a parallel-plate capacitor can be constructed to counteract the static electricity that causes card jams in a radial stacking assembly. Evaluation of several models with varying parameters proved that the device effectively eliminates the card-fall delay in the radial stacker assembly.

Automatic Map Compilation Using Digital Techniques,† J. V. Sharp, R. L. Christensen, W. L. Gilman and F. D. Schulman, *Photogrammetric Engineering* **31,** No. 1, 223-239 (March, 1965).

Experimental systems have been developed that are capable of digitizing and processing photographic data of various quality levels, ranging from TV-satellite, X-ray, and radar-camera quality to that obtained with aerial-reconnaissance and precision-mapping cameras. Up to one hundred million bits of digitizable data are scanned from a stereo photo and recorded on magnetic tapes for data processing purposes.

In the digital map compilation system, data associated with a pair of aerial photographs are simultaneously digitized. The most important data of this type are those concerned with control, obtained from ground control surveys, and related measurements made on an experimental photo-digitizing stereo-comparator; and other digitized data required consists of flight data, lens data, and other instrument calibration measurements. This digitized photo and control measurement data are recorded on tape for processing with a computer.

Although these operations are basically automated, human skill is required for the stereoscopic identification and precise measurement of diapositive control points. In addition, the final editing of maps to conform to topographic practice requires the skill of expert cartographers.

† This work supported jointly by U. S. Army GIMRADA and IBM.

Automatic Packaging of Computer Circuitry, C. H. Haspel, *IEEE International Convention Record—Part 3* **13,** pp. 4-20 (March, 1965).

This paper describes a series of heuristic methods which—given as input logical functions, interconnections between them, and a library of standard printed circuit cards—performs the following tasks: selection of cards to package the functions, assignment of the functions to the cards, and assignments of the cards to boards. The objectives are minimum card counts, assignment of related functions to the same card, and related cards to the same board. The emphasis has been on a global approach rather than the usual local one. These methods were programmed and are now in production aiding the design of IBM System/360.

Calculation of Zero Field Splitting in NH. I. One-Center Minimal Basis and Atomic Orbital Representations of the Ground State, J. B. Lounsbury, *Journal of Chemical Physics* **42,** No. 5, 1549-1554 (March 1, 1965).

The zero field splitting parameter D is calculated for the ground state of $NH(^3\Sigma_g^-)$ using a variety of single Slater-type atomic orbitals and atomic SCF functions for nitrogen. A minimal basis (five basis functions) one-center expansion SCF calculation has been performed for $^3\Sigma_g^-NH$. The resulting molecular orbitals produce $D = 1.6279$ cm^{-1}. Spin-orbit contributions to D are estimated and found to be small.

Certain Constraints in the Admittance Discriminants of Networks, H. T. Lee, *Proceedings of the Second Annual Allerton Conference on Circuit and System Theory* pp. 699-744 (1964).

A study was made of the realizability of a given positive homogeneous multilinear algebraic form (p.h.m.l. form) as an admittance discriminant of an electrical network. In the study, a set of algebraic operations, intended to decompose and cross-examine the given form, was developed. These operations, through the topological interpretation of their graphical counterparts, clearly evidence a number of constraints in the structure of realizable p.h.m.l. forms. The constraints are presented in this paper as a set of associated necessary conditions for realizability, together with their applicable operations. Furthermore, several additional constraints and conditions in the realizable forms, which are numerical or algebraic consequences of certain graphical events but do not relate to any algebro-graphical operation, are also included.

An outline of a rather practical procedure for an empirical realizability test is presented as an incidental result. This followed the introduction of the concept of an essential minimum graph which is called for in the study of the original problem.

A Chemical Polish for Lead Telluride, M. R. Lorenz, *Journal of the Electrochemical Society* **112,** No. 2, 240 (February, 1965).

A chemical polish for PbTe is reported. The polishing solution is composed of saturated aqueons $K_2Cr_2O_7$ and concentrated nitric acid. The volume ratio of the two components is an optimum at about 4.5 $K_2Cr_2O_7$ solution to nitric acid. The rate of dissolution at 25°C is about 30 μ/min. The polished surfaces are indistinguishable from those obtained by use of the Norr electrochemical polish.

Computer-Aided Digital System Design and Analysis Using a Register Transfer Language, Herbert Schorr, *IEEE Transactions on Electronic Computers* **EC-13,** No. 6, 730-737 (December, 1964).

This paper presents the results of an attempt to automate part of a formalized method of system design. Basic to this method are two languages, Boolean algebra and a register transfer language. From a Boolean algebra description a digital system can be constructed while the second language can be used in step-by-step description of the execution of each instruction. To illustrate, a register transfer language is used to give a description of an adder considered as part of a digital system. This description is then translated into a set of Boolean equations.

Next, the automation of this translation by using a syntax-directed compiler is explained. The compiler requires a syntactic description of register transfers. This description is given using a meta-language called Backus normal form. A Backus normal form description of Boolean equations that is used for translating Boolean equations into register transfers is also given; this translation process is called analysis. The feasibility of computer-aided design and analysis is thereby demonstrated.

The computer-aided design method described in this paper, besides eliminating drudgery and error, would permit several system designs to be attempted and evaluated; a permanent record of the chosen system would also be available for future modifications, maintenance, and simulation. The analysis programs could be used to check the effect on the system of any changes made in the Boolean equations (or equivalently the logical diagrams) and the effect of any unused operation codes.

Conjugate-Concentric Laser Resonator, R. V. Pole, *Journal of the Optical Society of America* **55,** No. 3, 254-260 (March, 1965).

A laser resonator is described in which both reflective and refractive surfaces are used as parts of the "resonating circuit." The basic geometry of the resonator, termed conjugate-concentric resonator, is that of a simple imaging system in which the passive lens is replaced by an active one while the external concentric mirrors occupy an object and an image surface. The eigenvalue problem for this resonator is formulated in both Cartesian and polar coordinates and the corresponding eigenvalues and eigenfunctions are computed numerically. It is then shown that the basic property of this resonator is its high angular degeneracy. This property makes it well suited for the application of internal spatial filtering techniques. The practically interesting case of a cosine-shaped spatial filter is considered in some detail.

Control of an Exothermic Reactor, P. E. A. Cowley and D. E. Johnson,* *ISA Journal* **12,** No. 2, 81-84 (February, 1965).

A study was required to determine the relative merits of two different control systems proposed for an exothermic reactor. Although the pilot plant reactor might have been used, over one year would have been needed to observe all the responses of interest. In addition some hazard would have been involved. Therefore, the necessary comparative information was obtained from an analog computer study.

The paper describes all phases of the study. Process dynamics were determined on the pilot plant reactor using special techniques required to overcome the problems involved. The experimental techniques, measured dynamic responses and the analog simulation are reported. Finally, some comparative responses to the more important disturbances are shown.

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Correlation of Electrons in a Narrow s Band, Martin C. Gutzwiller, *The Physical Review* **137,** A1726-A1735 (March 15, 1965).

The ground-state wave function for the electrons in a narrow s band is investigated for arbitrary density of electrons and arbitrary strength of interaction. An approximation is proposed which limits all the calculations to counting certain types of configurations and attaching the proper weights.

The expectation values of the one-particle and two-particle density matrix are computed for the ferromagnetic and for the nonferromagnetic case. The ground-state energy is obtained under the assumption that only the intra-atomic Coulomb interaction is of importance. Ferromagnetism is found to occur if the density of states is large at the band edges rather than in the center, and if the intra-atomic Coulomb repulsion is sufficiently strong. The relation of this approximation to certain exact results for one-dimensional models is discussed.

Coupling of Optical Fibers and Scattering in Fibers, A. L. Jones, *Journal of the Optical Society of America* **55,** No. 3, 261-271 (March, 1965).

The phenomena of optical coupling of parallel fibers and scattering of light from a fiber due to rough walls are considered from a mode point of view. With the use of a Green's function, the problems are cast in the form of integral equations. Coupled ordinary differential equations are obtained which are used to study the coupling of modes in parallel fibers, including the case when the diameters are slowly-varying functions of the axial distance. The analysis of the problem of propagation in an optical fiber having rough walls shows that the various modes in a fiber will couple and that the roughness will cause radiation through the walls of the fiber. The character of the radiation may be determined if the spatial spectral density of the surface roughness is known.

Cr^{3+}-Cr^{3+} Ion Exchange Interactions in $LaAlO_3$, K. W. Blazey and G. Burns, *Physics Letters* **15,** No. 2, 117-119 (March 15, 1965).

Exchange interactions between magnetic ions are of considerable interest as they form a major part in the theory of magnetism. The exchange interaction between Cr^{3+} ion pairs has been studied previously by optical and E.P.R. techniques in ruby but the agreement is not good. Here the exchange interaction between pairs of Cr^{3+} ions in $LaAlO_3$ has been investigated by optical fluorescence. The results are interpreted in terms of an isotropic Heisenberg Hamiltonian. The coupling between the nearest neighbor ions is antiferromagnetic, as expected, and the value of the exchange constant J_1 is -39.8 ± 1.0 cm^{-1}, which is in good agreement with the value derived from the molecular field model for the very similar compound $LaCrO_3$. The next nearest neighbor interaction is ferromagnetic with $J_2 = +3.5 \pm 0.3$ cm^{-1}.

Data Processing Using Photogrammetric Instrumentation, J. V. Sharp, *Photogrammetric Engineering* **31,** No. 1, 144-153 (January, 1965).

Digital data processing equipment can perform many of the functions of classical photogrammetric and related map-producing equipment. The recent GIMRADA—IBM automatic map compilation system digitizes and processes photographs. The system incorporates control data and is capable of accomplishing the usual photogrammetric functions including stereoscopy, orientation, triangulation, rectification, scaling, contouring, orthographic printing, profiling, lettering, etc. The digitized input information is stored on magnetic tape, and the resultant data after processing are also stored on a similar output tape which can be returned to graphic form by means of a special printer. The system constitutes one possible method for automating the complete photogrammetric procedures.

Determination of Exchange Constants from Relaxation Specific Heat Measurements on $GdCl_3$, E. L. Boyd and W. P. Wolf, *Journal of Applied Physics* **36,** No. 3—Part 2, 1027-1028 (March, 1965).

Measurements of the magnetic contribution to the specific heat have been made on polycrystalline samples of $GdCl_3$ at temperatures between 20° and 77°K, using a relaxation method with frequencies up to 40 Mc/sec. The results, when combined with the Weiss constant determined by Marquard and Wyatt, give two sets of values for the nearest- and next-nearest-neighbor exchange interaction between Gd^{3+} ions. The first set gives ferromagnetic values for both J_{nn} ($+0.071 \pm 0.005$°K) and J_{nnn} ($+0.011 \pm 0.005$°K), while the other gives a small antiferromagnetic J_{nn} (-0.020 ± 0.011°K) and a larger ferromagnetic J_{nnn} ($+0.041 \pm 0.002$°K). These results are discussed in terms of other experimental data.

Differential Visual Feedback of Component Motions, John D. Gould, *Journal of Experimental Psychology* **69,** No. 3, 263-268 (March, 1965).

New closed-circuit television techniques allowed the joint action of S's hand, control instrument, and operational effects to be visually fed back singly or in combination. Eight visual feedback conditions and two levels of task precision were used. The results showed that the effects of visual feedback were determined by the component motions fed back, with the operational effects being the most important followed by control-instrument and hand-arm movements. A significant interaction between visual feedback and precision of movement occurred where feedback of the operational component became more important as more over-all precision of movement was demanded.

Diffusion of Gold into Silicon Crystals, G. J. Sprokel and J. M. Fairfield, *Journal of the Electrochemical Society* **112,** No. 2, 200-203 (February, 1965).

Profiles are obtained for gold diffusing into silicon wafers of finite thickness. The profiles do not obey Fick's law. The effects of shallow diffusions of phosphorus and boron on the gold concentration are described; gold concentration is higher in areas of high phosphorus concentration.

Diffusion Versus Surface Limitations in Vapor-Solvent Growth of Germanium, F. Jona, *Journal of Chemical Physics* **42,** No. 3, 1025-1027 (February 1, 1965).

Measurements of transport rates as functions of pressure in the systems germanium-iodine and germanium-bromine have been carried out. The results are discussed in terms of Lever's theory for diffusive transport. It is concluded that while the germanium-iodine system is highly diffusion limited, the germanium-bromine system is noticeably surface controlled.

Diffusion-Induced Imperfections in Silicon, M. L. Joshi and F. Wilhelm, *Journal of the Electrochemical Society* **112,** No. 2, 185-188 (February, 1965).

Diffusion-induced dislocations and precipitates have been studied through electron microscopy as a function of the diffusion depth. High concentrations of phosphorus and arsenic we rediffused in (111) Si wafers to a shallow depth under the condition of constant solute surface concentration. Extensive dislocation networks were observed in phosphorus diffused wafers, whereas only a few single dislocations were detected in arsenic-diffused wafers. The results are shown to be in general agreement with Prussin's model of dislocation generation by relief of the stress due to solute lattice contraction of P and As.

Digital Fictitious Data for Automatic Mapping Research, J. D. Newton and H. F. Dodge, *Photogrammetric Engineering* **31,** No. 1, 166-175 (January, 1965).

Techniques for generating digital fictitious stereograms on an IBM 7094 Data Processing System are described. The stereograms are obtained by a perspective projection of a ground model with known elevation and gray shade detail upon two "photo" planes with known special position and orientation. Realistic photographic and geometrical errors can be introduced into the data if desired. Such fictitious data are very useful for evaluation of digital automation mapping programs now being developed at IBM.

Dynamic Pulse Hysteresis of Magnetic Devices, C. H. Sie, *Journal of Applied Physics* **36,** No. 3—Part 2, 1066-1068 (March, 1965).

Dynamic pulse hysteresis is defined as the instantaneous hysteresis of a magnetic device during the rise time of an applied pulse field. A method of measuring the dynamic pulse hysteresis of magnetic devices has been developed. The pulse hysteresis differs from the quasistatic hysteresis in its ability to display magnetic damping phenomena. By applying sampling techniques the flux sensitivity of this method is extended to 10^{-4} maxwell. The theoretical pulse hysteresis obtained by computer solution of Gilbert's equation is compared with the measured pulse hysteresis of a 10,000 Å uniaxial permalloy film at 7 nsec rise time. From the comparison, the intrinsic damping constant of the film is determined to be 8×10^8 sec^{-1}. The measured pulse hysteresis of a ferrite core in the time-limited partial switching mode is also presented.

Dynamics of a Simple Many-Body System of Hard Rods, D. W. Jepsen, *Journal of Mathematical Physics* **6,** No. 3, 405-413 (March, 1965).

General formulas are given for the exact calculation of the nonequilibrium properties of the one-dimensional system of equal-mass hard rods both for a finite but large system and in the limit of infinite size.

Efficient Low Pressure Sputtering in a Large Inverted Magnetron Suitable for Film Synthesis, W. D. Gill and E. Kay, *Review of Scientific Instruments* **36,** No. 3, 277-282 (March, 1965).

Electrical and sputtering characteristics of a 10-cm-diam inverted magnetron configuration have been investigated in the transition region from positive to negative space-charge modes. Radial voltage and ion energy distributions were obtained for both modes. The positive space-charge mode resulted in the most efficient transport of sputtered material from cathode to anode. Dependence of space-charge sign reversal on apparatus dimensions and magnetic field strength is discussed showing that operation in the 10^{-5} Torr range can be expected for a 40-cm-diam configuration. The deposition profile at the anode was in good agreement with the calculated profile showing that ion current and hence sputtering are uniform over the effective cathode area.

Electric Field Dependence of Conduction by Electrons in Nearly Pure Germanium, T. N. Morgan and C. E. Kelly, *The Physical Review* **137,** A1573-A1575 (March 1, 1965).

We have measured dc resistivity and its dependence on the electric field strength of 3-cm microwaves in *n*-type germanium and compared the data with values determined from numerical solutions of the Boltzmann equation. The variation of resistivity with temperature was sensitive to ion concentration and approached $T^{1.75}$ for the purer samples. An optical scattering coefficient of 0.55 times acoustical, chosen to give this exponent theoretically, also gave agreement with measurements of field dependence of resistivity and of its variation with microwave frequency for the purer samples.

Electroluminescence and Lasing Action in $GaAs_xP_{1-x}$, M. Pilkuhn and H. Rupprecht, *Journal of Applied Physics* **36,** No. 3—Part 1, 684-688 (March, 1965).

The electroluminescence of Zn diffused diodes was studied in forward and reverse bias. Emission spectra obtained for forward biasing showed a near-edge as well as a low-energy line. In the composition range $x > 0.55$, where the lowest conduction band minimum is at $k = 0$, most photons are emitted in the near-edge line. Lasing action could be observed in this range, and the shortest wavelength where stimulated emission was obtained at 77°K was 6380 Å. For $x < 0.55$, where the lowest conduction band minimum is the (100) minimum, the low-energy emission becomes dominant. The energy separation between near-edge and low-energy line varies between 0.4 and 0.47 eV at 77°K depending on composition. This suggests that the same defect is responsible for the low-energy emission in all these diodes (including GaAs and GaP). In reverse bias, near-edge emission and emission at higher energies than bandgap could be observed for $x < 0.55$. The cutoff energy of the emission on the high-energy side was measured as a function of composition. It was found to vary in a manner similar to the variation of the energy of the (000) conduction band minimum.

The external quantum efficiency of the forward bias emission drops sharply by two orders of magnitude at the composition $x = 0.55$ when x is decreased. The efficiency of the reverse bias emission is independent of composition.

Electron Microscopic Study of Precipitates and Defects in Germanium and Silicon, R. D. Weltzin, R. A. Swalin,* and T. E. Hutchinson,** *Acta Metallurgica* **13,** No. 2, 115-123 (February, 1965).

The precipitate particles and defects formed during precipitation of lithium from solid solution in germanium and silicon have been studied by transmission electron microscopy.

Kinetic studies on the same systems have been reported previously.

From the microscopic investigation, it has been determined that the precipitate particles in germanium are spherical, maintain a coherent interface with the parent phase, and are randomly distributed. The experimental evidence obtained from microscopy has been interpreted through the application of the theoretical work of Ashby and Brown on diffraction contrast of coherent, spherical precipitate particles. Various contrast effects in silicon have been noted.

The number density of precipitate particles in germanium has been determined from electron micrographs. This number density has been compared to the number density obtained from precipitation experiments on the same sample, the precipitation number density determined using the theory of Ham on diffusion limited precipitation for spherical precipitate particles. The agreement is found to be quite good, covering a range of number densities 8×10^{11} cm^{-3} to approximately 10^{14} cm^{-3}.

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Environment Simulation for Studying the Effects of Air Pollutants on Computers, T. W. Steading, *Journal of the Air Pollution Control Association* **15,** No. 3, 99-101 (March, 1965).

This paper describes a study directed toward the laboratory simulation of parameters of the office environment related to airborne gaseous and particulate pollutants and initial operating experience of a particular test chamber, instrumentation, and control techniques. Also discussed is the design of a simple gaseous test chamber that is being constructed. Gas dilution procedures, control and general operating approach are described.

Epitaxial Growth of SiC, W. Spielmann and K. Brack, *Zeitschrift für angewandte Physik* **18,** No. 4, 321-323 (1965).

The epitaxial growth of SiC on SiC substrates by a pyrolitic reaction of $SiCl_4$ and CCl_4 has been investigated in an open tube process. The structure of the epitaxial layers is dependent on the growth rate. Using hexagonal substrates, the layers have a hexagonal structure if the growth rate is less than 0.5 μ/min and a cubic structure if the growth rate is higher than 0.5 μ/min. The modifications were identified by etching and by electron diffraction. It was established by neutron-activation analysis that phosphorus is incorporated during growth and can be used as an *n*-type dopant. Grown *p-n*-junctions and heterojunctions produce electroluminescence in the visible part of the spectrum.

Exchange Coupling of Uniaxial Magnetic Thin Films,† William T. Siegle, *Journal of Applied Physics* **36,** No. 3—Part 2, 1116-1117 (March, 1965).

The properties of two uniaxial magnetic films in intimate contact have been investigated. It is shown that when the uniaxial easy axes of the two films are orthogonal, and the magnitude of the uniaxial anisotropy the same in each film, uniaxial anisotropy in the composite film vanishes, to be replaced by a field-dependent biaxial anisotropy. The theoretical analysis relates this biaxiality to exchange coupling between the two halves of the composite film. Experimental measurements on several films are compared with the theory and imply for A, the exchange coupling constant, an average value of 0.4×10^{-6} erg/cm in a 66-34 Ni-Fe alloy film.

† This work was supported in part by the National Science Foundation.

Exchange Narrowed Pseudodipolar Ferromagnetic Resonance Linewidths in Metals, P. E. Seiden, *Physical Review Letters* **14,** No. 10, 370-372 (March 8, 1965).

Evidence is given for attributing the non-exchange conductivity part of the ferromagnetic resonance linewidth in metals to a two-magnon scattering process using the fluctuations in the pseudodipolar field as a scatterer. It is shown that the linewidth of thin platelets of nickel where the exchange conductivity effect can be neglected can be accounted for by this mechanism.

Frequency Dependence of the Two-Magnon Ferrimagnetic Resonance Linewidth, P. E. Seiden, *The Physical Review* **137,** A1278-A1281 (February 15, 1965).

The Sparks-Louden-Kittel (SLK) two-magnon linewidth theory is modified in a way that takes into account a more reasonable model of the scattering center due to magnetic inhomogeneities. The inverse-square frequency dependence of the linewidth at high frequencies given by SLK is eliminated, and a weak frequency dependence similar, but not identical, to that found by the theories of Geschwind and Clogston and of Schlomann is obtained. Experimental data ranging over a factor of about ten in applied field divided by magnetization ($\propto$ frequency) gives excellent agreement with the modified SLK theory.

Das Frequenzspektrum von ungeordneten Ketten in der Konfigurationsmittel-Approximation, W. A. Schlup, *Physics of Condensed Matter* **3,** No. 3, 227-236 (1965).

It is shown that the spectrum following from the configurational average of the eigenfrequency equation is positive and normalized. It satisfies the long-wave approximation and the Rayleigh-theorem. The frequency distribution has been calculated for mass ratios $\mu = 4/5, 2/3, 1/2, 1/3, 1/10$ and concentrations $q = 1/10, 3/10, \cdots, 9/10$ and has been compared with the self-consistent field approximation of the spectrum.

GaAs Injection Laser with Novel Mode Control and Switching Properties, M. I. Nathan, J. C. Marinace, R. F. Rutz, A. E. Michel, and G. J. Lasher, *Journal of Applied Physics* **36,** No. 2, 473-480 (February, 1965).

The effects of nonuniform current densities on the properties of GaAs injection lasers are investigated. The structure studied is an injection laser with a channel etched on the *p* side of the junction parallel to the reflecting ends. It is found that the threshold current is higher for nonuniform currents than for uniform currents. The mode in which the laser oscillates depends on the distribution of current. A simple model of the transition and the energy vs density of states for the semiconductor is presented to explain these effects. Bistable operation of the structure has been observed.

Gaussian-Type Functions for Polyatomic Systems, I. S. Huzinaga, *Journal of Chemical Physics* **42,** No. 4, 1293-1302 (February 15, 1965).

In view of rapid progress of computer capability, it is very desirable to have a reliable assessment of the usefulness of Gaussian-type orbitals as basis functions for large-scale molecular calculations. In the present paper several attempts are made to answer this question mainly at the level of atomic Hartree-Fock calculations. The necessary number of terms of Gaussian-type basis functions in the analytical Hartree-Fock expansion calculation is apparently more than twice as much as the number of terms needed in the expansion with Slater-type basis functions. However, this fact does not necessarily suggest a definite choice of Slater-type orbitals. Discussions pertinent to this point are presented in the latter part of the present paper.

A General Approach to the Simulation of Stock Preparation and Fourdrinier Dynamics, P. R. Sullivan and J. D. Schoeffler,* *Proceedings of the 50th Annual TAPPI Conference* (1965).

This paper presents a technique for simulation of the stock preparation and Fourdrinier dynamics. The technique is flexible, convenient, and detailed enough to allow the user to study physical process modifications and transient response during upsets and furnish changes, and to evaluate simplified mathematical models and control schemes.

* IBM consultant.

A Graph-Theoretic Algorithm for Matching Chemical Structures, E. H. Sussenguth, Jr., *Journal of Chemical Documentation* **5,** No. 1, 36-43 (February, 1965).

In a flexible chemical information retrieval system it must be possible to make detailed atom-by-atom comparisons between a query structure and the structures contained in the main file. An algorithm for making such comparisons is presented in this report. The algorithm permits searches not only for a complete match between the query and file structures but also for specified fragments of the file structures. The technique, which is based on simple concepts of set and graph theory, is novel in that it avoids the backtracking required by other atom-by-atom matching procedures. The algorithm is explained in terms of examples, and its mechanization for a digital computer is discussed.

Growth of Europium-Doped Single Crystals of BaO and SrO, R. J. Gambino, *Journal of Applied Physics* **36,** No. 2, 656-657 (February, 1965).

Single crystals of BaO and SrO have been grown by a modified Verneuil method with an induction-coupled plasma torch as a heat source. The modified apparatus was designed to prevent the vaporization of the oxide feed powder by minimizing its dwell time in the plasma. Boules up to 5 mm in diameter and 20 mm long have been grown at rates of 2 to 5 cm/hr. The crystals show good (100) cleavage and are transparent.

Image Quality Requirements in Optical Systems for Reproducing Typewritten Documents, M. E. Rabedeau and A. D. Bates, *Applied Optics* **4,** No. 4, 439-443 (April, 1965).

To determine the modulation transfer function requirements for optical systems used in reproducing typewritten documents, sample reproductions were made with apparatus set for different modulation transfer functions in the negative-to-positive steps of the reproduction system. The 96 samples were presented in random order to 30 evaluators, who were asked to rate them as acceptable or not acceptable, in order to establish the relationship between objective and subjective image quality. Data are given showing the influence of negative-to-positive image quality degradation on the acceptability of document reproductions.

Implications of a Failure Model for the Use and Maintenance of Computers, P. A. W. Lewis, *Journal of Applied Probability* **1,** No. 2, 347-368 (December, 1964).

In a previous paper a branching Poisson process model was derived to explain deviations from a Poisson process in computer failure patterns. Physically the deviations arise because an attempt to repair a computer is not always successful and the failure recurs a relatively short time later. In this paper we discuss the implications of this model for the use and maintenance of computers.

Inherent Errors in Mathematical Computations, I. Belson, *Evaluation Engineering* **3,** No. 6, 32-33 (November/December, 1964).

Accuracy of published data is affected by two major factors: (1) the operations on and analysis of the data, and (2) the quality or accuracy of the initial data. In a previous article (I. Belson, *Evaluation Engineering,* July/August, 1964), the effect of roundoff on accuracy was covered; now, the second factor, the effect of inherent errors, is discussed.

Instabilities of Current and of Potential Distribution in GaAs and InP, J. B. Gunn, *Proceedings of the 1964 Symposium on Plasma Effects in Solids*—Paris (1965).

A summary is given of previous experimental data on the instabilities of current which occur when an electric field of several thousand volts per centimeter is applied to *n*-type GaAs or InP. New experiments are described which show that the current instability in GaAs is associated with the occurrence of moving regions of very high electric field (shock waves), which propagate from the cathode to the anode with a velocity of the order of 10^7 cm sec^{-1}. The existence of shock waves provides a phenomenological explanation for several puzzling features of the previous data.

Interface Problems Between Digital Computers and Analog Controllers, R. N. Pond and G. Sangregorio, *Proceedings of the 19th Annual ISA Conference* (October, 1964).

Adapting a digital computer output to either a pneumatic or electronic analog control station is a problem facing the computer control system manufacturer. This paper dis-

cusses this problem and the considerations that must be given, not only to signal compatibility, accuracy, loading effects, and interconnection expense, but also to the operator tool necessary for switching over to computer control. Methods of accomplishing this operator objective with different basic control station designs and locations are discussed.

An Interpretive Program for Matrix Arithmetic, F. H. Branin, Jr., L. V. Hall, J. Suez, R. M. Carlitz, and T. C. Chen, *IBM Systems Journal* **4,** No. 1, 2-24 (1965).

The structure and use of an interpretive program for matrix operations is treated. The discussion emphasizes the nature of the programming language and the method of storage allocation. The system provides automatic storage allocation for external disk storage as well as for core memory.

Das magnetische Impulsfeld einer unsymmetrischen Parallelbandleitung (The magnetic pulse field of an unsymmetrical stripline), Wilhelm Jutzi, *Archiv der Elektrischen Uebertragung* **19,** No. 3, 119-125 (March, 1965).

The magnetic fields of slotted unsymmetrical striplines are computed as the responses of line currents with the shape of a step and a sine square function. The influence of current spreading in the ground plate is demonstrated. The computed results are checked by measurements on thin magnetic films.

Magnetization of Polycrystaline EuS as Determined by the Pyromagnetic Method, B. E. Argyle, *Journal of Applied Physics* **36,** No. 3—Part 1, 679-683, (March, 1965).

Measurements of magnetization of polycrystalline EuS powder are obtained by the pyromagnetic method between 4.2° and 60°K in fixed applied fields ranging from 4 to 14 kOe. For fields sufficient to saturate ($H_0 \geq 12$ kOe), the data, as analyzed by Weiss molecular field theory with a new graphical technique, specify $T_c = 16.5° \pm 0.2°$K, in good agreement with the specific heat anomaly at 16.2°K. The observed behavior of the approach to saturation suggests a preferred choice of mechanisms for the origin of the large saturation field.

Magnetization Processes in Spin Screw Structures, H. Thomas and P. Wolf, *Proceedings of the 1964 International Conference on Magnetism,* pp. 731-734 (1965).

In spin screw structures, a number of interesting magnetization processes can occur. We investigate some of these processes for a one-dimensional model. First, we study the possibility of reversing the sense of the screw by applying two rotating magnetic fields with opposite senses of rotation to the two surfaces of the sample. If the sample contains a uniform screw, quite large torques are necessary before the screw becomes unstable. Two types of instabilities are found. However, if the sample already contains both types of screws separated by walls, the critical torque is much smaller. We find that depending on the magnitude of the uniaxial anisotropy, one of two different wall types will occur. The structures and energies of these walls are investigated. Finally, we study the magnetization process in a uniform magnetic field and the stability with respect to the transition screw $\rightleftarrows$ fan. We find that in our one-dimensional model, the screw is stable up to fields higher than the fan field and that the fan is stable down to almost zero field.

Metastable Alloy Films, S. Mader, *Journal of Vacuum Science and Technology* **2,** No. 1, 35-41 (January/February, 1965).

Metastable alloy films of a number of binary alloy systems with limited terminal solubilities were prepared by simultaneous vapor deposition of the two components onto a cold substrate. The resulting structures are either crystalline solid solutions (of concentrations higher than the terminal solubility) or amorphous solutions. Several examples for both types of structures are described. The conditions for occurrence of the amorphous structure are found to be a difference of atomic radii of the components in excess of 10% and a sufficiently low substrate temperature. The composition range of the amorphous structure increases with increasing difference of the atomic size of the components. Amorphous structures generally decompose at about 0.3 T_m (where T_m is the average melting temperature), while metastable crystalline structures decompose near 0.45 T_m. Thus, for many of the alloys studied, the metastable structure persisted to room temperature and above.

Microstructural Properties of Thermally Grown Silicon Dioxide Layers, P. Balk, C. F. Aliotta, and L. V. Gregor, *Transactions of the Metallurgical Society of AIME* **233,** No. 3, 563-567 (March, 1965).

The structure of silicon surfaces, thermally oxidized in dry oxygen and in steam, was studied using the electron microscope. It was found that the structure on the original (etched) surface is retained at the outer surface of the oxide, whereas the oxide-silicon interface is smoothed out considerably. This supports the idea that, both in oxygen and in steam, the oxidation reaction occurs at the oxide-silicon interface. Mechanical damage of the original silicon surface affects the rate of oxidation. It also changes the chemical properties of the oxide, as shown by the enhanced rate of etching in buffered HF at the locations of damage. However, the oxide at the originally damaged surfaces still exhibits a high electrical breakdown strength. Exposure of thermal oxides to P_2O_5 or B_2O_3 vapor, which will yield phospho- or borosilicate layers, results in complete annihilation of all fine structure on the surface. Reaction of silicon with CO_2 gives a surface film which probably does not consist of pure SiO_2.

Multisystem Operation of the IBM System/360, G. A. Blaauw, *1965 IEEE International Convention Record —Part 3,* **13,** 226-235 (March, 1965).

A multisystem is defined as a system consisting of two or more central processing units that can communicate without manual intervention. This definition is intended to encompass a large variety of systems configurations, in particular those which provide improved cost/performance ratio and availability. Factors which influence cost/perform-

ance are technology limitation, processing unit specialization, equipment separation, and component pooling. The character of a multisystem designed for high availability is discussed in the light of time allowed for reconfiguration, the ability to fail safely or softly and the multiplicity and modularity of the system.

Communication between the CPU's of a multisystem may be achieved by transmitting information from one CPU to another, or by giving them access to a shared storage medium such as disk file, drum, tapes, and main storage. The method of interconnection via a concentrated or distributed crossbar switch is discussed, and the multiple tail approach followed in System/360 is described. Communication between CPU's should be supplemented in various applications by: 1) Multiprogramming of supervisory and problem programs, 2) Signaling that a message has been or is to be transmitted, 3) Interlocking the use of storage to prevent conflict, 4) Requesting intervention in the case of malfunction, and 5) Permitting initialization to attempt recovery from malfunction. Machine features within System/360 which facilitate these functions are discussed.

Notes on Testing Real-Time System Programs, M. G. Ginzburg, *IBM Systems Journal* **4,** No. 1, 58-72 (1965).

Procedures for program testing associated with implementation of a large complex real-time system are discussed step by step. The discussion includes testing both in a simulated environment and in real time. Final testing and monitoring of system performance are also briefly considered.

The Numerical Solution of the Time-Dependent Nernst-Planck Equations, H. Cohen and J. W. Cooley, *Biophysical Journal* **5,** No. 2, 145-162 (March, 1965).

Calculations are reported of the time-dependent Nernst-Planck equations for a thin permeable membrane between electrolytic solutions. Charge neutrality is assumed for the time-dependent case. The response of such a membrane system to step current input is measured in terms of the time and space changes in concentration, electrical potential, and effective conductance. The report also includes discussion of boundary effects that occur when charge neutrality does not hold in the steady-state case.

On Cyclic Codes for Multi-Phase Data Transmission Systems, M. Hanan and F. P. Palermo, *Journal of the Society for Industrial and Applied Mathematics* **12,** No. 4, 794-804 (December, 1964).

An isomorphism between a vector space F_s of dimensions s over an arbitrary field F and a finite extension field K of degree s over F is defined. Necessary and sufficient conditions are given for an ideal in the quotient algebra $F[x]$ modulo $x^{ns} - 1$ over F to be isomorphic to an ideal in the quotient algebra $K[y]$ modulo $y^s - 1$ over K. In general, these conditions are expressed as rather complicated recurrence relations. The applications of these ideas and results to coding theory are discussed. For example, if a multilevel transmission unit is used to transmit binary information, binary codes are found which are isomorphic to codes in the new symbols. Also a new interpretation is given to the interlaced codes. Examples are given when F is taken to be the field of two elements.

On the Reliability of Polymorphic Systems, P. D. Welch, *IBM Systems Journal* **4,** No. 1, 43-52 (1965).

The reliability aspects of polymorphic systems are examined within the confines of a simple failure and repair model. Emphasized are the derivation and use of easy-to-calculate approximations to the unavailabilities of system capacity levels.

On the Solution of the Two-Dimensional Boundary-Layer Flow Equations for a Non-Newtonian Power Law Fluid, A. Acrivos,* M. J. Shah, and E. E. Petersen,** *Chemical Engineering Science* **20,** No. 2, 101-105 (February, 1965).

An asymptotic method is presented for solving approximately the laminar boundary layer equations for a power-law non-Newtonian fluid under conditions where the flow external to the boundary layer has a general form. The few available exact solutions are shown to be in excellent agreement with the results of the present approximate analysis.

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Optical Second-Harmonic Generation in Crystalline Amino Acids, K. E. Rieckhoff and W. L. Peticolas, *Science* **147,** No. 3657, 610-611 (February 5, 1965).

Optically active amino acids contain many highly efficient optical second-harmonic generators. When light from a ruby laser at 6943 Å falls on the crystalline amino acids with sufficient intensity, the second harmonic of the light at 3471 Å can be observed. Although the symmetry requirements for optical second-harmonic generation are always met by isomerically pure optically active substances, there is considerable variation in efficiency for the generation of the second harmonic, ranging from almost zero to greater than that of potassium dihydrogen phosphate, the most efficient known.

Paramagnetic Faraday Rotation of EuSe, J. C. Suits and B. E. Argyle, *Journal of Applied Physics* **36,** No. 3—Part 2, 1251-1252 (March, 1965).

Faraday rotation and absorption measurements were made on a bulk single crystal and on evaporated polycrystalline films of EuSe. Bulk EuSe is ferromagnetic, transparent in the red, and exhibits an unusually large Verdet constant at room temperature: −9.7 min/Oe-cm at 6660 Å where the absorption is 173 cm^{-1}. Measurements at 77°K show that the Verdet constant varies approximately inversely with temperature and thereby correlates with the magnetic susceptibility. These properties are due to the Eu^{++} ion and are comparable to those we have observed in other divalent europium compounds such as Eu_2SiO_4.

The evaporated films of EuSe exhibit a broad but well-defined absorption band at 4600 Å which is essentially duplicated in similarly prepared films of EuS and EuO at 5200 and 5800 Å, respectively. The wavelength dependence of the Faraday rotation of EuSe exhibits a rather complicated structure with two sign reversals in the region of the absorption band. At 6660 Å the Verdet constant measured at room temperature is −6.3 min/Oe-cm, agreeing in sign and approximately in magnitude with the bulk value, whereas the maximum value of Verdet constant, +25 min/Oe-cm, occurs at 4330 Å.

Paramagnetic Resonance and Relaxation of Cu^{2+} and Ni^{3+} in MgO and CaO: The Determination of Jahn-Teller Energy Splittings, U. Höchli and K. A. Müller, *Physics Letters* **15,** No. 1, 5-6 (March 1, 1965).

Spin relaxation times T_1 are reported which depend exponentially on temperature. From this it is concluded that an excited level exists due to the Jahn-Teller effect. The excitation energy of this level exceeds the energy attainable by the phonon spectrum. This shows that relaxation is caused by localized modes which were predicted by Slonczewski.

A Perspective View of Discrete Automata and Their Design, C. C. Elgot, *The American Mathematical Monthly* **72,** No. 2, 125-134 (February, 1965).

Some relationships between the theory of Turing machines and the theory of finite automata are discussed. An attempt is made to indicate some relationships between these mathematical theories and the physical devices called "digital computers."

Preparation and Crystal Chemistry of Divalent Europium Compounds,† M. W. Shafer, *Journal of Applied Physics* **36,** No. 3—Part 2, 1145-1152 (March, 1965).

A number of new divalent europium compounds have been prepared and their magnetic properties investigated. Ferromagnetism was found in the silicates Eu_2SiO_4 and Eu_3SiO_5, the aluminates $Eu_3Al_2O_6$ and $Eu_5Tl_4O_8$, and the phosphate $Eu_3(PO_4)_2$.

Other divalent europium compounds in which the europium concentration is lower but which had simple well-known crystal structures were also investigated. These included $EuTiO_3$, $EuZrO_3$, and $CsEuF_3$ with the perovskite structure, EuF_2 with the fluorite, $EuWO_4$ with the scheelite, Eu_2CaWO_6 and Eu_2SrWO_6 with the cryolite, and Eu_2ZrO_4 with the K_2NiF_4 structures. None of these compounds were shown to be ferromagnetic despite the fact that the nearest-neighbor Eu-Eu distances were less than 4.5 Å, the distance determined from the chalcogenide series to be the critical one for a positive ferromagnetic Eu-Eu interaction. The absence of ferromagnetism in these compounds is discussed in relation to the fact that, except in $CsEuF_3$, the coordination number of the Eu^{+2} ion is not six as it is in the chalcogenides. The assumption that the ferromagnetic interaction takes place via overlap of 5*d* orbitals is considered and discussed in relation to their structures.

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Problems of Network Flow, William Prager, *Zeitschrift fuer angewandte Mathematik und Physik* (ZAMP) **16,** No. 2, 185-190 (March 25, 1965).

A wide class of problems of network flow is formulated in terms of extensive variables (outflows or inflows) and intensive variables (prices at the nodes, price differentials for the arcs). The flow intensity along the typical arc is assumed to be a nondecreasing function of the price differential for this arc. The uniqueness and extremum properties of the solutions are stated. Examples are presented that stress the practical importance of "mixed boundary conditions" specifying outflows or inflows for some nodes and prices for the remaining nodes.

A Programmed Algorithm for Designing Multifont Character Recognition Logics, C. N. Liu, *IEEE Transactions on Electronic Computers* **EC-13,** No. 5, 586-593 (October, 1964).

This paper contains a discussion of a programmed algorithm for designing multifont recognition logics. This design algorithm automatically derives effective recognition logics from representative samples of characters. It has been applied to design translation invariant logics for upper and lower case typewritten alphabets. Recognition performances in the order of a few errors per thousand characters have been achieved for mixed-font characters from 6 to 11 different fonts over a wide range of printing quality.

The Recursive Theory of Slow Viscoelastic Flow Applied to Three Basic Problems of Hydrodynamics, W. E. Langlois, *Transactions of the Society of Rheology* **8,** 33-60 (1964).

The flow-field and stresses, correct to the third order, are calculated for three basic problems of viscoelastic flow: the Poiseuille problem, helical flow in an annulus, and torsional flow between discs. The slow flow equations are set out in general tensor notation, then specialized to cylindrical polar coordinates and to spherical polar coordinates.

Reduction of the Turn-Off Delay of a Germanium NPN Mesa by Plastic Deformation, P. A. Schumann, Jr. and A. J. Rideout, *Solid State Electronics* **7,** No. 12, 849-851 (December, 1964).

The turn-off delay of a germanium *npn* mesa transistor was reduced by plastic deformation. The evaporated SiO diffusion mask was used at temperatures above the plastic deformation temperature to produce slip. Dependence of the dislocation density on process parameters is given. The method of lowering the turn-off delay is discussed.

Saturable Optical Absorption in Phthalocyanine Dyes, J. A. Armstrong, *Journal of Applied Physics* **36,** No. 2, 471-473 (February, 1965).

Strong optical absorption lines have been almost totally saturated in two phthalocyanine molecules. A giant pulse ruby laser served as the source of intense resonance radiation. The qualitative behavior of the nonlinear absorption is in good agreement with theory.

Saturation of the Optical Absorption in GaAs, A. E. Michel and M. I. Nathan, *Applied Physics Letters* **6,** No. 6, 101-102 (March 15, 1965).

The observation of nonlinear absorption in GaAs is reported. A GaAs injection laser was used as a light source. This permits the realization of very high light flux densities ($>10^5$ W/cm^2) at energies close to the direct absorption edge in GaAs. Increases in transmission by as much as a factor of 14 have been observed. Detailed results for an Mn-doped crystal are presented. Results on GaAs containing only shallow impurities are discussed.

Self-Compensation-Limited Conductivity in Binary Semiconductors. IV. nZn_xCd_{1-x} Te, F. F. Morehead and G. Mandel, *The Physical Review* **137,** A924-A925 (February 1, 1965).

The electrical conductivity of heavily Al-doped Zn_xCd_{1-x} Te has been studied. The sharp transition expected from theory in the conductivity as a function of x is confirmed at a value of $x = 0.69$. Above this value only high-resistivity material is obtainable which becomes high-resistivity p-type for x above ≈ 0.75. The fact that the transition from low to high resistivity as a function of x is not nearly so sharp as expected from the theory is attributed to the spread in vacancy sizes and hence energy levels of the compensating vacancies that one expects in such an alloy system; pairing effects may also play a role.

Serial Compilation and the 1401 FORTRAN Compiler, L. H. Haines, *IBM Systems Journal* **4,** No. 1, 73-80 (1965).

This paper discusses a compiler organization in which phases act sequentially on a source program held in core storage. A brief description of each phase of the 1401 FORTRAN compiler is given to illustrate the general scheme.

Set Point Stations, P. E. A. Cowley, *Instruments & Control Systems* **38,** No. 2, 99-104 (February, 1965).

The function of the set point station is to couple a digital control computer to an analog control loop. An example is given in which both electric and pneumatic control loops are coupled to a digital control computer. The requirements of the set point station are examined in some detail and the implementation in the first and second generation of set point stations is discussed. The article is illustrated with photographs of the IBM Set Point Station Model 891.

Simple Device Gives Controlled Gating and Improves Quality of Injection Molded Parts, A. Kelch and H. Vickerson, *Plastics Design and Processing* **5,** No. 2, 16 (February, 1965).

This paper describes a new method for gating a mold. The method has been used in injection molding of developmental parts. The size of the gate can be varied for use with different plastics, obviating the need, in many cases, to build a new mold.

Substrate Orientation Effects and Germanium Epitaxy in an Open Tube HI Transport System, A. Reisman and M. Berkenblit, *Journal of the Electrochemical Society* **112,** No. 3, 315-318 (March, 1965).

The results of the thermodynamic analysis of the system Ge-I_2-H_2-He were used as a guide in designing a germanium epitaxial reactor. The equipment incorporates an instantaneous demand HI generator and is free of lubricated joints and valves. Cleaning of the apparatus is effected by the use of liner tubes and the system operates semiautomatically. Vapor growth studies were conducted to determine the effects on the surface morphology of grown layers caused by substrate parameters such as crystal orientation, resistivity, and conductivity type. It was found that the latter two parameters did not affect surface morphology, but that small crystal misorientations off of ⟨111⟩ surfaces had pronounced effects. Growth rates in the system were of the order of 0.7 μ/hr under the conditions used, and values of N_D-N_A of 10^{15} electrons/cm^3 were obtained routinely using undoped sources. Mobilities for the deposits were in the 14,000 cm^2/V-sec range at liquid nitrogen temperature.

Surface Tension and Surface Modes in Semi-infinite Lattices, D. C. Gazis and R. F. Wallis,* *Surface Science* **3,** No. 1, 19-32 (January, 1965).

A free surface may be created in a crystal by starting with an infinite crystal and removing all interactions between particles on one side of the boundary and those on the other side. In general, the particles near the surface must move to new equilibrium positions and the force constants characterizing small oscillations of these particles will be different from those of the infinite crystal. Explicit calculations are presented of the new equilibrium positions in a semi-infinite, one-dimensional monatomic lattice with nearest and next-nearest neighbor interactions including an anharmonic interaction between nearest neighbors at the free end. The appearance of surface modes of vibration due to the changed force constants at the boundary is investigated in detail for a semi-infinite, one-dimensional monatomic lattice with nearest and next-nearest neighbor harmonic interactions. Conditions of stability for such a lattice are established. In addition, the influence of a free surface on the localized mode due to a force-constant imperfection at some distance from the boundary is investigated.

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Synthesis of GaAs by Vapor Transport Reaction, H. R. Leonhardt, *Journal of the Electrochemical Society* **112,** No. 2, 237-240 (February, 1965).

A flow system is described in which synthesis and epitaxial growth of GaAs are combined. The formation of GaAs occurs by means of a reaction between arsenic and gallium moniodide, the latter being prepared from elemental gallium and hydrogen iodide. Thermodynamic calculations have been made to determine feasible parameter settings. Growth behavior for different conditions and electrical properties of the vapor deposited material are discussed. Electron mobilities at room temperature up to 6530 cm^2/V-sec were obtained.

The Tangible Benefits of Standardization, W. F. Arnold, *Standards Engineering* **17,** No. 2, 4-6 (February, 1965).

This article discusses the tangible benefits of standardization through reduced costs, consistency of design, and reduction of development time. It explains the role of the Standards Engineer in setting up the program to achieve maximum benefits within a company.

A Technique to Control Waiting Time in a Queue, S. Shapiro, *IBM Systems Journal* **4,** No. 1, 53-57 (1965).

This paper describes a control technique for regulating the waiting times of jobs in a discrete manufacturing process. The technique is based on the second method of Lyapunov, which has been extensively used for deterministic processes. Two illustrations of the method are included. Experimental evidence of the effectiveness of the technique is indicated.

Theory of Acoustic Attenuation in Insulators, P. B. Miller, *The Physical Review* **137,** A1937-A1938 (March 15, 1965).

A Green's-function theory of the attenuation of an acoustic phonon by its interaction through the anharmonic lattice potential with thermal phonons is derived. A general mechanism scattering the thermal phonons is included by the use of the full Green's function for the thermal phonons. The theory thus provides a unified treatment for the entire range of values of the thermal-phonon lifetime. When the acoustic period is long compared to the thermal-phonon lifetime, our result reduces to the formula obtained by Akheiser only for a certain class of mechanisms scattering the thermal phonons (e.g., normal three-phonon processes). For other scattering mechanisms (e.g., random point defects), we obtain a qualitatively different result which reflects the fact that the acoustic phonon now interacts most strongly with thermal phonons of energy considerably below kT.

Theory of EPR of Ti^{3+} in Trigonal Environments, H. M. Gladney and J. D. Swalen, *Journal of Chemical Physics* **42,** No. 6, 1999-2010 March 15, 1965).

For a single d electron in a trigonal environment, the complete ligand-field Hamiltonian, including the interactions with the upper states of the cubic splitting, has been diagonalized in order to re-examine critically the theory of the EPR spectra of various Ti^{3+} compounds. The compounds for which there are adequate experimental data to justify a detailed discussion of the parametric theory of the electronic structure are titanium in corundum, cesium titanium alum, titanium acetylacetonate, and titanium-doped aluminum trichloride. Only for the first of these is it possible to fit the magnetic properties with crystal-field parameters. In each of the others, covalency is qualitatively indicated, but it is not possible from the present experimental data to give good numerical values either for the trigonal components of the effective potential or for the parameters describing covalency. We suspect that similar uncertainty exists in many of the published interpretations of iron-group compounds.

Transfer of Electrostatic Images to Dielectric Surfaces, R. M. Schaffert, *Photographic Science & Engineering* **9,** No. 1, 40-54 (January/February, 1965).

The transfer of latent electrostatic images to dielectric surfaces is a unique characteristic of xerography. Three phenomena have been proposed to account for charge transfer: (1) ionic conduction when the air gap separating the two surfaces is greater than about 8 μ; (2) field emission when the air gap is less than 8 μ; and (3) direct migration when the two surfaces are in intimate contact. Data are presented to show agreement between theory and experiment.

Transpiration Studies of the Ge-I_2-Inert Gas System, A. Reisman, M. Berkenblit, and S. A. Alyanakyan, *Journal of the Electrochemical Society* **112,** No. 2, 241-242 (February, 1965).

The vapor transport of germanium by the disproportionation of germanium di-iodide was investigated in a dynamic flow system. Requirements for equilibrium and reaction rates are studied in a transpiration type experiment. Conditions for transpiration through a germanium source bed were determined as a function of temperature and various H_2-He mixtures as carrier gas. Results are compared with those predicted from thermodynamic data.

The Transport of Silicon by Gas Reaction with Small Separation Between Source and Substrate, W. Spielmann and V. Doo, *Zeitschrift für angewandte Physik* **18,** No. 4, 318-391 (1965).

A process for epitaxial growth of Si-layers with predetermined electrical properties and high quality surfaces is described whereby special attention is focused on the problem of producing simultaneously several layers of identical quality in the same reactor. Silicon is transported from a polycrystalline or single crystalline source to a Si-substrate using H_2, HCl, or chlorosilanes as transport agents. The distance between the source and the substrate is only 0.3 mm. A 1:1 transport ratio was found for n- and p-doping additions to the source, and good quality p-n junctions could be produced.

Use of a Refrigerator with the Field Ion Microscope, W. T. Pimbley and R. M. Ball, *The Review of Scientific Instruments* **36,** No. 2, 225-226 (February, 1965).

A great deal of the ion microscopy work to date has been performed at 21°K using liquid hydrogen as a coolant. Müller, however, performed a set of experiments at temperatures down to 12°K by pumping on liquid hydrogen. He found some small improvement in resolution for large tip radii. This note describes the use of a Collins helium refrigerator, rather than liquefied gas cooling, to provide very low temperatures.

Vibrational Frequencies of Phosphate Derivatives, J. Kumamoto *Spectrochimica Acta* **21,** No. 3, 345-350 (March, 1965).

Tri-potassium phosphate, di-potassium monomethyl phosphate and lithium dimethyl phosphate have been found to be ideal model systems on which to base a vibrational analysis of the P-O stretching modes in various orthophosphate salt derivatives. We find that a stretching mode which lies about 1200 cm^{-1} ($<$8.7 μ) can be used as a characteristic for disubstituted monobasic salts since the highest modes observed for dibasic derivatives lie below 1150 cm^{-1} ($>$8.7 μ).

Worst-Case Circuit Design, J. B. Atkins, *IEEE Spectrum* **2,** No. 3, 152-161 (March, 1965).

Worst-case design aims for reliable circuit operation even under extreme conditions, including components degrading to end-of-life limits. Examination of pertinent factors is based on logic switching circuits but is applicable to all circuits.

Letters to the Editor

Amplification of Sidebands by a Power Sensitive Impedance, A. H. Nethercot, Jr., *Proceedings of the IEEE* **53,** No. 2, 161 (February, 1965).

The Boundary Matrix of Threshold Functions, C. H. Mays, *IEEE Transactions on Electronic Computers* **EC-14,** No. 1, 65-66 (February, 1965).

The Inductive Effect in the Toluene Anion Radical, D. Lazdins* and M. Karplus, *Journal of the American Chemical Society* **87,** No. 4, 920-921 (February 20, 1965).

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On the Space Group of $LaAlO_3$ Below 720°K and on the Compounds $NdAlO_3$ and $PrAlO_3$ Probably Isomorphous at Room Temperature, B. Derighetti,* J. E. Drumheller,* F. Laves,**, K. A. Müller and F. Waldner,* *Acta Crystallographica* **18,** No. 3, 557 (March, 1965).

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Primary Processes in the Photochemistry of Tetramethyl-1, 3-Cyclobutanedione, I. Haller and R. Srinivasan, *Journal of American Chemical Society* **87,** No. 5, 1144 (March 5, 1965).

The Relationship of Algorithms Used with Adjustible Threshold Elements to Differential Equations, C. H. Mays, *IEEE Transactions on Electronic Computers* **EC-14,** No. 1, 62-63 (February, 1965).

Self-Induced Oscillations in the Stimulated Light Emission from GaAs Injection Lasers, R. S. Levitt* and M. H. Pilkuhn, *Journal of Applied Physics* **36,** No. 3—Part 1, 859 (March, 1965).

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Transverse Traveling-Wave Light Modulator, R. A. Myers, *Proceedings of the IEEE* **53,** No. 2, 159 (February, 1965).