

Technical Papers by IBM Authors Published Recently in Other Journals

Amides as Ligands. VI. Spectrochemical Studies of γ -Thiobutyrolactam and N-Methyl- γ -thiobutyrolactam Cobalt(II) Complexes, S. K. Madan† and M. Sulich,* *Journal of Inorganic Chemistry* **5**, No. 10, 1662-1669 (October, 1966).

The syntheses, electronic absorption spectra, infrared spectra, magnetic susceptibilities, and conductance measurements of a series of cobalt(II) complexes of the general formulas $[\text{Co}(\text{TBuL})_2](\text{ClO}_4)_2$, $[\text{Co}(\text{NMTBuL})_2](\text{ClO}_4)_2$, $[\text{Co}(\text{TBuL})_2\text{X}_2]$, and $[\text{Co}(\text{NMTBuL})_2\text{X}_2]$ (TBuL = γ -thiobutyrolactam, NMTBuL = N-methyl- γ -thiobutyrolactam, and X = Cl, Br, I, SCN, and NO_3) are described. The usual ligand field parameters Dq , B , and β are calculated for these complexes. The parameters indicate that these complexes are tetrahedral and sulfur coordinated. The ligands TBuL and NMTBuL are each assigned a position relative to the other sulfur-containing donors in the spectrochemical series. With NMTBuL, an inductive effect, rather than a steric effect, previously observed for some fully substituted amides and cyclic lactams, is found to exist for the coordinated thio-lactam. The $[\text{Co}(\text{NMTBuL})_2(\text{NO}_3)_2]$ complex seems to possess an octahedral stereochemistry, a conclusion based on the electronic spectra, infrared spectra, and magnetic moment.

† State University of New York at Binghamton.

* Based in part on a dissertation to be submitted by M. Sulich to the Graduate School of the State University of New York at Binghamton in partial fulfillment of the requirements for the degree of Master of Arts, 1966.

Analysis of the Time-Dependence of Multi-Freedom Mechanical Systems in Relative Coordinates, M. A. Chace, *ASME Second Conference on Mechanisms*, Paper No. 66-Mech-23 (October 10-12, 1966).

A theoretical model and a computational procedure are proposed for the analysis of the time-dependence of highly constrained, multi-degree-of-freedom mechanical systems. Problems are formulated as a simultaneous set of Lagrange differential equations in the system relative coordinates, accompanied by second-order constraints. The equations are linear in the second-order terms and are solved by a numerical integration procedure.

Anomalous Polarity-Dependent Electro-optic Effect in Cubic ZnS and ZnTe,* R. A. Myers and C. G. Powell, *Applied Physics Letters* **9**, No. 9, 326-328 (November 1, 1966).

An electro-optic effect with noncubic symmetry has been observed in cubic single crystals of ZnS and ZnTe. It is anomalous in that for one field polarity the result is an apparent decrease in the birefringence for small voltages rather than the expected increase. A likely explanation is

the presence in our samples of a small polar strain, which is partially removed by one polarity electric field.

* Supported in part by the U. S. Air Force Avionics Lab., Research & Technology Division, Air Force Systems Command, Wright-Patterson Air Force Base, Dayton, Ohio, Contract No. AF 33(615)-3655.

Barrier to Internal Rotation in Ethane, E. Clementi and D. R. Davis, *Journal of Chemical Physics* **45**, No. 7, 2593-2599 (October 1, 1966).

A series of SCF LCAO MO computations for the ethane molecule are reported for both the staggered and eclipsed form. The obtained wave functions are better than those previously reported in literature. From this work the following conclusions can be derived. (1) The height of the internal rotation barrier is rather insensitive to the choice of the basis set. This explains the good agreement between computed and experimental barrier height found by Pitzer and Lipscomb. These authors obtained a total energy of -78.99115 a.u. for the staggered form and -78.98593 a.u. for the eclipsed form. Our best computation gives a total energy of -79.10824 a.u. for the staggered form and -79.10247 a.u. for the eclipsed form. The experimental barrier height is 0.0048 ± 0.0005 a.u. (3.03 ± 0.3 kcal). (2) The SCF LCAO MO functions are adequate in reproducing the barrier; therefore correlation effects are rather unimportant. As a consequence, these computations support indirectly the simple electrostatic model advanced, for example, by Karplus and Parr.

Behavior of Selenium in GaAs, G. Schottky, *Journal of the Physics and Chemistry of Solids* **27**, Nos. 11/12, 1721-1726 (November/December, 1966).

The relation between Se concentration and room temperature free electron density is analysed theoretically assuming that part of the Se forms neutral complexes $V_{\text{Ga}}\text{Se}_3$ (V_{Ga} is a Ga vacancy). Incomplete equilibration during cooling and the role of vacancy concentration is discussed. Results are dependent upon values of the binding enthalpy of the complex, H_B , and formation enthalpy of vacancies, H_v , in the combination $H_B - H_v/2$. The theory is in good agreement with published experiments on doping efficiency and on dependence on annealing temperature for fixed Se content. A value of $H_B - H_v/2 \approx 1.8\text{eV}$ is derived, yielding, an estimate of about 4eV for the binding energy of the complex.

Biased Resonance Circuits for Electro-optic Digital Deflectors, C. F. Haugh, *Applied Optics* **5**, No. 11, 1777-1781 (November, 1966).

A number of circuits for electro-optic digital deflectors is presented. These circuits minimize power dissipation by utilizing the novel technique called biased resonance. This

technique is based on the coincidence of zero points of a raised cosine and its derivative. Test results are reported for one circuit that operated at 220 V, with a load capacitance of 200 pF, and at greater than 100 k baud rate. Dissipation for this breadboard model was 10 W. Other circuits are shown; their advantages and disadvantages are discussed. Also discussed are some future switching device requirements.

Bibliography on Network-Based Project Planning and Control Techniques, S. Lerda-Olberg, *Operations Research* **14**, No. 5, 925-931 (September/October, 1966).

An unexhaustive bibliography covering 78 papers in English, 15 in other languages and 16 books on the subject of PERT, CPM, and related techniques. All articles were published in well known journals during the years 1962-1965. The English language papers are classified as to General, Theory, Programming, and Applications.

Chemical Transport in Nonconvective Systems, R. F. Lever and F. P. Jona, *A.I.Ch.E. Journal* **12**, No. 6, 1158-1166 (November, 1966).

Many practical chemical vapor transport systems are gaseous diffusion limited. For a single-reaction system under moderate supersaturations, the diffusive transport rate is readily expressed in a form which enables the effect of surface kinetic limitations to be included. Attempts to observe surface limitations in a closed-tube experiment are described together with experiments which confirm the diffusion theory. The treatment of multireaction systems is briefly discussed.

Cobalt-Substituted $\gamma\text{-Fe}_2\text{O}_3$ as a High-Density Recording Tape, J. R. Morrison and D. E. Spiliotis, *IEEE Transactions on Electronic Computers* **EC-15**, No. 5, 782-793 (October, 1966).

In this study we investigated the recording performance of a surface composed of Co-substituted $\gamma\text{-Fe}_2\text{O}_3$ particles. These particles were cubic in shape with edge length of 500 to 1000 Å, and coercivity of 500 to 600 Oe. This high coercivity is due primarily to the large magnetocrystalline anisotropy of the cobalt cation in the spinel lattice. The recording surface exhibited higher output, better dynamic range, and considerably smaller half-pulse width than typical acicular $\gamma\text{-Fe}_2\text{O}_3$ surfaces. Coercivity and squareness were found to decrease dramatically with increasing temperature, and with adverse consequences affecting recording performance. Heating a prerecorded tape to 150°C results in a 50 percent loss of signal; the conventional $\gamma\text{-Fe}_2\text{O}_3$ tapes experience no loss.

Compatibility of Immittance Matrices, S. K. Mullick, *Proceedings of the Allerton Conference on Circuit and System Theory*, pp. 674-683 (October 5-7, 1966).

Two driving-point immittances are compatible, according to Schoeffler, if one of them can be realized as a lossless two-port terminated in the other. The purpose of the present study is to extend this concept of compatibility of driving-point immittances to immittance matrices characterizing physically realizable networks composed of passive,

linear, lumped, and time-invariant circuit elements. The study has practical importance for its relevance to the problems of multi-port matching and lossless reciprocal imbedding.

Complementary Regulator Design, E. Thomas, *Electronic Design* **14**, No. 18, 64-65 (August 2, 1966).

A high-speed shut-off dc regulator may easily be converted into a more versatile, conventional dc power source. Moreover, the modified unit requires no fuses or special circuit breakers for protection against shorted loads. The new system is put together with two simple series regulators connected in complementary fashion. This provides two regulated, commonly referenced, interdependent, dc outputs driven by the same ac supply. The complementary, interconnected configuration assures both safety against shorts and a reset capability.

Computer-Aided Kinematic Synthesis of a General Planar Mechanism, I. S. Kiss, *ASME Second Conference on Mechanisms*, Paper No. 66-Mech-40 (October 10-12, 1966).

This paper describes a computer-aided kinematic synthesis method. The method is restricted to the synthesis of a general planar mechanism with a single degree of freedom. The program solves a large class of synthesis problem combinations and is capable of optimizing many of the important mechanism and motion characteristics. The range of the program, together with the method of solution, is discussed and a sample computer input and output listing is included. The program is part of a computer-aided design system called COMMEND.

Computer Applications of Lasers, W. V. Smith, *Applied Optics* **5**, No. 10, 1533-1538 (October, 1966).

The applicability of lasers to the logic, memory, input-output, and data transmission linkage portions of computers is analyzed qualitatively. The more promising potential applications are considered to lie in the memory, interconnection, and input-output areas, and the least promising in the fast logic area. Coherent optical data preprocessing is cited as an example of an already clearly useful laser application.

Computer Graphics—Where Are We?, F. D. Skinner, *Datamation* **12**, No. 5, 28-31 (May, 1966).

Computer-linked graphic devices promise a breakthrough comparable to the introduction of data processing itself. This article reports on the use of display consoles—cathode ray tube displays with versatile entry devices—now and in the near future. The many display devices now available range from small alphameric units to fairly sophisticated terminals which permit the display of graphic images with points or lines.

Computerized Design Information Systems and Their Impact on Draftsmen, V. L. Hoberecht, *Journal of Industrial Arts Education* **25**, No. 5, 15-17 (May-June, 1966).

Design information systems differ from other data processing systems primarily in the equipment used for gating information into and out of the system. Special input/output equipment has been developed for design information systems which allow a draftsman/designer and a computer to communicate with each other more quickly and effectively. They permit the handling of designs and other graphic data as well as printed data. Communication can be carried on in a "conversational" mode with questioning, interruptions, and decisions by both the draftsman/designer and the computer.

Computer Program Aids Circuit Analysis, E. T. Johnson, *Electronic Design* 14, No. 23, 56-61 (October 11, 1966).

S-plane or Laplace transform techniques for analysis and design have formed the basis for much of the linear circuit theory in recent years. Knowledge of the pole and zero locations can be an important aid in circuit design and network syntheses by providing insight into circuit stability, frequency and transient responses. However, tedious manual calculations required by these techniques limit practical application. This limitation can be removed by shifting the calculating task to a computer through an experimental program called LISA (*L*inear *S*ystem *A*alysis). A free-format, applications-oriented input language makes the program easy to learn and use. Input to the system is entered as Nodal circuit descriptions or as transfer functions. Outputs may be poles and zeros, frequency and transient response, root locus or sensitivity. Data is returned to the engineer in the form of listings or plots. Features such as the ability of the program to reflect parameter and topological changes allow the user to experiment, study and solve his design problems without getting lost in algebraic or programming details.

A Computer Program for the Statistical Analysis of Series of Events, P. A. W. Lewis, *IBM Systems Journal* 5, No. 4, 202-225 (1966).

This paper discusses general considerations that arise in the statistical analysis of point stochastic processes (series of events) and a computer program called SASE designed to implement such an analysis. The program is written as a sequence of independent subroutines. The computations performed in each subroutine are described and an example of an analysis of a series of events is presented and discussed.

Current Ideas in the Philosophy of Testing Electrical Contacts, H. B. Ulsh, *IEEE Transactions on Parts, Materials and Packaging* PMP-2, No. 3, 68-70 (September, 1966).

In computer equipment, the large number of connector type contacts alone requires a very reliable component. There is a definite need for obtaining a better understanding of the modes of failure in real-life environments so that new and better test methods can be developed. This article reviews testing methods and the philosophy of evaluating electrical contacts.

Design of a Hydraulic Drive for a Computer Memory, H. C. Lowe, *Hydraulics and Pneumatics* 19, No. 10, 122-128 (October, 1966).

Use of hydraulic power drives in data processing equipment is a break with tradition. From the design of the hydraulic drive system for the IBM 2321 Data Cell Drive, it has been proved that a medium pressure hydraulic system of proper design and packaging can meet the office environment requirements. The analysis of system design requirements indicates the need of a 1500 psig system pressure. The hydraulic drive design establishes the necessary valving for safety and the sequence of operation. The hydraulic power supply design produced a power supply unit that can meet the most power-demanding condition continuously.

Diffusion Coefficient of Oxygen in Neutral and Basic Solutions, S. L. Phillips, *Journal of Analytical Chemistry* 38, No. 12, 1714 (November, 1966).

The potentiostatic method in which a constant applied potential is maintained at a stationary mercury electrode in unstirred solutions was used to determine the diffusion coefficient of oxygen in the absence and presence of some adsorbable substances. Experimentally, it was found that the Fickian diffusion coefficient of oxygen in 0.1M phosphate buffer (pH 6.8) was 2.15×10^{-5} cm.²/sec when calculated from the first oxygen reduction step, and 1.77×10^{-5} cm.²/sec when calculated from the second reduction step. However, both reduction steps gave essentially the same average value of 2.70×10^{-5} cm.²/sec in 0.1M potassium hydroxide solution. Addition of Triton X-100 and tetrabutylammonium ion to the phosphate buffer solution resulted in a lowering of the faradaic current for both reduction steps, while currents for the first reduction step were higher in the presence of catalase. The addition of gelatine caused the faradaic current for the first step to be lower at short times, but did not significantly affect the second reduction process.

Diffusion-Controlled Adsorption at Spherical Electrodes, S. L. Phillips, *Journal of Electroanalytical Chemistry* 12, No. 4, 294-299 (October, 1966).

Both the diffusion coefficient and maximum surface concentration of a surfactant may be calculated from potentiostatic current-time curves obtained using spherical electrodes. The theoretically derived relation between the maximum surface concentration, diffusion coefficient, and time at which maximum surface coverage is attained was tested by adding tetrobutylammonium ion to a solution of cadmium (II) in 0.1M perchloric acid.

Adsorption at a planar electrode under conditions of diffusion controlled mass transfer has been investigated both theoretically and experimentally by several workers. In these studies, the boundary condition normally applied is that the solution concentration of the adsorbable substance is equal to zero at the electrode surface throughout the course of the experiment. Assuming this condition holds, the time at which the faradaic current falls to zero is supposed to coincide with formation of the maximum equilibrium surface coverage of the surfactant. Although this relation between the interfacial concentrations and time was derived for a planar electrode, it has most often been applied to instantaneous current-time data obtained using a dropping mercury electrode.

The equation based on a planar electrode predicts a linear relation between the reciprocal of the bulk concentration of surfactant and the square root of the time at which the faradaic current is zero. The slope of this line is proportional to the ratio of the maximum surface concentration of the surfactant, and the square root of the

diffusion coefficient of the adsorbing substance. From the value of this slope alone, it is not possible to calculate separately either the maximum surface coverage or the diffusion coefficient of the surfactant in the bulk of the solution. Thus, in order to calculate both of these quantities, either the diffusion coefficient or the equilibrium surface coverage must be determined from a separate experiment.

On the other hand, the form of the theoretical equation relating the maximum surface coverage, bulk concentration and time at a spherical electrode permits calculation of both bulk diffusion coefficient and equilibrium surface coverage from a series of current-time curves. This is shown in the following derivation.

Digital Equipment Design: Automatic Tunnel Diode Analyzer, A. Croisier, *Electromechanical Design* 10, No. 10, 22-24, 26-28 (October, 1966).

An automatic tunnel diode analyzer which measures both the constant current and extremum (peak and valley) current of tunnel diodes uses the IBM Card Punch. Meeting the needs of the development laboratory and small pilot line, the analyzer fulfills specific requirements that are not met by laboratory setups and for which high-speed production testers are too expensive, too complicated and not flexible enough. The system provides precision measurements (0.1% on peak current) and sufficient flexibility to accommodate a wide range of devices without rewiring and to allow any special measurement by pushbutton operations. A punch programming technique measures and records parameters automatically, making optimum use of the card punch to sequence measurement and program operations. Up to 9 parameters can be measured at a rate of 1000 units per day or shift, including setup and maintenance adjustments.

Digital Light Deflectors, T. J. Harris and H. Fleisher, *Applied Optics* 5, No. 10, 1657-1666 (October, 1966).

Several electro-optic digital light deflection techniques have been proposed. The maximum number of resolvable deflection positions for all methods is determined, essentially, by economic reasons, the tolerable amount of background light, and aberrations. In this paper, three different types of deflection methods (split angle, total internal reflection, Wollaston prism) are described. Design construction details, and performance of three deflector models are reported. Combined deflection systems use the advantageous properties of each of these methods to obtain economically the maximum number of resolvable deflection positions. A suggested combination to achieve 1024×1024 positions arranged in a two-dimensional field would consist of one total internal reflection stage, seven stages of split angles, and two stages of Wollaston prisms for each dimension.

Dislocations in Silicon Due to Localized Diffusions, G. H. Schwuttke and J. M. Fairfield, *Journal of Applied Physics* 37, No. 12, 4394-4396 (November, 1966).

Dislocations generated through localized diffusions in silicon are investigated through x-ray diffraction microscopy. It is shown that dislocations are produced at the interface diffused-undiffused silicon as a consequence of elastic strains resulting most likely from steep lattice constant gradients. From the device point of view these dislocations are undesirable because their axes lie outside the diffusion plane; consequently they can cause device failure.

Domänenwandkriechen im unipolaren Nanosekunden-Impulsfeld, (Domain wall creeping in unipolar nanosecond pulse fields), Th. Mohr, *Zeitschrift für angewandte Physik* 21, No. 5, 411 (November 2, 1966).

Domain wall creeping has been studied in continuous NiFe films applying nanosecond pulse fields in the hard direction of magnetization by means of current pulses through a stripline and a steady Helmholtz field in the easy direction. The dependence of creeping width on the number of pulses is shown to be well approximated under the assumption of a minimum threshold pulse field to initiate creeping and a linear decrease of the single pulse creeping step with the amplitude of the pulse field. The influences of pulse length, pulse rise time and homogeneous bias fields in the hard direction on the saturation value of creeping are discussed in relation to the experimental results.

A Dynamic Performance Measurement System for Inspection Departments, H. H. Falik, *Proceedings of the 1966 Seventeenth Annual AIIE Conference*, pp. 197-205 (October, 1966).

This paper describes a new performance measurement system for inspection departments which, through slight system modifications, can be adapted to other indirect-labor departments. The system is founded on the principle of a time base that readjusts to changing work conditions in the inspection department. The Dynamic Performance Measurement System described is a management tool, the objective of which is to help improve inspection personnel performance. It provides the manager with a monthly departmental performance rating, a measure of work output, efficiency and manpower planning. Accurate and valid labor performance measurement is provided by the system through the use of actual, constantly measured influencing factors of the working conditions in the department. The factors are converted into work load, rejection rate, lot size, and parts mix indices. The indices serve to update the Dynamic Performance Measurement System. Finally, the system is used to generate the departmental performance rating. The three phases of the DPM System are described in detail. This unique perpetual system eliminates the need of costly resetting of the performance criteria, with stopwatch or other methods, which is usually necessary because of changing work conditions in industry.

The Effect of Residual Gases on Sputtering Rates, E. Stern, *The Journal of Vacuum Science and Technology* 3, No. 5, 304 (September-October, 1966).

Sputtering has now become accepted as a practical tool for deposition of thin films. The technique is still plagued by the difficulty of monitoring film thickness, and a lack of reproducibility in deposition rates. In this paper, mass spectrometer data is presented which indicates that residual water vapor can play a chief role in determining the deposition rate in a given run. It is shown that dissociation of water vapor by the glow discharge gives rise to copious quantities of hydrogen which can become a significant fraction of the sputtering atmosphere. A simple model is suggested to explain the effect of hydrogen, and this is compared with data obtained for a number of metals sputtered in a glow discharge apparatus.

Effective Fields in Cubic Lattices with Extended Charges. II, F. Stern, *Physical Review* **149**, No. 2, 681 (September 16, 1966).

The results obtained by Guertin and Stern for the effective electric fields acting on rigid charge distributions in cubic crystals are extended to arbitrary wavelength. The results include two terms in addition to the one given by Cochran. Some numerical results for the rocksalt lattice are given.

Electron-Hole Recombination in Bismuth Below 20°K, A. A. Lopez and S. H. Koenig, *Solid State Communications* **4**, No. 10, 513-517 (October, 1966).

We have obtained a measure for τ_R , the electron-hole recombination time in bismuth, from 2 to 20°K. The value of τ_R at 4.8°K is 6×10^{-9} sec and decreases exponentially as the temperature increases with an activation energy of 42°K. The results were obtained from measurements of the acoustomagnetoelectric effect (AME) at 11.3 and 29.5 Mc/sec. An ancillary result is a T^{-2} dependence for the trigonal hole mobility above 8°K.

The Electrostatic Storage Display Tube: A New Projection Display System, J. M. Engel, *11th Technical Symposium of the Avionics Panel of AGARD* (November 7, 1966).

The Electrostatic Storage Display Tube (ESDT) is a special tube which combines the intrinsic charge storage property of a dielectric membrane with the high-speed, high-resolution capability of a newly developed electron gun and an independent optical system to provide bright, high-contrast, large-screen displays. The writing and recording functions of this tube have been completely separated from the actual display function, thus providing several advantages over conventional storage display tubes. A single tube may be used for theater-size displays or for hard-copy outputs on photosensitive media. Several different tube structures are described, all of which offer resolutions of about 2000 TV lines per useful field of view, good contrast, and erasure times of under two seconds. Other advantages include writing times varying from one frame per hour to commercial TV speeds, and long storage of the developed image (requiring no electric power) without flicker. Brightness of the display is determined entirely by external light sources.

Excitation and Range of Electrons in Metals and Their Determination by Thin Film Methods, H. Thomas, *Proceedings of the International Symposium on Basic Problems in Thin Film Physics*, p. 307 (1966).

A survey is given of the elementary processes of photoemission, especially of the excitation of electrons and their transport to the surface. The state of experimental knowledge is discussed.

Ferromagnetic Exchange Coupling in the Spinel Lattice, K. W. Blazey, *Solid State Communications* **4**, No. 10, 541 (1966).

The ferromagnetism of the recently discovered ferromagnetic spinels is thought to be due to nearest neighbor Cr^{3+} superexchange interactions. The presence of such inter-

actions is confirmed by measurements of the fluorescence of Cr^{3+} in the spinel ZnAl_2O_4 . Structure is observed that may be clearly associated with exchange coupled Cr^{3+} pairs with a ferromagnetic exchange constant $J = +10.2 \text{ cm}^{-1}$.

Forward Feed Stabilizes dc Differential Amplifier, F. Sordello, *Electronics* **39**, No. 24, 84 (November 28, 1966).

This circuit is used as a high-gain dc preamplifier to a bridge circuit that delivers up to 2.5 amps to a servo motor on the IBM 2310 Disk Storage Drive. The power bridge must have but one side turned on at a time corresponding to velocity-transducer information. Any differential drift due to nontracking of transistors will give a false drive to the motor. The velocity transducer is a low-level differential output device. Unwanted signals are picked up by the lines from the velocity transducer to the electronic circuits. These unwanted signals are common mode which, should they appear at the power driver bridge, cause circuit failures because both sides are turned on. (Any common mode drift caused by nontracking of transistors in common mode will tend to produce the same results.) The circuit provides both common mode and differential tracking. The preamplifier is able to reject the common mode signals.

Free Energy of Displacive Ferroelectrics,* P. C. Kwok and P. B. Miller, *Physical Review* **151**, No. 2, 387-404 (November 11, 1966).

A power series for the free energy is derived in the linear anharmonic approximation. This free energy is expressed in terms of a complete set of microscopic order parameters which determine the ionic displacements in the ferroelectric transition. In general this complete set of microscopic order parameters is larger than the set of order parameters used in the phenomenological free energy of Devonshire. However, for those ferroelectric crystals which are characterized by only one soft optical branch, this larger set may be reduced to the same number as used by Devonshire. Such a reduction is explicitly carried out for the perovskite structure and the resulting expression is the same as that derived phenomenologically by Devonshire with the coefficients expressed in terms of microscopic lattice parameters.

* Supported in part by Contract DA 36-039 AMC-02280(E) (U. S. Army Electronics Command, Fort Monmouth, New Jersey).

Future Trends in Magnetic Recording, C. D. Mee, *Zeitschrift für angewandte Physik* **21**, No. 2, 175-178 (August, 1966).

The requirements of new mass storage systems are projected in those areas where magnetic recording is presently used. Audio, video, and digital data recording are considered with respect to their future trends in recording density, data rate, and access time to the stored data. The limitations of the existing magnetic recording technology are then examined with respect to future requirements. Advanced recording techniques, with the potential to extend the performance towards the future requirements, may be anticipated through the application of beam transducers and beam-sensitive storage media. Recent developments in magnetic films with large magneto-optical and thermo-magnetic effects are considered for application as magnetic storage media operated by laser beam transducers. Estimates of

the recording and reading efficiency are made for some transparent garnets, ferrites, and europium compounds. Account is taken of the magnetic properties required to give high efficiencies and small demagnetization losses. This review of the potential of some materials for beam operated magnetic recording indicates that very fast readout rates from high density recording can be predicted. The application of these materials will satisfy some, although not all, of the requirements for future systems.

Gallium Arsenide Four-Layer Device, W. von Münch, *Solid-State Electronics* **9**, No. 6, 667-668 (1966).

Gallium arsenide *npn*- and *pnp*-transistors have already been produced by means of the planar technology. In this note the fabrication of a planar four-layer device by triple-diffusion will be reported.

Graphics in Design Engineering, W. H. Sass, *Paper Summaries of the SAE Advanced Launch Vehicles Conference*, Paper No. 660459, 1-24 (June, 1966).

Men and computers can work together in the design of complex components and systems using graphic input/output devices. Man-oriented I/O devices, such as light pens, keyboards, and displays, extend the capabilities of men and computers in evolving a design. Close man-machine rapport allows the designer to aid the computer in performing tasks beyond its programmed capability. This paper describes, in detail, one such graphic application that has been implemented for the design of digital computer circuit cards. References are made to an extended program for the design of complete computing systems.

Growth of Dislocation-Free Silicon Web Crystals, G. H. Schwuttke and T. N. Tucker,* *Applied Physics Letters* **9**, No. 6, 219-221 (September 15, 1966).

This note reports the growth of dislocation-free silicon web crystals. These crystals are grown reproducibly in the thickness range of 15 to 45 microns and approximately 4 to 8 mm wide. Phosphorus, arsenic, and boron were used as dopants to achieve controlled resistivities from 0.05 to 20 ohm-cm.

* Dow-Corning.

Hyperfine Structure $^2D_{5/2}$ and $^4F_{9/2}$ States of Ag^{107} and Ag^{109} , A. G. Blachman, D. A. Landman* and A. Lurio, *Physical Review* **150**, No. 1, 59-68 (October 7, 1966).

The hyperfine structure of metastable electronic states Ag^{107} and Ag^{109} have been measured by the atomic-beam magnetic-resonance method. The results, including the hyperfine structure dipole interaction constants, have been corrected for second-order interactions with neighboring fine-structure levels.

* Present address: New York University, University Heights, Bronx, N. Y.

IBM Graphic Display System, R. J. Houldin, *Information Display* **3**, No. 5, 34-40 (September/October, 1966).

Computer displays with graphic capabilities have added a

new dimension to data processing by making information more accessible and more easily assimilated. Summaries, graphs, and charts can be quickly retrieved and viewed on many screens simultaneously. Several of the more advanced displays are beginning to link the creativity of man and the calculating power of the computer to design applications.

Indirect Exchange in Semiconductors, J. F. Janak, *Journal of the Physics and Chemistry of Solids* **27**, No. 10, 1571-1576 (October, 1966).

Indirect exchange of the Ruderman-Kittel type is discussed for donor and conduction electrons in a semiconductor. It is found that the indirect exchange no longer shows the spatial oscillations characteristic of a metal, and is increased in magnitude, though limited spatially to the size of the wavefunction, when the electrons are localized on nonoverlapping donors. The indirect exchange is much too small in magnitude to lead to ferromagnetism in either extrinsic or intrinsic semiconductors.

The Influence of Crystallographic Defects on Device Performance, J. M. Fairfield and G. H. Schwuttke, *Journal of the Electrochemical Society* **113**, No. 11, 1229-1231 (November, 1966).

Imperfections in the crystallographic structure of silicon diodes influence their reverse characteristics, and an understanding of this phenomenon is necessary for the effective design of high-quality semiconductor devices. Usually, investigators have shown a statistical or circumstantial relation between crystal imperfections and device performance; however, Queisser and Goetzberger have shown that excessive leakage currents may occur at stair rod dislocations, and Barson has observed such leakages at arbitrary points on stacking faults in epitaxial material.

This paper describes a study of the effects of crystallographic imperfections introduced during typical fabrication procedures and shows that leakage currents do occur at edge dislocations. It also discusses methods by which such imperfections can be controlled and their effects minimized. This investigation has been accomplished by studying simple diffused silicon diodes that were made using standard diffusion techniques. Their reverse characteristics were measured and compared with the crystallographic perfection of the silicon wafers, examined by means of transmission x-ray diffraction microscopy.

The Influence of EDM on Engineering Design, F. J. DeMaine, *Progressive Plastics* **8**, No. 11, 33, 54 (November, 1966).

More and more uses for EDM (electro-discharge machining) have been found at IBM since it was first tried in 1958. Today it is used throughout the corporation for production as well as modeling. For designers, it has removed some of the limitations imposed by common metalworking methods. Before EDM reached its present use, an analysis of the various factors that affect its use was made. This analysis helped to determine the optimum characteristics for the best results.

Infrared Dielectric Dispersion and Lattice Dynamics of Uranium Dioxide and Thorium Dioxide, J. D. Axe and G. D. Pettit, *Physical Review* **151**, No. 2, 676-680 (November 11, 1966).

Measurements at room temperature of the infrared reflectivity of single crystals of ThO_2 and UO_2 have been carried out and analyzed by Kramers-Kronig relations. A single strong resonance is found in each case with $\omega_{\text{TO}} = 279$ (± 2) cm^{-1} , $\omega_{\text{LO}} = 568$ (± 4) cm^{-1} , $\epsilon_0 - n^2 = 15.5$ for ThO_2 ; $\omega_{\text{TO}} = 278$ (± 2) cm^{-1} , $\omega_{\text{LO}} = 556$ (± 4) cm^{-1} , $\epsilon_0 - n^2 = 17.7$ for UO_2 (TO = transverse optic; LO = longitudinal optic). The best classical dispersion formula fit to the reflectivity yields the following parameters: for ThO_2 , $\omega_0 = 282.7$ cm^{-1} , $\epsilon_0 - n^2 = 14.85$, $\gamma = 16.2$ cm^{-1} ; for UO_2 , $\omega_0 = 283.2$ cm^{-1} , $\epsilon_0 - n^2 = 15.80$, $\gamma = 18.5$ cm^{-1} . The low-frequency (0.3-Mc/sec) dielectric constant of ThO_2 was measured to be 18.9 ± 0.4 . For UO_2 the mode frequencies are in excellent agreement with those obtained by neutron spectroscopy, and can be reconciled with existing infrared absorption data by taking into account particle-size corrections which can shift the polar mode frequency by a factor $\sim (\epsilon_0 + 2/n^2 + 2)^{1/2} \sim 1.8$ for small spherical samples. The above data are used to evaluate (Szigeti-type) effective charges ($Z'_{\text{Th}} + 4 = 2.33$, $Z'_{\text{U}} + 4 = 2.42$) and to discuss several approximate relations between the long-wave elastic and optical properties of the fluorite (CaF_2 -type) lattice. Absorption bands were measured in the two-phonon-combination region in UO_2 and their assignment is discussed.

Kernel Analysis of Elliptic Partial Differential Equations, S. G. Hahn and E. V. Hankam, *IBM Systems Journal* **5**, No. 4, 248-270 (1966).

The extrapolated Liebmann method for solving partial differential equations is selected for study. With typical computer characteristics in mind, several schemes for organizing the requisite data flow are discussed. To share the potentialities of timing formulas, as well as their limitations and the problems encountered in their construction, one of the data-flow schemes is treated at length. Kernel programs are included, and timing formulas needed in making comparisons of various configurations of two computers are developed.

Large-Scale Integrated Metal Oxide Semiconductor Applied to Data Acquisition, L. L. Boyssel and D. R. Hill, *NEREM Record*, Vol. 8, pp. 74-75 (November, 1966).

This paper describes the development of several general purpose metal oxide semiconductor arrays for use in data acquisition systems. It discusses how—with only a modest investment in special equipment—the system logic, circuit design and layout, wafer testing and circuit reworks, and design of production test equipment can be done at the user facility.

Large-Scale Logic Arrays: Testing for the Millions, J. W. Lind, *Electronics* **39**, No. 21, 98-101 (October 17, 1966).

Computer logic circuits are attaining a high level of integration in advanced computer technology. Consequently, many circuit tests per circuit block are required as a result of this integration trend. DC functional testing of logic circuits is one type of test required. In this type of testing, logic inputs ("1" and "0"), DC loads and logic power supplies must be applied to a large number of circuit pins at an accuracy of a few tenths of a percent. In addition, the application and measurement of "1" and "0" logic levels must be accomplished at a high rate of speed to insure a reasonable test time per circuit block. This paper describes

the analog portion of an advanced logic test system designed and built by an IBM test equipment group to meet the rigorous test requirements dictated by high density, low level integrated logic circuits.

Linear Degenerate RC Network, S. Au, *Proceedings of the Allerton Conference on Circuit and System Theory*, p. 71 (October 5, 1966).

A network is defined as degenerate if it has loops which consist only of capacitors and independent voltage sources and/or cut-sets which consist only of inductors and independent current sources. If a network is not degenerate, all the capacitive voltages and inductive currents are continuous. Discontinuities may be encountered in degenerate networks. The discontinuous voltages and currents can be solved by means of conservation of charge and flux linkage or by using generalized functions. However, there is a well-known discrepancy in energy loss which cannot be answered analytically. The purpose of this paper, then, is to explain this energy discrepancy analytically by using a linear lumped system.

Measuring Transistor Current Amplification Directly, F. Hilsenrath, *Electronic Products* **9**, No. 5, 142-143 (October, 1966).

It is often desirable to plot the DC h_{FE} of a transistor vs emitter current I_E . This requires that h_{FE} be measured at various bias points, from which the desired plot can be obtained. Such a method is time consuming when many transistors are to be characterized. This article describes two circuits for direct, continuous h_{FE} measurements. The first is an analog technique. The emitter current of the transistor under test is used as input to an operational amplifier, while the base current controls the feedback. Thus, the ratio of the two currents which is $(h_{\text{FE}} + 1)$ is directly obtained at the output of the amplifier. This method is simple but is limited to currents where self-heating effects are negligible. The second is a pulse technique valid also at high current levels. Here the ratio of the collector and base current pulse is obtained by letting the base current pulse amplitude control the width of the collector current pulse. Either circuit provides one output proportional to h_{FE} and another proportional to I_E and I_C , respectively. Thus, a plot can be obtained on an x-y recorder.

Mechanism of the Photoisomerization of cis, cis-1, 5-Cyclooctadiene to Tricyclo (3.3.0.0^{2,6}) Octane, I. Halper and R. Srinivasan, *Journal of the American Chemical Society* **88**, No. 22, 5084-5086 (November 20, 1966).

The mechanism of the photoisomerization of cis, cis-1, 5-cyclooctadiene to tricyclo (3.3.0.0^{2,6}) octane has been studied in the vapor phase as a mercury-sensitized reaction, and in ether solution with cuprous chloride as catalyst. In the gas phase the use of oxygen as a radical scavenger failed to eliminate the reaction. The reaction in the condensed phase was followed by the use of 1, 5-cyclooctadiene-d₁₂. No loss of the deuterium label was detectable in either the tricyclooctane that was formed or in the cyclooctadiene that was recovered at conversions ranging from 23 to 70%. The reaction is best formulated as an intramolecular process and not as a free-radical reaction as proposed by Baldwin and Greeley.

Meeting the Metric Problem, A. Saliby, *Engineering Digest* **12**, No. 10, 54-56 (October, 1966).

When machines developed in one country are to be manufactured in other countries which use a different method of measurement and different methods of orthographic projection, difficulties arise. A method of overcoming these problems has been found and is being used now by IBM engineers. It involves a dual dimensioning system where all dimensions are given in both inches and millimetres.

Merge-Sort Analysis by Matrix Techniques, C. E. Radke, *IBM Systems Journal* **5**, No. 4, 226-247 (1966).

Previous work, which analyzed certain merge-sorting methods with the aid of difference equations, is extended to include a wider range of methods. Matrices are introduced to represent the set or sets of difference equations associated with a merge-sort. Two or more matrices are required to define a Class II method, whereas a Class I method can be defined with one matrix. The merge-sorts of most interest fall into a special subclass called Class Ia. It is shown that an asymptotic solution to the set of difference equations for a Class Ia merge-sort is readily obtained. Carter's analysis of cascade and polyphase merge-sorts is generalized and extended to include, among other things, the compromise merges. Various properties of the Class Ia merge-sorts, including relative performance measures and explicit merge patterns, are shown to be obtainable by matrix multiplication. Although the analysis emphasizes Class Ia merges, suggestions are given for applying the matrix technique to other merge-sorts of Classes I and II.

Method for Studying Sputtered Particles by Emission Spectroscopy, E. Sawatzky and E. Kay, *Review of Scientific Instruments* **37**, No. 10, 1324-1329 (October, 1966).

An f/6.8 scanning spectrometer with a photomultiplier output was used to monitor the presence of particles sputtered from a target surface by ion bombardment. The ion source was a conventional duoplasmatron providing a high density, high energy ion beam. The density of sputtered particles available for analysis was of the order of 10^8 cm^{-3} . A fraction of these particles was electronically excited by a high density, low energy electron beam, and the emission spectra characteristic of the target material were recorded with either an electrometer or a phase sensitive detector. Some intense atomic copper lines were easily observed when a Cu target was bombarded with 5000 eV Ar^+ ions. The intensities of these lines have been analyzed to obtain the sputtering yield and some relative excitation functions for copper. A comparison between the conventional mass spectrometric technique and the present scheme is presented.

Micron-Movement Device: For Precise Positioning, J. J. Dalton, *Journal of Photochemical Etching* **1**, No. 7, 17-19 (September, 1966).

The experimental device described in this paper is being used to provide critical focusing of an ultra-high resolution camera used for testing optical system films. The device, a linear micron positioner, enables the camera operator to move a lens exactly two microns simply by turning a focusing knob one revolution.

A Modified Bode Criterion for Stability of Feedback Systems, P. J. Granata and H. B. Aasnaes, *EEE* **14**, No. 10, 97-99 (October, 1966).

A convenient method has been developed for the design of a stable single-loop feedback system. This method involves superimposing the curve of the inverse of the feedback transfer function on the Bode plot of the forward transfer function. If preestablished restrictions on the slope difference between these two plots are fulfilled at their intersection, system stability is obtained. The method permits the proper compensation network to be determined, while satisfying closed-loop gain and stability requirements through separate manipulation of the forward and feedback transfer functions.

Narrow Optical Waveguides and Instabilities Induced in Liquids, R. G. Brewer and J. R. Lifshitz, *Physics Letters* **23**, No. 1, 79-81 (October, 1966).

Self-trapped light beams having a 4μ diameter, a power density $\geq 4\text{GW/cm}^2$, and a 0.5 nsec duration are observed in liquids. Instability effects, saturation in stimulated scattering processes, and the origin of the intensity-dependent refractive index are discussed.

New Dimensions in IC's Through Films of Glass, J. A. Perri and J. Riseman, *Electronics* **39**, No. 20, 107-116 (October 3, 1966).

This survey article describes the uses and potential uses of glass in monolithic and hybrid circuits. Included is a description of various glassing techniques and their applications.

A New Device for Versatile Display Systems: The Electrostatic Storage Display Tube, J. M. Engel and A. J. Eldridge, Jr., *Proceedings of the 7th Annual Symposium of the Society for Information Display*, 32-35 (October 18, 1966).

A novel approach to the storage and display of information combines the intrinsic charge-storage property of a dielectric membrane and the high-speed, high-resolution capability of a newly developed electron gun with an independent optical system to provide bright, high-contrast, large-screen display. This technology has now been incorporated in a new sealed tube which does not require the use of vacuum pumping equipment. The tube essentially separates the writing/recording function from the actual display function and thus provides several significant advantages over conventional storage display tubes. The write gun can be designed for high resolution at very high writing speeds. It does not draw a high current since there is no phosphor to be excited. The optical display system can be independently designed to fit a number of specific applications from high-density recording on film to bright, flicker-free, theater-size displays. Other advantages include resolutions of the order of 2000 TV lines per useful field of view, frame writing times varying from about an hour down to a few milliseconds, storage times of over one month (requiring no electric power), and update or cycle times of less than 3 seconds.

Non-Destructive Detection of Phosphorus Oxide Layers on Semiconductor Wafers, E. A. Corl, S. L. Silverman and Y. S. Kim, *Solid-State Electronics* **9**, No. 10, 1009-1017 (October, 1966).

A simple non-destructive technique using an i.r. spectrophotometer is described which detects accurately the presence of the phosphosilicate layer in the oxide structure on wafers used in fabricating silicon semiconductor devices. By comparing differences in phosphorus oxide thickness on the basis of absorption characteristics, this technique can be used to monitor the phosphorus content and, subsequently, reduce the failure incidence due to inversion in diodes and *npn* transistors.

Non-Destructive Measurement of Glass on Silicon Dioxide Through Near-Infrared (NIR) Interference, E. A. Corl and K. Kosanke, *Solid-State Electronics* **9**, No. 10, 943-948 (October, 1966).

A simple non-destructive technique is described for measuring the thickness of glass films on reflective substrates. Interference patterns are obtained by scanning with a spectrophotometer the near-infrared region of the spectrum between 0.6 and 2.7 μ . The glass layer does not have to be etched or metalized. This method is quick to use (scan time about 30 sec), and provides a permanent record in the form of a plot, thus eliminating the problem of visual interpretation prevalent with interferometer and similar optical methods. The technique is particularly suited for films thicker than 10,000 Å. To accurately measure thinner transparent films, one may utilize interference patterns that develop when scanned in the u.v.—visible region of the spectrum. The procedure is readily adaptable for machine operation.

Numerical Calculation of the Energy and Wavefunction of the Ground State of Beryllium, A. Kotchoubey and L. H. Thomas, *Journal of Chemical Physics* **45**, No. 9, 3342-3349 (November, 1966).

An algorithm for the numerical calculation of the energy and wavefunction of the lowest state of the beryllium atom has been developed and used on the IBM 7090/94 computer systems.

The method is variational in nature. Its object is to find the solution of proper symmetry of the time-independent, nonrelativistic Schrödinger equation for the beryllium atom, for which the energy is a minimum (most negative). The wavefunction in configuration space is expanded in terms of a sum of products of one-electron functions of a complete basis set. These basis functions are chosen to be hydrogenlike functions, all with the same exponential factor. The sum is truncated, and the coefficients are adjusted to minimize the energy, subject to the condition that the function has the symmetry required for a singlet state. Rotational symmetry conditions are also used, to restrict the function to correspond to an *s* state, thus decreasing the number of coefficients that must be evaluated. The coefficients of the expansion are determined by an iterative procedure rather than by direct solution of the variational equations. Two parameters are introduced in the algorithm. One is the result of transforming the Schrödinger equation to have a discrete spectrum, in which the eigenvalue of least magnitude corresponds to the lowest energy. The other parameter is introduced in order to shift the eigenvalue spectrum and increase the separation between the smallest

eigenvalue and the next smallest, thus improving the convergence of the iteration process.

Using a 20-function basis, corresponding to eight *s* states and four *p* states, an energy of -14.6533 a.u. was found for the lowest state of beryllium. This value is an upper bound to the true eigenvalue of the Schrödinger equation, and has a relative error of about 0.10% with respect to the experimental estimate of the true eigenvalue.

Die numerische Berechnung der Wurzeln eines Polynoms* (Numerical computation of the roots of polynomials), K. Nickel, *Numerische Mathematik* **9**, No. 1, 80-98 (1966).

The paper deals with a new method for the computation of all (complex) roots of a polynomial of the degree *n* with given (complex) coefficients. The result is an approximate value plus an error bound for each root. The algorithm does not need initial values. It never fails, not even in the case of multiple roots or of clusters of roots. Experiments have been taken with random-generated polynomials with many more than 100,000 roots. In the range of *n* = 1 to *n* = 30 the number of iterations necessary for the evaluation of one root never exceeds six in average and 16 in the worst case. The experimental results also give much information about the dependence on *n* for error and error bound in average and in the most disadvantageous case, respectively. It is essential for the algorithm given that an "error bound arithmetic" as mentioned in the previous paper is available and can be used.

* Work performed while the author was at the Notre Dame University, as visiting professor.

Observation of the Superconducting Energy Gap in a Semiconductor (GeTe), P. J. Stiles, L. Esaki* and J. F. Schooley** **23**, No. 3, 206-207 (October 17, 1966).

A report of the first observation of the superconducting energy gap in a semiconductor, GeTe, is given. The gap was observed in a tunnel junction of Al-A₁₂O₃-GeTe.

* Sponsored in part by the Army Research Office, Durham, N. C., under Contract DA-31-124-ARO-D-478.

** Sponsored in part by the Advanced Research Projects Agency.

On Constructing Formal Integrals of a Hamiltonian System Near an Equilibrium Point* F. G. Gustavson, *Astronomical Journal* **71**, No. 8, 670-686 (October, 1966).

A procedure is given for constructing formal integrals of a Hamiltonian system of *n* degrees of freedom near an equilibrium point. The method consists of performing a series of canonical transformations which reduces the Hamiltonian to a normal form. The integrals then appear as quadratic forms. A computer program carries out the construction procedure by manipulating polynomials symbolically. For a given Hamiltonian system, it determines approximate integrals (truncated power series) and expresses them in the original coordinates. In the case of two degrees of freedom, level lines of the intersection of the integral with some appropriate surface are plotted. To illustrate this technique

* The results reported in this paper were obtained in the course of research jointly sponsored by the Air Force Office of Scientific Research (Contract AF 49(638)-1474) and IBM.

the problem of the existence of a third isolating integral of motion in an axisymmetrical potential is investigated; a comparison is then made between computed orbits and the curves generated by the approximate third integral.

On the Flow of Blood in a Tube, A. L. Jones, *Biorheology* **3**, 183-188 (September, 1966).

A solution is obtained for the flow of a non-Newtonian fluid in a circular tube. Since cell slippage exists at the wall in the case of blood, the velocity of the fluid at the wall is not taken equal to zero as is commonly done. By using Casson's equation for a constitutive relation, the flow profile and flow rate are found. It is shown that a region of plug flow exists. This plug may extend all of the way to the wall at low flow rates. The theoretical results are compared to some experimental results.

Optical Flatness Measurement, T. K. Dehmel, *Instruments and Control Systems* **39**, No. 6, 123-124 (June, 1966).

A new technique for measuring the optical flatness of opaque objects has been developed. No physical contact with the object being measured is required. The technique has been used successfully to analyze the flatness of film, punched cards, tapes, disks, heads, and other opaque surfaces.

Optical Properties of Europium and Barium, W. E. Müller, *Solid State Communications* **4**, No. 11, 581-583 (1966).

Observed structure in the real part of the conductivity $\sigma(\omega)$ for the two elements Eu and Ba has been assigned to optical interband transitions with the help of recent energy-band calculations.

Performance Deterioration of Optimum Systems, J. J. Rissanen, *IEEE Transactions on Automatic Control* **AC-11**, No. 3, 530-534 (July, 1966).

This paper deals with the problem of evaluating the extent to which system parameters may be changed and still guarantee that system performance will remain within a specified limit. Particular attention is given to linear systems with quadratic performance indices. A sampled data system is analyzed by way of example.

A Photo-Digital Mass Storage System, J. D. Kuehler and H. R. Kerby, *AFIPS Conference Proceedings, Fall Joint Computer Conference*, pp. 735-742 (1966).

The photo-digital mass storage system, an IBM advanced development, is a very large direct-access system which uses a silver halide photographic film for storing great quantities of digital data. In addition to providing on-line accessibility to file modules of 1/3 trillion bits each, essentially unlimited shelf storage can be quickly entered into the system. Based on a combination of technologies new to data processing, the system employs film chips, cells, cell storage, pneumatic delivery of the cells to the recording and reading stations, and electron-beam recording. Primary objectives in selecting these technologies were significant cost reductions per bit of storage while maintaining direct accessibility and reliable

operations. The system is oriented toward the growing need for storing and retrieving reference data which has the characteristics of large block size, low change rate, and rapid expansion.

Practical Bang-Bang Design, T. R. Fredriksen, *Control Engineering* **13**, No. 10, 78-84 (October, 1966).

An experimental control system illustrates a typical variation of bang-bang control where a detent provides the required second mode. Exclusive use of solid-state switching logic and power control gives performance not possible with previous relay controllers. The control concepts are described in terms of modern control theory.

Preparation and Properties of Solution-Grown Epitaxial p-n Junctions in GaP, M. R. Lorenz and M. Pilkuhn, *Journal of Applied Physics* **37**, No. 11, 4094-4102 (October, 1966).

The technique of epitaxial growth from solution has been applied to GaP. Single-crystalline overgrowths up to 80 μ thick on (111)-oriented substrate crystals were obtained by the slow cooling of GaP-saturated Ga solutions. *n*-type overgrowths (Te-doped) on *p*-type substrates (Zn, O-double doped) gave planar *p-n* junctions free of gross defects. The I-V characteristics of these diodes show an exponential behavior of the form $I = I_0 \exp (eV/\beta k T)$. Values for β were mostly between 1.5 and 1.8 at 300°K. At low currents, the I-V characteristics are interpreted by tunneling. The junctions emitted red light at 300°K in a broad band with the peak at about 1.77 eV (7000 Å). The emission intensity varies with I^2 at low currents, changes to a linear dependence at intermediate currents, and is sublinear at high currents. The external differential quantum efficiency was measured to be as high as 7.5×10^{-3} . The temperature dependence of the emission intensity and the efficiency were measured and are discussed.

Properties of Diffused Resistors, M. S. Hess, O. R. Viva and W. J. Armstrong, *Electrochemical Technology* **4**, No. 11-12, 544-546 (November-December, 1966).

The properties of diffused resistors have been examined to determine the effects of different impurity types, diffused surface concentrations, diffused junction depths, and bulk concentrations on the temperature coefficient of resistance. Surface concentrations of 10^{18} - 10^{20} atoms-cm⁻³ and background concentrations of 10^{15} - 10^{18} atoms-cm⁻³ have been investigated. The resistance as a function of temperature has been found to have a relatively constant slope for the temperature range from 25° to 90°C and then increases with increasing temperature through 150°C. In the linear range the temperature coefficient of resistance is a steep function of diffused surface concentration and passes through a minimum at 1.5 - 2×10^{19} atoms-cm⁻³ for both arsenic and boron resistors. The TCR is a less sensitive function of background doping and is independent of junction depth and sheet resistances.

A Real Time Operating System for the Saturn V Launch Computer Complex, F. R. Palm, *Proceedings of the Real Time Systems Seminar*, pp. 4/1-8 (November, 1966).

As missile systems become increasingly larger and more complex, the automation of checkout and launch becomes a necessity. For the Saturn V system, the National Aeronautics and Space Administration has selected a three-computer complex and special input/output and interface equipment to assist in the checkout and launch phases. This complex of equipment is required to do three basic tasks in parallel during these phases. These tasks include: 1. Intercommunication between man and vehicle, 2. Monitoring of system parameters, and 3. Performance of vehicle tests. In order to make these computers function as a system and to allow efficient accomplishment of the above tasks, IBM has implemented an operating system. This operating system, while providing for these tasks, is programmed so that loss of most types of input/output equipment due to hardware malfunctions does not keep the system from providing services for the main tasks.

Real-Time Optimal Guidance, K. R. Brown and G. W. Johnson, *Proceedings of the Real-Time Systems Seminar*, pp. 3/1-11 (November, 1966).

This paper describes an algorithm for repetitive inflight calculation of optimal rocket steering laws for orbital injection and rendezvous missions. The algorithm is based on a general "indirect" method of solving the optimal trajectory problem as a boundary value problem in ordinary differential equations, and it avoids assuming artificial physical simplifications or specialized mission definitions. At each guidance cycle, the solution to the boundary value problem is updated by a single iteration of a modified Newton's method using partial derivatives obtained by numerical integration of variational differential equations. Simulation results show that a precalculated linear steering law provides adequate initialization to assure that this iterative guidance scheme recovers from worst-case inflight perturbations and achieves desired end conditions with near-minimum cost.

Reactor and Linear Accelerator Induced Effects in Dielectrics, F. A. Frankovsky and M. Shatzkes, *IEEE Transactions on Nuclear Science NS-13*, No. 5, 8-21 (October, 1966).

The currents induced by nuclear radiation from a pulsed reactor on several commercial capacitors are compared with those induced by the electron beam of a linear accelerator (LINAC) source. Dependence of the radiation induced current on applied voltage, geometry, dose and dose-rate are contrasted for mylar, polystyrene, mica, tantalum, glass, and ceramic capacitors. These effects are analyzed in terms of models appropriate for the various capacitors and values of parameters defining these relationships are given. The relative effectiveness of neutron and gamma radiation in producing induced currents in these capacitive elements at the reactor environment was also obtained.

Semiconductor Lasers, M. I. Nathan, *Applied Optics* 5, No. 10, 1514-1528 (October, 1966).

This paper is a review of semiconductor laser work. The principles of operation are discussed. The stress is on work since early 1964. The present state-of-the-art in GaAs junction lasers is described.

Shallow Acceptor States in ZnTe and CdTe, B. L. Crowder and W. N. Hammer, *Physical Review* 150, No. 2, 541-545 (October 14, 1966).

The group VA element P and the group IA elements Li and Na give rise to shallow acceptor centers in ZnTe and in CdTe. An analysis of the carrier concentration data for Li-doped ZnTe and P-doped ZnTe on the basis of a single-level acceptor and nondegenerate statistics indicates that P and Li produce shallow, hydrogenic-type acceptor levels in ZnTe. Annealing studies demonstrate that the shallow levels in Li-doped ZnTe and CdTe may be removed by heat treatment at 250°C for tens of hours. The concentrations of shallow acceptors in P-doped ZnTe and Na-doped ZnTe are relatively unchanged by the annealing procedure. The effective mass for holes in ZnTe as deduced from the Hall analysis is $0.36m$, where m is the free-electron mass.

Spin Wave Resonance, P. Wolf, *Proceedings of the International Symposium on Basic Problems in Thin Film Physics*, p. 392 (1966).

An introduction to spin wave resonance is given without, however, completely covering the subject. Experimental results are briefly reported and the interpretation of these results is dealt with. It will turn out that structural disturbances of the films are of great importance. Finally, measurements of the exchange constant are discussed, certainly the most significant aspect of spin wave resonance.

Stacking Faults in Steam-Oxidizing Silicon, M. L. Joshi, *Acta Metallurgica* 14, No. 10, 1157-1172 (October, 1966).

Silicon wafers oriented along (111) and in which surface damage was removed were annealed in vacuum at 800, 1000 and 1200°C. After steam of oxidation at 1150°C, only the wafers annealed at 1000 and 1200°C showed significant generation of stacking faults. The faults were observed through both chemical etching and transmission electron microscopy. The faults often showed accumulation of impurities believed to be silicon-oxygen complexes. Single-stacking faults were identified as extrinsic, and mechanism of generation of these faults is discussed.

A Statistical Analysis of Telephone Circuit Error Data, P. A. W. Lewis and D. R. Cox, *IEEE Transactions on Communication Technology COM-14*, No. 4, 382-389 (August, 1966).

Berger and Mandelbrot in 1963 proposed a particular renewal process as a model for the occurrence of errors in data transmitted over telephone circuits. Besides the assumed independence between the successive intervals between errors, they assume that the intervals have a Pareto distribution. Their graphical analyses of large amounts of data indicated departures from the model which Mandelbrot proposed in 1964 to account for in an extended model.

Some simple formal statistical procedures are given for analyzing this sort of data, procedures that are not affected by the possibility that the population mean-interval-between-errors is infinite. The departures from independence of intervals noted by Berger and Mandelbrot are formally verified from the analysis of data from a single data transmission test. A separate analysis of another set of data is also made and the results are compared to see what features of the error patterns are general, and what features are particular to different transmission conditions.

In both sets of data analyzed, the outstanding feature detected is the strong positive correlation between successive long intervals between errors. Evidence is also found which indicates that the upper tail of the marginal distribution of intervals between errors does not follow a hyperbolic law.

Stresses in a Layered Rotating Disk, N.-G. Wu and J. H. Ramsey, *International Journal of Mechanical Sciences* **8**, No. 10, 629-639 (October, 1966).

The solution for the state of stress of a symmetrical, three-layer circular disk, rotating about its own axis, with top and bottom layers of the same material and thickness, but differing from the center substrate, to which they are rigidly bonded, is obtained in terms of Fourier-Bessel integrals. The solution applies to that for a solid rotating disk when the elastic properties of the layered materials are the same as those of the substrate. Numerical results are obtained to show the effect of the difference in the elastic properties between the layers and the substrate on the state of existing stresses and are compared with Timoshenko and Goodier's solution for the case of a solid disk.

A Study of Computer-Assisted Instruction in Industrial Training, H. A. Schwartz and R. J. Haskell, Jr., *Journal of Applied Psychology* **50**, No. 5, 360-363 (October, 1966).

The study was undertaken to test the feasibility of remote computer-assisted instruction as an industrial training technique. 79 newly hired electronic technicians received their required training in basic data-processing principles through programmed texts, the standard method used for this presentation. 25 equivalent students received the same training through a keyboard-operated terminal device linked remotely to an IBM 1440 computer system. No significant differences in examination scores were obtained; however, there was a significant saving (approximately 10%) in the time required to complete the course. In an attitude questionnaire administered subsequent to the courses, both groups rated their respective method of instruction as approximately equal to regular classroom techniques in terms of effectiveness and desirability.

A Survey of Diffusion Processes for Fabricating Integrated Circuits, M. C. Duffy and R. P. Gnall, *Semiconductor Products and Solid State Technology* **9**, No. 10, 27-36 (October, 1966).

The present state of the art of diffusion technology is discussed. A basis for the discussion is laid by a review of the diffusion equations. This is followed by a presentation of the requirements at each step involved in the fabrication of integrated circuits. The open and sealed tube techniques are treated. Materials used in solid, liquid, and gas diffusions, and their advantages and disadvantages are dealt with.

Theory of Ion Pairs Coupled by Exchange Interaction, P. Erdős, *Journal of the Physics and Chemistry of Solids* **27**, Nos. 11, 12, 1705-1720 (1966).

The theory of the properties and magnetic behavior of a system of two coupled spins is given. The coupling is of the most general linear exchange type, including asymmetric

and anisotropic contributions. The system shows many properties of a weak ferromagnet when the interaction is predominantly antiferromagnetic. The energy level scheme, static and dynamic susceptibility, magnetic resonance, and the behavior in the classical limit of large spins are studied in detail.

'Thinking Small' With Microanalysis Techniques, W. F. Traber, *Industrial Research* **8**, No. 11, 80-85 (October, 1966).

Most materials analyses problems arising in the electronics industry cannot be solved by conventional microanalytical techniques. In this industry, special instrumental methods are needed to meet requirements imposed by the continuing trend toward miniaturization of components and the small size of the samples typically available for investigation. Attention is focused in this article upon the analysis of very small specimens with a diameter of 1000 microns or less, rather than upon trace elemental analysis of impurities in a large sample. Four major approaches to microanalysis are presented, including (1) microscopy, (2) electron microprobe, (3) x-ray fluorescence and diffraction, and (4) infrared spectrometry.

Tracer Controlled Milling for Short-Run Parts, R. S. Gwynn, *Proceedings of the ASTM Prototype and Short Run Tooling Seminar*, Paper No. MR66-576 (October, 1966).

A system employing a tracer controlled milling machine for machining short run and prototype parts is described. The break-even point for a tracer part is less than one. A highly skilled operator is not necessary.

A general explanation of how the tracer automatically follows lines is given together with the problems involved in maintaining accuracy. Advantages, such as dependability and minimum set-up time, and modifications made to increase productivity are also presented. Particular emphasis is placed on machining irregular shaped parts which comprise the bulk of the model shop's work. The paper is concluded by discussing possible future applications for the system such as computer oriented design.

Tube Flaring to Space Industry Requirements, R. F. Richardson, *Proceedings of the ASTM Prototype and Short-Run Tooling Seminar*, Paper No. MF 66-580 (October, 1966).

The Marshall Space Flight Center (MSFC) Design Standard No. 146 requires tight tolerance controls on all flared tubing used for flight hardware. The flare must be round within 0.0008 and concentric to the tube outside diameter within 0.0003. A minimum surface finish of 16 rms on stainless steel and 32 rms on aluminum tubing is required. The inside angle must be held to 74 +1 and the outside angle held to 66 +1.

International Business Machines Corporation, Federal Systems Division, Huntsville, Alabama, equipped a standard Leonard 3 CP-HD Flaring Machine with special Orbital Adapter Flaring Heads developed by MSFC-Huntsville. The machine bore was held to a close fit and squareness of the spindle to the support bracket maintained within 0.0008. The machine was then equipped with an air cylinder, limit switch, turret locating stops, and a time delay relay. Special control set-up procedures were developed for all sizes of

tubing from 1/8 inch through 1 inch. Using this equipment and the control procedure, small and large production lots of flight tubing were flared to the MSFC Design Standard No. 146, set-up time was considerably reduced, and quality acceptance increased from 60% to 96%.

Tunneling and Collective Excitations in a Microscopic Model of Ferroelectricity,† R. Brout,* K. A. Müller and H. Thomas, *Solid State Communications* 4, No. 10, 507-510 (October, 1966).

Equilibrium properties and collective excitations are studied for a simplified microscopic model of ferroelectricity. The $q = 0$ mode changes in character from a rest-strahl mode at $T = 0$ to a tunnelling mode at $T > T_c$, and shows the correct Cochran behavior in the transition region.

† Partially supported by European Office of Air Research, Grant No. ESOAR. 65-91.

* Faculté des Sciences, Université Libre de Bruxelles.

Ueber die Notwendigkeit einer Fehlerschranken-Arithmetik für Rechenautomaten,* (On the Necessity of Error-bound Arithmetic for Automatic Computation), K. Nickel, *Numerische Mathematik* 9, No. 1, 69-79 (1966).

In extension of Moore's "interval-arithmetic," a new "error bound arithmetic" has been suggested. Each "number" in this new arithmetic consists of a couple of real numbers: the approximate value and an error bound for the given number. It is shown in four examples that for arithmetical and logical reasons such a new arithmetic is necessary for most algorithms. With the aid of this arithmetic it is possible, for example, to find approximate roots of numeric equations and to give error bounds for them. It is also possible to give a criterion for the number of iteration steps without any additional *a priori* knowledge about the solution (such as: stop, if the difference between two consecutive approximation is less than 10^{-18}). In the paper it is suggested that the new algorithm be written in FORTRAN, ALGOL or PL/I.

* Work performed while the author was at the Notre Dame University, Indiana, USA, as guest professor 1964/1965.

The Universal Logic Block (ULB) and Its Application to Logic Design, D. C. Forslund and R. Waxman, *IEEE Conference Record of the 1966 Seventh Annual Symposium on Switching and Automata Theory*, pp. 236-250 (October, 1966).

This paper describes the techniques used to obtain two three-variable universal logic blocks from NAND circuits. The emphasis for one of these ULB's is on minimizing input pins. The techniques used for the three-variable ULB realization are extended to handle realization of a four-variable ULB. Possible compromises to be made in the ULB approach to logic design, and a proposed system application of the ULB, are also reviewed.

Using Silicones in a Low Cost, High Reliability Microcircuit Package, E. Sailer and A. Kennedy, *Electronic Packaging and Production* 6, No. 11, 118-122, 124, 126-127 (November, 1966).

This report describes a low cost, high volume approach to

microcircuit packaging. The modules are capable of withstanding all commercial and most military requirements as effectively as hermetically sealed modules. The package is being used in fabricating microelectronic circuitry for use in the IBM System/360 computers.

X-Ray and Neutron Diffraction Study of the Substitutional Disorder in the Yttrium-Iron-Gallium Garnets, P. Fischer,* W. Hälg,* E. Stoll* and A. Segmüller, *Acta Crystallographica* 21, No. 5, 765-769 (1966).

The distribution of Ga^{3+} and Fe^{3+} ions on the tetrahedral and octahedral sites, (d) and (a), of the yttrium-iron-gallium garnets has been determined from x-ray and neutron diffraction intensity measurements on powder samples by a least-squares refinement. The results of both methods are in good agreement. The preference of the smaller Ga^{3+} ions for the smaller tetrahedral sites (a), already concluded from magnetic measurements, has been confirmed. No deviation from Néel's model of antiferromagnetism could be observed.

* Institut für Nukleartechnik, Eidgenössische Technische Hochschule, Zürich.

Letters

Automatische Spracherkennung, (Automatic Speech Recognition), E. Rothhauser, *Umschau in Wissenschaft und Technik* 66, No. 22, 748 (November 15, 1966).

Dispersion of Acoustical Phonons in Biological Polymers, W. L. Peticolas and M. W. Dowley, *Nature* 212, No. 5060, 400-401 (October 22, 1966).

Fast Domain Wall Motion in Double Nickel-Iron Films, S. Middelhoek and D. Wild, *Nature* 211, No. 5054, 1169 (September 10, 1966).

A Frequency Selective Device Utilizing the Mechanical Resonance of a Silicon Substrate, R. J. Wilfinger, D. S. Chhabra and P. H. Bardell, *Proceedings of the IEEE* 54, No. 11, 1589-1591 (November, 1966).

Nucleation of Epitaxial SiC on Si Surfaces, E. Biedermann and K. Brack, *Journal of Applied Physics* 37, No. 11, 4288-4289 (October, 1966).

On the Transformation to (Phase-Variable) Canonical Form, W. G. Tuel, *IEEE Transactions on Automatic Control* AC-11, No. 3, 607 (July, 1966).

Preparation of GaAs Specimens for Transmission Electron Microscopy, E. Biedermann and K. Brack, *Journal of the Electrochemical Society* 113, No. 10, 1088 (October, 1966).

Signs of the Rotational Magnetic Moment and Electric Dipole Moment of CO, A. D. McLean and M. Yoshimine, *Journal of Chemical Physics* **45**, No. 9, 3467-3469 (November 1, 1966).

Trapezoidal i-v Characteristics of GaAs Tunnel Diodes, B. Agusta and R. P. Nanavati,* *Proceedings of the IEEE* **54**, No. 10, 1498-1499 (October, 1966).

* Syracuse University.