Technical Papers by IBM Authors
Published Recently in Other Journals

An Active Network Equivalent to the Constant-Resistance Lattice with Delay Circuit Applications, R. W. Calfee, *IEEE Transactions on Circuit Theory* **CT-10,** 532-533 (December, 1963).

A circuit combining a phase splitter with a ladder network is demonstrated to have the same transfer function as a constant-resistance lattice. Further, this phase-splitter circuit will realize any given all-pass function with a minimum of reactive elements. A realizable all-pass, nonminimum-phase transfer function is derived which approximates an ideal delay by having a maximally flat envelope delay response. The delay characteristics are described and the network realizations are presented.

Advances in Communications Systems, M. C. Andrews, *Signal* **18,** 32-33 (May, 1964).

Over the past two decades some of the most outstanding developments in technology, in mathematics, and in the physical sciences have dealt with discrete systems. Some have been closely related: digital computer technology, combinatorics and switching theory, for examples. Others, such as quantum electronics, have deeper independent roots in modern science. But regardless of their relationships, origins and causes, the changes are having a profound effect on the communications field.

The specific areas in which the impact of discrete systems appears to promise the greatest advances are: (1) Coding and digital modulation techniques; (2) Design and control of complex communications networks; and (3) Quantum electronic systems in the optical and near optical range.

Advances in Ferrites, Part I, Bernard Schwartz, *Semiconductor Products and Solid State Technology* **7,** 26-30 (June, 1964).

The applications of ferrites are traced historically from their first recorded application in 600 B.C. to the present. The dramatic increase in production and application during the past ten years is discussed, including the use of "square loop" ferrites in computer systems and "high frequency" ferrites in linear applications. A description of improved fabrication technology, with a resultant higher quality and lower cost, suggests a continued growth in this field.

Algorithm for a Gear-Train Problem, H. G. ApSimon, *IBM Systems Journal* **3,** No. 1, 95-103 (1964).

An algorithm for the numeric solution of a common gear-train problem is developed. A number-theory approach, relatively novel in current engineering practice, is used in deriving the algorithm. The form of the algorithm obtained is suitable for programming on a digital computer.

Approximate Relativistic Correction for 10-18 Electrons in Atoms, Enrico Clementi, *Journal of Molecular Spectroscopy* **12,** 18 (January, 1964).

The eigenvalues for the relativistic Hamiltonians for the isoelectronic series with 10 to 18 electrons and with atomic number Z from 10 to 36 were obtained by perturbation theory from the computed Hartree-Fock functions. To the computed relativistic energies I have added an empirical estimate of the spin-orbit energy, making use of the experimental spin-orbit splitting in the atomic spectra. The data we have obtained shows that the contribution of the relativistic energy to the total energy is very important even for atomic systems which are well described in the L-S coupling scheme.

Asymptotic Stability of a Time-Delayed Diffusion System, P. K. C. Wang, *Journal of Applied Mechanics* **30,** 500-504 (December, 1963).

This paper discusses the asymptotic stability of the equilibrium states of a nonlinear diffusion system with time delays. It is assumed that the system is describable by a partial differential-difference equation of the form:

$$\frac{\partial u(t, X)}{\partial t} = \mathcal{L}u(t, X)$$
$$+ f(t, X), u(t, X), u(t - T, X), \cdots,$$
$$\frac{\partial u(t, X)}{\partial x_i}, \cdots, \frac{\partial u(t - T, X)}{\partial x_i}, \cdots$$
$$i = 1, \cdots, M$$

where $\mathcal{L}$ is a linear operator uniformly elliptic in X defined for all $X \epsilon \Omega \ldots$ a bounded, open M-dimensional spatial domain; f is a specified function of its arguments. In the development of this paper, the physical origin of the foregoing equation is discussed briefly. Then, conditions for asymptotic stability of the trivial solution are derived via an extended Lyapunov's direct method. Specific results are given for a simple one-dimensional linear heat equation with time-delayed arguments.

Automatic Design of Optimal Structures, W. S. Dorn, R. E. Gomory, and H. J. Greenberg, *Journal de Mécanique* **3,** 25-52 (March, 1964).

The design of optimal structures is reduced to the selection, by mathematical programming, of a structure which optimizes a criterion of merit over a large, well-defined class of admissible structures. For the case of pin-jointed structures, this approach is carried through in detail with an analysis of the corresponding mathematical optimization

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problem. In this approach to design not only the sizes of the members but their locations as well are determined for the optimal structure. Some properties of optimal structures are derived and discussed and the ideas are illustrated by the design of a series of optimal bridge trusses.

Business Simulator Sharpens Decision Makers, S. H. Brounstein, *Aerospace Management* **7,** 42-45 (April, 1964).

How do managers sharpen their decision-making ability? The same way as any type of ability is developed: mostly through practice. In time, experience builds the capacity to intuitively choose the "right" course of action—without overt consideration of all the variables involved. But in the intensely competitive climate of the aerospace industry the price of experience comes high, as profit margins come low. The hazards of financial loss make the selection of decision makers a "go-slow" process. There may be a way around it—simulation. Just as the industry uses environmental tests to enhance equipment reliability, it could use business simulators to sharpen managers.

Cavitation in Valve-Controlled Hydraulic Actuators, P. K. C. Wang and J. T. S. Ma, *Journal of Applied Mechanics* **30,** 537-546 (December, 1963).

Results of analytical and experimental studies of cavitation in valve-controlled hydraulic actuators under various dynamic conditions are presented. The analytical work consists of deriving approximate critical cavitation conditions for various operating modes. The experimental investigation includes both a high-speed photographic study of cavity formation and tests to check the validity of the derived cavitation conditions. Close agreement between analytical and experimental results was obtained. The mechanisms governing cavity formation and cavitation effects are discussed qualitatively.

Centralization: Good or Bad? H. G. Kolsky, *Journal of Data Management* **1,** 14-19 (November, 1963). A condensation of this article appeared in *The Executive: The Digest of Current Literature for Top Management* **7,** No. 9, 32-35 (February, 1964).

During the past decade one of the strong trends in data processing has been that toward larger and more centralized systems. This has been particularly necessary in the "real-time" systems such as radar-based air warning systems or airline reservation systems. The same trend has been very strong in other non-real-time computing applications. In some respects these systems can be more complex theoretically than the single large real-time problems, because of the properties of the unrelated or partly related problems brought together by the consolidation process.

There have been many outstanding successes along the road to centralization but there have been many cases where the results have been less than was expected. As systems have gotten larger, faster, and more expensive, the rumblings of dissatisfaction have grown louder.

Product planners concerned with tomorrow's computer systems must seriously consider whether or not these opinions represent the start of a real trend back toward the decentralization of function.

A Character Computer for High-Level Language Interpretation, J. E. Meggitt, *IBM Systems Journal* **3,** No. 1, 68-78 (1964).

This paper discusses the design of an experimental character-processing computer for the interpretive execution of higher-level language programs. The design specifies a 100-nsec instruction cycle for the microprogram instructions stored in a read-only memory, a fast memory for intermediate "scratch pad" computation, and input/output through a conventional computer coupled to a 2-nsec main memory. The object program to be interpreted is stored in the main memory. As a part of the research, the design was simulated on standard equipment.

Computed Potential Curve and Spectroscopic Constants for Beryllium Oxide Ground State in Molecular Orbital Approximation, M. Yoshimine, *Journal of Chemical Physics* **40,** 2970-2976 (May 15, 1964).

A set of single configuration self-consistent field molecular orbital wave functions for the $^1\Sigma$ ground state of BeO is presented. A potential curve which is approximately 0.3 eV above the Hartree-Fock potential curve for the molecule is presented, together with the results of a spectroscopic analysis on it. A further calculation at a nuclear separation corresponding to the minimum in the computed potential curve, which gives a total molecular energy of -89.44787 a.u., is presented. This is probably less than 0.1 eV above the Hartree-Fock limit. The mean value of the dipole moment of the molecule computed with this wave function is 7.29 Debyes. A comprehensive selection is given of other mean values computed at points along the potential curve, and for the more accurate calculation at the minimum in the curve.

A Concordance Generator, K. F. Scharfenberg, P. H. Smith, Jr., and R. D. Villani, *IBM Systems Journal* **3,** No. 1, 104-111 (1964).

The structural design of a general purpose program for concordance preparation is described. Options in the input format, the operating mode, and the output edit provide wide flexibility in organizing data in a form convenient for many analytical purposes. An experimental program was written, and some results obtained in testing the program are included.

The Consistency of Human Judgments of Relevance, A. Resnick and T. R. Savage,* *American Documentation* **15,** 93-95 (April, 1964).

A comparison of the ability of humans to consistently judge the relevance of documents to their general interests from bases of citations, abstracts, keywords, and total text was made under controlled experimental conditions. The results showed that (1) humans are able to make such judgments consistently, and (2) the consistency of the judgment is independent of the particular base from which it is made. Apparent inconsistency arising from judgments made on the basis of abstracts remains unexplained. This experiment, as well as others concerned with human evaluations of text material, leave unexplored the basic problem of providing a metric scale on which such evaluations can be measured.

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Coupled Biaxial Films, Hsu Chang, *Journal of Applied Physics* **35,** No. 3 (Part 2), 770-771 (March, 1964).

Biaxial films were proposed by Pugh for storage elements of a noncoincident memory. In this paper, it is demonstrated that two identical uniaxial films with their easy axes at a right angle and driven by interposed striplines that carry currents also exhibit biaxial properties.

Cross-Field Forward Wave Amplifiers Offer New Advantages for Radar Systems, L. E. Brown, *The Microwave Journal* **7,** 66-71 (May, 1964).

The newer radar system requirements have to a large degree dictated that amplifier chains be used rather than power oscillators, as was previously the case. The amplifier chain approach is dictated in general because of good phase frequency stability and/or wide bandwidth requirements. In addition to these requirements, high efficiency and low operating potential are also becoming of more importance for airborne applications and for certain ground radar applications. It is the intent of this article to point out the advantages of the cross-field forward wave amplifier for such systems, as well as to point out other inherent, interesting features of the device itself.

The Cubic Field Splitting of the Ground State of Eu^{2+} in Alkaline Earth Oxides, J. Overmeyer and R. J. Gambino, *Physics Letters* **9,** 108 (April 1, 1964).

It is shown that for the Eu^{2+} ion in alkaline earth oxide lattices, the sign of the cubic field splitting parameter b_4 reverses as function of lattice constant. This behavior can not be explained by present theories of the splitting of the ^8S ground state.

Cylindrical Film Memory Device Characteristics, C. J. Townsend and P. E. Fox, *IEEE Transactions on Electronic Computers* **EC-13,** 261-268 (June, 1964).

This device is a single-bit storage element consisting of a 100-mil piece of 25-mil glass tubing with a 6000-Å nickel-iron film coating. This paper describes those properties of the device which pertain to its operation in high-speed linear-word-selection memories.

The device is used in the orthogonal mode, with an axial word field. The circumferential bit (digit) field coincides with the easy axis of magnetization, which is induced by a dc field during deposition of the film. The closed magnetic path avoids the limitation on thickness which exists in open-path elements. Thus, the cylindrical device can be designed to have large signals over a wide range of cycle times.

Experimental data are included on the following characteristics: optimum device and drive-conductor geometry, effect on signals of one-zero duty cycle, sensitivity of stored information to disturbance by bit and stray word fields, and drive-current requirements. The test specification developed from these data includes allowances for drive current tolerances, device temperature coefficient and information duty cycle. Sufficient quantities have been tested to this specification to show that this device is a workable, reproducible memory element.

Delay Between Current Pulse and Light Emission of a GaAs Injector Laser, K. Konnerth and C. Lanza, *Applied Physics Letters* **4,** 120-121 (April 1, 1964).

Measurements have been made of the transient characteristics of light from a gallium arsenide injection laser at 77°K. A delay was noted between the application of the current pulse and the emission of light. The spontaneous recombination lifetime, as found from a simple model for the delay mechanism, is about 2 nsec. The rise time of the stimulated light was less than 0.2 nsec, indicating the possibility of modulation into the gigacycle per sec region.

A Description of the SIMSCRIPT Language,† B. Dimsdale and H. M. Markowitz, *IBM Systems Journal* **3,** No. 1, 57-67 (1964).

This paper describes the SIMSCRIPT system simulation language and the philosophy of system structure on which it is based. Application of the language to programming both discrete and continuous models is indicated and illustrated with examples. SIMSCRIPT processing is described and statistics regarding operating characteristics are given.

† The SIMSCRIPT system was developed at the RAND Corporation by a group including the second author.

Design of an Integrated Programming and Operating System: Part VI—Implementation on the 7040/44 Data Processing System, B. White and J. Trimble, *IBM Systems Journal* **3,** No. 1, 79-94 (1964).

This paper compares factors governing the implementation of the IBSYS/IBJOB operating systems for the 7090/94 and 7040/44 processing systems. Operation of the 7040/44 system's monitors and the means of communication between them are described. Familiarity with the content of the previous five papers of this series is assumed, though for the most part, the paper can be read independently.

Development and Present Status of Data Processing, I. A. Schulz, *Humanismus und Technik* **9,** No. 2, 56-65 (1964).

The author reports on historical development of data processing. He distinguishes between four stages: *First stage of development:* Mechanization of the writing and calculating process (typewriters and desk calculators) and coupling of the mechanized writing process with the mechanized calculating process in a single automatic accounting machine. *Second stage of development:* The punched card technique, which is not considered a special technology but investigated from an organizational point of view. *Third stage of development:* The electronic calculating machine. *Fourth stage of development:* The development of the electronic calculating machine towards data processing systems that are within the range of electronic data processing.

The author investigates the question: To what extent are electronic data processing systems to be employed in German High Schools and universities, for teaching as well as for research? The result reveals that there is a large still unexplored sphere of activity.

Differential Amplifier Based on the Feedback Pair,
D. M. Taub, *Proc. I.E.E.* **3**, 917-920 (May, 1964).

A transistorized differential amplifier based on the feedback pair is described. A preliminary analysis is given and the results are compared with measurements over the frequency range 15kc/sec to 30Mc/sec. At the center of the band the common-mode rejection ratio was 270:1. The effects of resistor tolerances and the accurate balancing of the two input impedances are discussed.

Diffusion of Sulfur, Selenium, and Tellurium in Gallium Arsenide, T. H. Yeh, *Journal of the Electrochemical Society* **3**, 253-255 (February, 1964).

A major problem in the diffusion of n-type impurities into p-type gallium arsenide has been the compound formation on the surface of the GaAs. By developing a diffusion technique that prevents such a compound formation and allows the n-type impurity to diffuse into p-type GaAs to form an n-p junction, one of the major difficulties in making a mesa or planar-type double-diffused pnp GaAs transistor would be removed.

The author has found that silicon monoxide can be used as a masking material against the diffusion of Cd and Zn in GaAs. Further studies show that a thin layer of SiO evaporated onto the surface of p-type GaAs wafer prevents the formation of Ga_2S_3, Ga_2Se_3, and Ga_2Te_3 on the wafer's surface during the diffusion of sulfur, selenium, and tellurium into GaAs. This process allows each n-type impurity to diffuse into p-type GaAs and to form an n-p junction.

Dissociation Energy of the CH Radical,[†] R. G. Brewer and F. L. Kester,[*] *Journal of Chemical Physics* **40**, 812-817 (February 1, 1964).

The 4300-Å band of CH has been observed in emission using a carbon furnace above 2400°C which contains 1atm of H_2 gas. From the CH emission intensity variation with temperature and a thermochemical cycle involving the heat of sublimation of graphite, a CH dissociation energy of 80 ± 5 kcal (3.5 ± 0.2 eV) is derived for the $^2\Pi$ state. The close agreement between this value and that obtained previously from a CH rotational predissociation, establishes not only that the CH dissociation energy is 80.0 kcal (3.47 eV) but further confirms that the heat of sublimation of graphite is 169.58 kcal. For this $^2\Pi$ state the atomic dissociation products are identified experimentally as ground-state $C(^3P)$ and $H(^2S)$ atoms. In addition, for the process $C_2H_2 = 2CH$ an acetylene dissociation energy of 228.1 kcal is derived.

Doppler-Shifted Cyclotron Resonance and Alfvén Wave Damping in Bismuth, Jordan Kirsch,[*] *The Physical Review* **133**, A1390-A1398 (March 2, 1964).

At large magnetic fields the transmission of microwaves through bismuth is essentially undamped and can be regarded as Alfvén waves in a solid-state plasma. A large kink has been observed in the 9-Gc/sec microwave absorption of bismuth as a perpendicularly applied magnetic field was varied through 1500 G. These experiments have been performed at 2°K with a field parallel to the binary axis. The kink has been identified as a Doppler-shifted cyclotron reso-

nance whose position is approximately given by the formula $\omega = \omega_c - \nu_{0x}k_A$ where ν_{0x} is the maximum Fermi velocity along the field and k_A is the wave number of the microwaves in the metal. The kink marks the onset of Alfvén wave behavior where the surface resistance is proportional to the magnetic field. A calculation of the surface resistance using a nonlocal theory applied to a three-carrier model yields a variation with field which shows both the Doppler-shifted peak and the high-field linear region which can be extrapolated back trough the origin. The frequency dependence of the peak derived from this calculation has been verified experimentally. By tilting the field slightly away from the perpendicular it was shown that the peak was a Doppler shift in the cyclotron resonance of the holes rather than of the electrons. This experiment provides a very accurate measure of the ratio of the Fermi velocity to the Alfvén velocity and thus, knowing one, the other may be determined. For this reason, the Alfvén velocity in the same crystals was independently measured using an interference technique. Oscillations with a constant period in $1/H$ were observed in the reflected power as the applied magnetic field was varied. From the period of oscillation and the thickness of the crystal, the velocity was deduced. The work also provides a graphic measure of the sharpness of the Fermi surface.

Dynamics of Externally-Pressurized Sliders with Incompressible and Compressible Films, L. Licht and J. W. Cooley, *ASME Transations, Journal of Basic Engineering* **86**, Series D, 396-404 (June, 1964).

The ability of an externally-pressurized slider to follow faithfully the runout, or waviness, of a rotating disk or drum is investigated. The response and stability of the slider are considered in terms of small displacements from the equilibrium gap width. The first part of the analysis treats the case of an incompressible lubricant. The dynamic Reynolds equation is integrated with respect to the space coordinate and the relative displacement of the slider is described by a nonlinear, second-order differential equation. Perturbation solutions are obtained, which permit successive approximations of small deviations from the equilibrium gap width. The second part of the analysis treats the case of a gaseous lubricant. A quasi-static variation of the pressure field is assumed and the problem is stated in terms of lumped parameters. The continuity equation and the equation of motion are linearized, yielding a third-order differential equation for small displacements of the slider from the equilibrium gap width. Results are discussed, with particular reference to the effect of the squeeze number, σ, on the response of the slider.

Effect of Correlation on the Ferromagnetism of Transition Metals, M. C. Gutzwiller, *The Physical Review* **134**, A923-A941 (May 18, 1964).

The wave function for the electrons is investigated when a set of narrow bands (valence states) has its energies within a wide band (conduction states). The valence states are linear combinations of localized states which are attached to each lattice site. The intra-atomic Coulomb and exchange integrals for the localized states are much larger than the bandwidths of the valence states. Some of the narrow bands are neither completely empty nor completely filled. The wave function is therefore expected to be correlated, because *it is disadvantageous for the electrons to crowd into*

the same lattice site, or take up some configuration contrary to Hund's rule. This correlation is important in transition metals, where it is considered to be the cause of ferromagnetism. The correlated wave function is obtained by applying to the uncorrelated antisymmetrized product of Bloch functions an operator that provides each configuration of detail for the case of few particles (electrons or holes) in the narrow bands with the help of a diagram analysis. The localized orbits of different lattice sites do not have to be orthogonal to one another, and the computational rules are actually simplified thereby. The example of a twofold degenerate band such as the upper part of the $3d$ band in Ni is treated, and the conditions for the occurrence of ferromagnetism are stated in the case of few $3d$ holes per lattice site.

Effect of Electron Concentration on Magnetic Exchange Interactions in Rare-Earth Chalcogenides, F. Holtzberg, T. R. McGuire,* S. Methfessel, and J. C. Suits, *Physical Review Letters* **13,** 18-21 (July 6, 1964).

The relationship of magnetic Curie temperature and electrical conductivity has been studied in solid solutions between semiconducting EuSe and metallic GdSe. With increasing GdSe concentration the electrical conductivity increases 12 orders of magnitude and the Curie temperature goes through a maximum to negative values. This behavior is attributed to magnetic interaction via conduction electrons in $5d$-orbitals.

The Effects of Particle Orientation on Interactions in Magnetic Recording Tapes, R. A. Cummings* and C. D. Mee, *Proceedings of the INTERMAG Conference* **T-159,** 6-3-1 to 6-3-4 (1964).

High frequency ac bias recording is a modification of the anhysteretic magnetization process. This process is analyzed for magnetic tapes consisting of assemblies of elongated single-domain magnetic particles taking account of the relative orientations between the axes of the particles and the magnetic fields acting on them. The angular variation of initial anhysteretic susceptibility and the anhysteretic magnetization curves are calculated for oriented particle arrays giving good agreement with measurements on some recording tapes.

* Singermetrics, South Norwalk, Connecticut.

Effect of Surface Scattering on Electron Mobility in an Inversion Layer on p-Type Silicon, F. Fang and S. Triebwasser, *Applied Physics Letters* **4,** 145-147 (April 15, 1964).

The electron mobility in an inversion layer on p-type silicon was measured in insulating gate field effect transistors. The transverse electric field dependence of the surface mobility is interpreted in terms of the electron surface scattering in a self-consistent field of a uniformly distributed charge layer in the channel.

Effect of Temperature and Environment on the Structure of Thin Single-Crystal Nickel Films, E. I. Alessandrini, *Journal of Applied Physics* **35,** 1606-1610 (May, 1964).

Annealing experiments under varying conditions of temperature and pressure were observed in the electron-diffraction instrument on epitaxially grown single-crystal Ni films mounted on 200 mesh Ni grids. Patterns from as-grown films showed {100} oriented Ni single crystal films with faulting resulting in streaking in all [111] directions. These faults were removed by annealing above 500°C for one hour at pressures lower than 1×10^{-5}. At an annealing temperature of 400°C and vacuum pressures controlled by leaking air into the diffraction unit the following results were observed. At a pressure of 1×10^{-5}, the film remained single crystal; as the pressure was increased to 5×10^{-5}, Ni plus the previously reported metastable Ni + O phase appeared. A new complex two-phase structure of Ni and Ni + O occurred at 7×10^{-5}, and at 1×10^{-4} only the equilibrium NiO phase was observed. At higher temperatures and constant pressure of 3×10^{-5}, there was an absence of any transition phases. Experiments were repeated with argon under similar conditions and no structural changes were observed. The changes are attributed to an increasing oxygen content in the film during annealing conditions and are interpreted to be dependent upon a complex type of precipitation in which the oxygen fault interpretation postulated by Heidenreich et al. may be the first stage in the precipitation of NiO in the film.

Effective Fields in Cubic Lattices with Extended Charges, R. F. Guertin* and Frank Stern, *The Physical Review* **134,** A427-A433 (April 20, 1964).

The effective field in cubic lattices is calculated for a simple model in which the electrons have spatially extended charge distributions. For simple cubic, body-centered cubic, and face-centered cubic lattices in which the electrons in each primitive cell are infinitesimally displaced from rigid cores, the effective field can be written $E_{eff} = E + (4\pi/3)\gamma P$, where E is the average electric field in the medium, and P is the polarization. The coefficient varies from zero for very extended electronic charge distributions to 1 for the limit of point charges. Values of γ for Gaussian distributions of intermediate width are given. Effective fields are also calculated for the rocksalt, zincblende, and cesium chloride structures. These results involve an additional coefficient γ', which also varies between 0 and 1. For moderate overlaps between electronic charge distributions of next-nearest neighbors the effective fields differ appreciably from the Lorentz field $E + (4\pi/3)P$.

* Sloane Physics Laboratory, Yale University.

Electronic Structure of N₂, CO, and BF, R. K. Nesbet, *The Journal of Chemical Physics* **40,** 3619-3633 (June 15, 1964.)

Approximate Hartree-Fock calculations are reported for the $^1\Sigma^+$ ground states of the isoelectronic 14-electron molecules N₂, CO, and BF. In each case calculations have been carried out at five internuclear distances, chosen as the roots of an appropriately scaled Chebyshev polynomial, in order to facilitate interpolation. Electronic kinetic and potential energies, mean values of $1/r$ about each nucleus, and mean values of z, $3z^2-r^2$, and r^2 are obtained at each internuclear distance. The production runs used basis sets consisting of

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of two exponential functions for each occupied atomic orbital plus d_σ and d_π orbitals on each atom, combined to form molecular orbitals by the matrix Hartree-Fock (SCF-LCAO) method. It was found that $4f_\sigma$ and $4f_\pi$ orbitals, with optimized exponents, contribute 0.3 eV to the dissociation energy of N_2, but these orbitals were not included in the production runs. The effect on CO and BF of $4f$ orbitals is expected to be somewhat smaller. Various spectroscopic quantities (r_e, ω_e, $x_e\omega_e$, B_e) and electric dipole and quadrupole moments are computed and are in general qualitative agreement with experimental values. The polarity of the dipole moment of CO, while not definitely determined by present calculations, is indicated to be C^+O^-. The experimental determination of this polarity is discussed critically, and it is concluded that a definitive determination of the sign is not possible from microwave data, which had previously been interpreted to imply the polarity C^-O^+. Thus an independent redetermination of this sign is required. Dissociation energies are discussed in connection with an empirical estimate of the net correlation energy contribution to molecular binding.

Electron Spinwave Scattering in Rare Earth Metals, B. Lüthi and F. Grüneisen, *Physics Letters* 10, 161-162 (June 1, 1964).

Experimental results are presented showing the change of electrical resistivity in high magnetic fields at low temperatures for some rare earth metals. These results enable, in principle, the direct determination of that part of the zero-field electrical resistivity which comes from electron spinwave scattering. This method works well for metals with small crystalline anisotropy energies, such as gadolinium. In this metal it would be difficult to determine that part of the resistivity from the temperature dependence of the total resistivity alone, which follows a $T^{3.7}$ law. The magnetic field dependence of this exchange scattering resistance is also discussed.

Experimental Comparison of Two Keyboard Interlock Systems, F. J. Minor, *Journal of Engineering Psychology* 3, 9-15 (January, 1964).

This study compared typists' performance under two conditions of keyboard interlock with an electric typewriter. Interlocks are typically used in special-purpose electric typewriters which prepare machine readable documents such as punched cards or punched paper tape. In principle, the interlock is designed to limit the speed of manual keying to the maximum speed of the slowest component which must serially accept the keyed information during the typing process. The results of this study demonstrate that typing speed and keying errors can be influenced by interlock systems. It does not justify generalizing that longer interdigital interlock time always generates greater accuracy.

Experimental Investigation of Speech Rate and Message Verification Procedures, F. J. Minor, *Ergonomics* 7, 205-210 (April, 1964).

Speech output devices are currently in development stages in the computer industry. These devices will permit an operator to perform an inquiry to a computer and receive a spoken response message. This study investigated speech rates and verification procedures with a simulated speech output device. Operators were required to write an alphanumeric response message during message transmission. Three speech rates were investigated: 45, 60 and 75 characters per minute (cpm). The results showed the 60 cpm to be the most favorable in terms of operator accuracy and preference. Three procedures for verifying response messages were investigated: Required Verification, Optional Verification, and No Verification. The results showed the Optional Verification method to be the most efficient.

Fact Retrieval and Deductive Question-Answering Information Retrieval Systems, W. S. Cooper, *Journal of the Association for Computing Machinery* 11, 117-137 (April, 1964).

Information retrieval systems may be classified as either document retrieval systems or fact retrieval systems. It is contended that at least some of the latter will require the capability for performing logical deductions among natural language sentences. The problem of developing systems of logical inference for natural languages is discussed, and an example of such an analysis for a sub-language of English is presented. An experimental fact retrieval system which incorporates this analysis has been programmed for the IBM 7090 computer, and its main algorithms are stated.

Ferromagnetism in Rare-Earth Group V_A and VI_A Compounds with Th_3P_4 Structure, F. Holtzberg, T. R. McGuire, S. Methfessel, and J. C. Suits, *Journal of Applied Physics* 35, No. 3 (Part 2), 1033-1038 (March, 1964).

The bcc structure $\overline{1}43d\text{-}T_d^6$ (Th_3P_4) occurs as a defect structure in 2:3 compounds of rare-earth elements with S, Se, and Te, or as an inverted structure in 4:3 compounds with group V_A elements. Gd_4Bi_3 and Gd_4Sb_3 are both ferromagnetic. The Curie temperature T_c varies in the solid solution system $Gd_4Sb_3\text{-}Gd_4Bi_3$ with composition from 260 to 340°K. The semiconducting compound Gd_2Se_3 has been found to be antiferromagnetic below $T_N = 6$°K. Solution of Gd in the holes of the defect Th_3P_4 structure decreases the electrical resistivity without a measurable variation of lattice constant ($a_0 = 8.718$ Å). With increasing conductivity the material changes from antiferromagnetic to ferromagnetic ($T_c = 80$°K). The relation between Curie temperature and electrical resistivity has been established.

Fluorescence and Energy Transfer in Y_2O_3:Eu^{3+}, J. D. Axe and P. F. Weller, *Journal of Chemical Physics* 40, 3066-3069 (May 15, 1964).

Experimental evidence for nonradiative resonant energy transfer between Eu^{3+} and other trivalent rare-earth ions in Y_2O_3 is presented and possible interaction mechanisms are examined. It is concluded that coupling via overlap of near zone quadrupolar fields is important. Measurements on the transient behavior of the Eu^{3+} fluorescence are also discussed.

For Repeated High Loads, Try Press-Fit Studs, J. H. Stroebel, T. L. Johnson, *Product Engineering* 35, 99-103 (May 25, 1964).

A comparison of fatigue strengths for typical copper brazed and press-fit studs is made. A method is presented for analytically determining the comparative strengths and factors of safety for various stud diameters up to 0.375 in. for varying loads from 50 lb to 200 lb, when fatigue is a consideration.

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Free Boundary Problems with Regions of Growth and Decay—An Analysis of Heat Transfer in the Dip Soldering Process, I. Tadjbakhsh and W. Liniger, *Quarterly Journal of Mechanics and Applied Mathematics* **17,** (Part 2), 141-155 (1964).

A method is developed for handling the free boundary problems that arise when phase changes produce regions growing and decaying in size during the same process. Perturbation and finite difference techniques are established which provide information valid for all time. The particular perturbation procedure can be extended to other free boundary problems in which the amplitude of the boundary remains finite or in which the boundary returns. With these methods the heat transfer aspects of the dip soldering process are investigated. The results of the solutions are compared with experimental measurements.

A General Purpose Digital Simulator and Examples of its Application: Part I—Description of the Simulator, R. Efron and G. Gordon, *IBM Systems Journal* **3,** No. 1, 22-34 (1964).

This part of the paper describes GPSS II, a general purpose digital systems simulation program based on a block diagram language. The program is a result of incorporating improvements dictated by extensive experience in the application of an earlier version. However, this article is self-contained. Development and application of the language are illustrated by means of an example.

A General Purpose Digital Simulator and Examples of its Application: Part II—Simulation of a Telephone Intercept System, C. R. Velasco, *IBM Systems Journal* **3,** No. 1, 35-40 (1964).

The simulator is employed to determine a set of parameters defining a telephone "intercept" system with appropriate characteristics. The intercept system is automatic and involves standard data processing components—data exchange, disk files, and audio response units.

A General Purpose Digital Simulator and Examples of its Application: Part III—Digital Simulation of Urban Traffic, A. M. Blum, *IBM Systems Journal* **3,** No. 1, 41-50 (1964).

This part discusses use of the simulator for problems associated with urban traffic studies. Included are simulation methods for intersections and networks, vehicular characteristics and input, and the network traffic control mechanism. The general purpose simulator is used to write a general traffic program which is used with data cards specifying the geometry, signal settings, statistical distributions, and other details of the particular network selected for simulation.

A General Purpose Digital Simulator and Examples of its Application: Part IV—Simulation of an Integrated Steel Mill, D. F. Boyd, H. S. Krasnow, and A. C. R. Petit, *IBM Systems Journal* **3,** No. 1, 51-56 (1964).

An approach to the simulation of an industrial enterprise for the purpose of evaluating alternative decision algorithms is illustrated. As an example, simulation of an integrated steel mill is discussed in sufficient detail to display programming techniques.

Harmonic Distortion in Variable-Transmittance Sinusoidal Test Objects, M. E. Rabedeau and A. D. Bates, *Photographic Science and Engineering* **8,** 149-152 (May/June, 1964).

Variable-transmittance sinusoidal test objects produced by a photographic process may contain harmonic distortion as a result of the nonideal characteristic curves of the photographic materials. A simple way of computing these distortions is given.

Heat Pulses in Quartz and Sapphire at Low Temperatures, R. J. von Gutfeld and A. H. Nethercot, Jr., *Physical Review Letters* **12,** 641-644 (June 8, 1964).

The propagation of heat pulses approximately 0.1 μsec long has been studied in quartz and sapphire. An appreciable fraction of the energy is found to travel in essentially uninterrupted direct line-of-sight propagation at the acoustic "wave" (energy) velocities. The remainder of the energy is found to be scattered primarily by a small angle scattering process. This scattering is also found to be relatively independent of the phonon frequency.

Hyperfine Structure Separation and Magnetic Moment of K^{42},[†] J. M. Khan,[*] N. Braslau, and G. O. Brink,[**] *The Physical Review* **134,** A45-A47, (April 6, 1964).

The atomic beam flop-in magnetic-resonance method has been employed to measure the hyperfine structure separation $\Delta\nu$ and the nuclear magnetic moment μ_I in the $^2S_{1/2}$ electronic ground state of the 12.4-h potassium-42. The results are: $\Delta\nu(K^{42}) = 1258.877(4)$ Mc/sec; $\mu_I(K^{42}) = -1.1395(30)$ nuclear magnetons (diamagnetic correction not included). With these values estimates of the hyperfine structure anomaly with respect to other potassium isotopes can be made: $^{39}\Delta^{42} = -0.25(25)\%$, $^{41}\Delta^{42} = +0.42(25)\%$.

Interaction of Paired Bases in Polynucleotides, R. K. Nesbet, *Biopolymers Symposia,* No. 1, 129-139 (1964).

Intensity changes in absorption spectra (hypochromism or hyperchromism) have been shown to result from the complex, frequency dependent, induced polarizability of interacting molecules. This theory, in a form not depending on the usual dipole approximation, is applied to the base pairs adenine-thymine and quanine-cytosine of DNA. Self-consistent molecular orbital calculations are carried out for each of the individual base molecules and singlet excited states are approximated by a 6×6 configuration interaction calculation. Integrals needed in the hypochromism calculations are estimated in analogy to the semi-empirical formalism of Pariser, Parr, and Pople, used here for the molecular orbital calculations. Large hyperchromic effects (up to 40%) are found for single base pairs, no account being taken of the interaction with other bases in a polynucleotide or with solvent molecules. This result differs qualitatively from earlier results obtained by Tinoco, Rhodes, and DeVoe, who used a formalism that omits the resonance interaction proposed by Bolton and Weiss and that necessarily overestimates the off-resonance effect for overlapping but nonidentical absorption bands. Sufficiently far off resonance the present formalism becomes equivalent to that of Tinoco, Rhodes, and DeVoe.

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Interferometric Measurements of Linewidth and Noise in GaAs Lasers, J. A. Armstrong and A. W. Smith, *Applied Physics Letters* **4**, 196 (June, 1964).

We have made interferometric measurements of the output of single mode CW gallium arsenide lasers and have found the full line width at half power to be less than 50 Mc/sec (0.0017 cm⁻¹) for 1 milliwatt of coherent power in the mode. We have also carried out measurements of the intensity fluctuations (i.e., the noise) of the coherent output and find the noise power to be at least some 10^6 times smaller than would accompany black-body radiation of the same spectral power density.

Intervalley Scattering by Donor Ions in Germanium, P. J. Price and R. L. Hartman, *The Journal of Physics and Chemistry* **25**, 567-570 (June, 1964).

A contribution to the intervalley scattering rate in n-germanium is the direct transition induced by the donor-ion potential, U. The scattering rate for this process is calculated to lowest order in U, using the relation between the intervalley matrix elements of U and the singlet-triplet splitting of the donor ground state. The predicted scattering rate for arsenic agrees with the experimental results of Weinreich, Sanders, and White for the intervalley scattering due to donor ions, above 40°K.

Introduction to the Molecular Viscoelastic Theory of Polymers and Its Applications, Warner L. Peticolas, *Rubber Chemistry* **36**, 1422-1458 (December, 1963).

This paper presents a review of the mathematical molecular theory of polymer viscoelasticity and gives a number of experimental verifications. It also shows how the theory can be used to learn something about molecular weight and molecular weight distribution and branching in polymers from rheological measurements.

Lifetime of the First ¹P₁ State of Zinc, Calcium, and Strontium, Allen Lurio, R. L. DeZafra,* and R. J. Goshen,** *The Physical Review* **134**, A1198-A1203 (June 1, 1964).

The lifetime of the first excited $^1P_1$ state of zinc, calcium, and strontium has been measured by the zero-field level-crossing technique. The results are: zinc, $\tau(^1P_1) = 1.41 \pm 0.04 \times 10^{-9}$ sec, calcium, $\tau(^1P_1) = 4.48 \pm 0.15 \times 10^{-9}$ sec, and strontium, $\tau(^1P_1) = 4.97 \pm 0.15 \times 10^{-9}$ sec. The results are compared to earlier experimental results and also to theoretical predictions. It is found that our results are in excellent agreement with the Bates and Damgaard Coulomb approximation method for estimating the oscillator strengths.

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Lifetime and hfs of the (5s5p)¹P₁ State of Cadmium, Allen Lurio and Robert Novick,* *The Physical Review* **134**, A608-A614 (May 4, 1964).

The lifetime and hfs of the $(5s5p)^1P_1$ state of cadmium have been measured by the level-crossing technique. Coherence narrowing of the zero-field level-crossing (Hanle effect) signal has been observed and found to be in agreement with Barrat's theory. The lifetime obtained from two independent experiments is $1.66 \pm 0.05 \times 10^{-9}$ sec. This value is considerably smaller than earlier values. The ratio of this lifetime to the $(5s5p)^3P_1$ state lifetime obtained by Byron et al. is $6.95 \pm 0.30 \times 10^{-4}$ in good agreement with the results of Filippov and Kuhn. The dipole interaction constant $A(^1P_1)$ obtained for Cd^{111} is $|A(^1P_1)| = 186 \pm 4$ Mc/sec. This result is compared to that obtained by Heydenburg. Using the present lifetime measurement and the known hfs intervals for the $^3P_2$ and $^3P_1$ states we find for the theoretical value of this constant $A(^1P_1) = -152 \pm 25$ Mc/sec. The single electron hfs constants for the $(5s5p)$ configuration are tabulated.

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Light Emission and Electrical Characteristics of Epitaxial GaAs Lasers and Tunnel Diodes, N. N. Winogradoff* and H. K. Kessler,* *Solid State Communications* **2**, 119-122 (April 27, 1964).

Lasing characteristics of epitaxially formed GaAs p-n junctions are compared with those of Zn diffused lasers. Abrupt epitaxially formed junctions only lased when a high concentration of donors was deliberately added to the p-type side. This result supports the Nelson et al. band filling model of the GaAs laser and relates the impurity band in this model to the n-type dopant.

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Linear Inequalities and Analysis, A. J. Hoffman and M. H. McAndrew, *American Mathematical Monthly* **71**, 416-418 (1964).

New proofs, in which calculus plays a forward role, are given for the elementary theorems of the transposition type on systems of linear inequalities.

Magnetoresistive Amplifiers with Superconductive Elements, T. D. English, Jr. and L. A. Finzi,* *Proceedings of the INTERMAG Conference* **T-159**, 2-3-1 to 2-3-6 (1964).

The construction and properties of certain superconductive amplifiers, in which the resistance of a gate element is controlled by the electromagnetic field of a signal coil, are described in this paper. Vacuum deposited films of tin, which have narrow resistive transition widths, have been used as the gate elements. The parameters of small-signal analysis are determined and the influence of temperature, bias magnetic field and zero-signal gate current upon power gains is shown. The limitations and merits of the device in its present form are discussed.

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Magnetostatic Interaction and Magnetization Reversal in Thin Ni-Fe Films, S. Middelhoek, *Proceedings of the INTERMAG Conference* **T-159**, 9-1-1 to 9-1-2 (1964).

A review is given of the reversal processes occurring in thin Ni-Fe films. The actual reversal processes deviate from those theoretically expected in many respects. This deviation is mainly due to the fact that a film consists of a multitude of small crystallites each exhibiting anisotropies of the same order of magnitude as the induced uniaxial anisotropy. The reversal processes are discussed as a function of the field strength and the angle between field and easy axis.

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A Mathematical-Physical Model of the Genesis of the Electrocardiogram, H. L. Gelernter and J. C. Swihart, *Biophysical Journal* **4**, 285-301 (July, 1964).

A fundamental problem of cardiac electrophysiology is that of relating quantitatively the electrical activity within the heart to the complete time-varying potential distribution at the body surface. A new numerical method is described for the calculation of the surface potential on an irregularly shaped closed external surface due to an arbitrary source distribution in a medium containing regions of different conductivity, subject to the appropriate boundary conditions. The method is intended to provide an exact theoretical analysis of the experimental data acquired by A. M. Scher and others who have been mapping the pathways of ventricular depolarization in dogs and other animals. In anticipation of the above research program, a number of exploratory computations are reported. For example, the surface potential distribution has been calculated for a cylinder of human torso cross section with a hemispherical dipole layer current source in approximate heart position and orientation and containing "lungs" of conductivity different from that of the surrounding medium. Under certain conditions, when lung-like inhomogeneities are introduced, a simple dipole source can generate a potential distribution having the multiple maxima and minima characteristic of higher multipole sources.

Minimal-State Stochastic Finite Systems,† G. C. Bacon, *IEEE Transactions on Circuit Theory* **CT-11**, 307-308 (June, 1964).

Carlyle's study of equivalence and state reduction in stochastic automata is extended to show the existence of a minimal-state form. Such a form differs from Carlyle's reduced form in that there is no equivalent machine with fewer states.

† This work was done while the author was a graduate student at the University of California, Berkeley.

Minimax Surveillance Schedules With Partial Information,† Robert Roeloffs, *Naval Research Logistics Quarterly* **10**, 307-322 (December, 1963).

An analysis is made of the problem of finding the optimal schedule for checking an operating system which is subject to failure detectable only by inspection of the system. If a cost is attached to each inspection of the system and also to undetected failure, then there exists the problem of scheduling inspections to minimize total costs. This problem also exists for the surveillance inspection of stored goods subject to deterioration with time. Reference is made to previous work by Barlow and Hunter and Derman. This paper assumes that the location of one percentile of the failure distribution of the units is known, and is concerned with the optimal use of this partial information.

† This work has been submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy under the Faculty of Pure Science at Columbia University.

Minimum Sample Size for Accepting a Criterion Error or Failure Rate With a Given Degree of Confidence, I. Belson, *Journal of the Electronics Division, American Society for Quality Control* **2**, 16-23 (March, 1964).

A technique is described that quickly gives the minimum number of operations needed to accept a criterion rate of error or failure with a specified degree of confidence. It can be utilized to determine the confidence limit for zero failure rates in the exponential or binomial case. The errors may be random or chance, but not a function of wear. No errors are to be found during the test, each sample or operation is either a success or failure, and the probability of success or failure is constant.

Multiprogramming and Multiprocessing, A. J. Critchlow, *IEEE Spectrum* **1**, 192-198 (March, 1964).

Some of the present knowledge of multiprogramming and multiprocessing can now be codified and classified to determine certain general principles underlying diverse techniques. Multiprogramming requires special considerations such as memory protection and allocation, facilities scheduling, interrupt provisions, priority controls, prevention of interference between programs and input/output switching and control. Alternative techniques for meeting these requirements are compared on the basis of speed, efficiency, cost and reliability. Analysis of some existing systems shows how the needs differ for each type of application, and how the system designer must balance these needs against the requirements of multiprogramming. Finally, on the basis of some present trends, an attempt is made to predict the future use of such systems and their effect on the world of business, industry, science, and daily living.

New Difference Equation Technique for Solving Nonlinear Differential Equations, J. M. Hurt, *AFIPS Conference Proceedings, Spring Joint Computer Conference* **25**, 169-179 (1964).

Simulating a complicated aircraft or space vehicle control system in real time for design or flight evaluation purposes requires the solution of a number of differential equations. This report describes a method of transforming a feedback control system represented in LaPlace notation to a set of difference equations.

New Ferromagnetic 5:2 Compounds in the Rare-Earth-Palladium Systems, A. E. Berkowitz, F. Holtzberg, and S. Methfessel, *Journal of Applied Physics* **35**, No. 3 (Part 2), 1030-1031 (March, 1964).

Gd_5Pd_2 is ferromagnetic below 335°K. The isostructural $Tb_{5.10}Pd_{1.90}$, $Dy_{5.07}Pd_{1.93}$, and $Ho_{5.04}Pd_{1.96}$ have paramagnetic transitions at 62, 41, and 27°K, respectively, and become ferromagnetic at lower temperatures with extremely high hysteresis. Energy products $(B \times H)_{max} = 20$ to 26×10^6 GOe at 4.2°K have been observed.

Nonlinear Optical Frequency Polarization in a Dielectric, E. Adler, *The Physical Review* **134**, A728-A733 (May 4, 1964).

A perturbation calculation of optical frequency polarization quadratic in the Maxwell field is made for a dielectric in which the electrons are localized on units of the crystal. The result is expressed in a power series in $K\langle r \rangle \sim 10^{-3}$, where $\langle r \rangle$ is the size of the unit and K is the wave number of the field. The term of zeroth order is the electric-dipole term which vanishes in a crystal with a center of symmetry. The term first order in $K\langle r \rangle$ is separated into electric-quadrupole and magnetic-dipole contributions by introducing a special gauge for the electromagnetic potentials. Higher power terms are neglected.

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Nonlinear Optical Theory in Solids, H. Cheng* and P. B. Miller, *The Physical Review* **134,** A683-A687 (May 4, 1964).

We use a simple rule giving the expectation value of a quantum operator for any perturbation order to calculate the general second-order conductivity tensor of a solid. The expression for the conductivity tensor amounts to a regrouping of terms in the conventional expressions and takes a considerably simplified form. The formula is applied to second harmonic generation in a free-electron gas and reduces to the classical equation given by Kronig and Boukema in the optical region. The second harmonic radiation generated in metals is shown to possess two resonances occurring at the plasma oscillation frequency for p polarization and at half the plasma frequency for p and s polarization. The amplitude of the resonance is related to the imaginary part of the dielectric constant at the plasma frequency $\epsilon_2(\omega_p)$. Only metals with $\epsilon_2(\omega_p) \ll 1$ (i.e., alkali metals, Ag and Al) will show resonant effects.

A Note on Shortest Path, Assignment, and Transportation Problems, A. J. Hoffman* and H. M. Markowitz,** *Naval Research Logistics Quarterly* **10,** 375-379 (December, 1963).

Algorithms are given for the assignment problem and the transportation problem which proceed inductively. In both cases, the inductive step is carried out by means of a shortest path algorithm on an appropriate directed graph in which the sum of the "lengths" of the edges around any cycle is nonnegative.

Nuclear Magnetic Resonance of La^{139} and Al^{27} and Electron Paramagnetic Resonance of Fe^{3+} in Lanthanum Aluminate, E. Brun,* B. Derighetti,* J. E. Drumheller,* F. Waldner* and K. A. Müller, *Physics Letters* **9,** 223-224 (April 15, 1964).

LaAlO$_3$ has perovskite structure and is cubic above 720°K. Below, it becomes rhombohedral, the distortion angle from cubic symmetry $\Delta\beta$ increasing almost linearly to 77°K. Therefore, the axial electric field gradient increases in a monotonic way, too. This has been studied for the two cation sites looking at the nuclear quadrupole splitting of Al^{27} and La^{139}. Further the paramagnetic resonance of Fe^{3+} ions substituting for an Al^{3+} ion was investigated. The parameters of the spin Hamiltonian were obtained. The only space group, below 720°K, which is compatible with the data is found to be $R\bar{3}c$.

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Numerical Computation of Body-Surface Potentials Produced by an Arbitrary Distribution of Generators in the Heart, H. L. Gelernter and J. C. Swihart, *Proceedings of the 1963 Milan Symposium on the Electrophysiology of the Heart,* Pergamon Press, 1964, pp 229-243.

A numerical method for determining the distribution of body-surface potentials produced by arbitrary electrical generators is described. The method, which makes use of an iterative procedure, is valid for irregularly shaped bodies containing regions of different conductivity. The results of a number of computations executed on an IBM 7094 computer are reported, including one of several test cases comparing the distributions produced by our method with known analytic solutions. Among the more realistic geometric configurations for which calculations have been performed are the case of the dipole and dipole layer generator in a dog torso, and that of dipole and quadrupole generators in a human male torso. For the dog torso, a comparison of the distribution produced by a hemispherical dipole layer with that generated by the equivalent dipole graphically illustrates the limitations of the equivalent dipole representation of the ECG.

Observation of the Jahn-Teller Splitting of Three Valent d^7 Ions via Orbach Relaxation,† U. Höchli* and K. A. Müller, *Physical Review Letters* **12,** 730-733 (June 29, 1964).

An investigation on the line broadening of octahedrally coordinated d^7 ions with t^6e configuration is reported. This broadening is due to an Orbach resonance relaxation. For Pt^{3+} in Al$_2$O$_3$ and for Ni^{3+} in SrTiO$_3$ the obtained energy separation Δ between the lowest two levels is shown to be the Jahn-Teller splitting of the ^2E ground state.

Observation of the Mössbauer Effect Using Coincidence Techniques, W. J. Nicholson, *Physics Letters* **10,** 184-186 (June 1, 1964).

A new method has been developed for performing Mössbauer absorption experiments applicable to excited states of nuclei above the first. The method, which uses coincidence techniques, affords an extremely high ratio of signal to noise under circumstances where the observation of the Mössbauer effect would ordinarily be difficult, if not impossible. The method has been tested by detecting the resonant absorption of gamma rays to the second excited state of Dy^{161}.

Occurrence of Maximum Quantum and Thermal Detection Efficiencies Attainable with a Planckian Radiator, A. D. Wilson, *Journal of the Optical Society of America* **54,** 482-486 (April, 1964).

The occurrence of maximum quantum or thermal detection efficiency (defined here as the ratio of utilized photons or energy to the total emitted by a Planckian radiator) was determined theoretically as a function of the absorption edge and bandwidth of the detector, and the temperature of the Planckian radiator. It is assumed that the quantum or thermal efficiency of the detector is constant within the bandwidth in question and zero elsewhere. The application of the specific results derived here is limited to source-detector combinations where the source spectral energy or photon distribution approximates that of a Planckian radiator. A "noise level" and its effect on the efficiency are not considered in the present analysis. The outcome of the analysis is a series of "displacement laws" which are similar to the Wien displacement law, $\lambda_m T = 0.2898$ cm °K.

It is shown that the temperature should be increased for maximum efficiency as the bandwidth of the detector is increased.

On Abstract Dual Linear Programs,[†] A. J. Hoffman, *Naval Research Logistics Quarterly* **10,** 369-373 (December, 1963).

This note examines the duality theorem of linear programming in the context of a general algebraic setting. It is well known that, when the constants and variables of primal and dual programs are real numbers (or any ordered field), then (i) any value of the function to be maximized does not exceed any value of the function to be minimized; and (ii) max = min. Property (i) is a triviality, and property (ii) depends on the hyperplane separation theorem, the simplex method or some other argument. All of the arguments used to prove (ii), however, seem to depend on the properties of a field. In the general algebraic setting described in the proof of the note, (i) remains trivial but (ii) is, in general, false. Nevertheless, examples (taken from set theory and number theory) are constructed in which (ii) does hold.

On the Correlation of Electrons in a Narrow Band, M. C. Gutzwiller, *Physical Review Letters* **10,** 159-162 (March 1, 1963).

A narrow band in a crystal lattice may be characterized by a set of atomic states attached to each lattice site, the bandwidth being small as compared to the Coulomb interaction between the states of any one site. An approximate ground state has been proposed, but it was evaluated only in the limit of few electrons (or holes) in the narrow band as compared to the number of sites. In order to compute expectation values for arbitrary particle densities, a procedure is developed that starts from averaging over all possible sets of wave vectors in reciprocal space. The probability for finding the particles in a certain configuration is then assumed to differ from the reciprocal of the total number of configurations by a factor analogous to the Boltzmann factor for a related configuration of spins interacting through an appropriate Ising of Heisenberg Hamiltonian. Various methods from the theory of ferromagnetism are then used to obtain the energy of the approximate ground state in the case of an *s* band, i.e., one atomic state per lattice site.

On Liapunov Stability vs Bounded-Input, Bounded-Output, G. W. Johnson, *IEEE Transactions on Automatic Control* **AC-9,** 178-180 (April, 1964).

Apart from the monumental work of Liapunov and more recent extensions, many definitions have been offered pertaining to the stability of physical systems. It would be difficult to specifiy all of these definitions in their detail. Rather, the most popular of these (credited initially to James and Weiss and paraphrased by many others) is considered here for comparison.

On the Limiting Law for Electrical Conductance in Ionic Solutions, Harold L. Friedman, *Physica* **30,** 537-562 (March, 1964).

The cluster theory of conductance presented in a preceding paper is applied to a model in which a single solute particle in the solvent obeys the law of Brownian motion. The force between two solute particles is derivable from macroscopic electrostatics and hydrodynamics, and the interactions among many solute particles in a solution may be expressed as a sum of pair contributions. These hypothetical solute particles are called *brownons*.

It is found that the relaxation term in the limiting law derives from the electrical part of the force between brownons, while the electrophoretic term derives from the hydrodynamic part of this force as well.

Onsager's relaxation term is recovered exactly in the case of a solution of a single cationic and a single anionic solute species observed at zero frequency. The $1 + q$ factor in the denominator, which was Onsager's improvement over the earlier theory of Debye and Hückel, is found to come from the sums over force propagator chains in the cluster theory.

On Pre-emptive Resume Priority Queues, P. D. Welch, *Annals of Mathematical Statistics* **35,** 600-612 (June, 1964).

The following queueing process is considered. The input is the superposition of r independent Poisson processes, each process corresponding to a priority level. The service times have a general distribution which is a function of the priority level. A single server operates under a pre-emptive resume priority service discipline. For this process, results are obtained which characterize the transient and asymptotic behavior of both the waiting times and the queue sizes.

On the Solvability of a Subclass of the Surányi Reduction Class, R. Goldberg, *Journal of Symbolic Logic* **28,** 237-244 (September, 1963).

The solvability of a subclass of the Surányi reduction class for the schemata of pure quantification theory is demonstrated. The subclass in question comprises all closed prenex schemata with prefixes of the form $(Y_1)(Y_2)(EX)(Y_3)$, and matrices which contain, in addition to $m \geq 0$ monadic letter atoms, dyadic letter atoms from the set:

$$F(Y_1, Y_2) \ F(Y_2, Y_1) \ F(Y_2, Y_3) \ F(Y_3, Y_2) \ F(Y_1, X) \ F(X, Y_1)$$
$$F(Y_2, X) \ F(X, Y_2) \ F(Y_1, Y_1) \ F(Y_2, Y_2) \ F(Y_3, Y_3) \ F(X, X).$$

On the Theory of the Low-Temperature Spontaneous Magnetization of Ferromagnetic Metals, J. F. Cornwell, *Proceedings of the Royal Society* **A279,** 346-357 (June 9, 1964).

The temperature variation of the low-temperature spontaneous magnetization ζ of a ferromagnetic metal is obtained from assumptions that are consistent with the usual band theory. The second-quantized Hamiltonian for the system is taken to contain electronic energy band terms as well as Coulomb and exchange energy terms. The Green function method is used. It is shown that spin-wave excitations of small wave vector **k** exist with energies proportional to k^2, from which it is deduced that $\zeta = \zeta_0 (1 - \gamma T^{3/2})$, with ζ_0 dependent on the average number of electrons per band. An analytical expression is found for the constant γ which differs from that obtained in the Heisenberg model.

Operating System for the 1410/7010, N. L. Barnett,[*] and A. K. Fitzgerald,[**] *Datamation* **10,** 39-42 (May, 1964).

The paper presents the objectives that were used as goals in the design of the 1410/7010 Operating System. In addition, the basic elements of the system are described in conjunction with a presentation of the system flow. The features of teleprocessing and system generation are detailed to enable the user to familiarize himself with the concepts of the Operating System.

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Optische Aktivität von Spin-Schraubenstrukturen (Optical activity of spin spiral structures), H. Thomas, *Zeitschrift für angewandte Physik* **17**, 158-160 (April 27, 1964).

Since a spin screw structure has no center of inversion, optical activity is possible. The effect would allow observation of a domain structure of right-hand and left-hand screw domains. For a simple model, the magnetic and the electric parameters of the optical activity are calculated and their orders of magnitude discussed.

An Optical Character Scanner, Robert J. Potter, *Society of Photographic Instrumentation Engineers Journal* **2**, 75-78 (February/March, 1964).

An experimental machine has been designed and constructed to be used for optical character recognition. As an integral part of the recognition system, an optical character scanner has been built which optically scans a 35 mm microfilm transparency and provides binary information for the rest of the character recognition system. An IBM 1401 computer system delivers gross commands to the character recognition machine, allowing the scanner and other parts of the system to be partially autonomous. The experimental system has been used to study the problems of character recognition. It offers opportunity for considerable flexibility to do research experiments, and it is not intended to be prototype of a commercial recognition machine.

Optimization of Molecular Wave Functions by Scaling, A. D. McLean, *Journal of Chemical Physics* **40**, 2774-2784 (May 15, 1964).

The conditions that a set of molecular electronic wave functions for different nuclear configurations be optimized by incorporation of scale factors, in general different for each wave function of the starting set, are derived. The relationship of these conditions to the quantum mechanical virial theorem in Born-Oppenheimer approximation is pointed out. The quantitative effects of such optimization on a set of accurate wave functions for the hydrogen molecule and a partially optimized single configuration molecular orbital wave function for lithium fluoride are discussed. Expectation values and spectroscopic constants are investigated in detail. It is shown that as the total molecular energy decreases the quantitative effects of scaling will become progressively smaller. A further conclusion is that, for sets of unscaled diatomic molecule wave functions only partially optimized, curves for kinetic energy and potential energy of the system as a function of internuclear separation are more accurately computed from the total molecular energy curve by use of the virial theorem than by use of computed mean values.

Output Procedures in Digital Measuring Techniques, W. Walter, *VDI-Berichte* **78**, 55-62 (1964).

Output procedures can be divided into two groups: (1) Procedures which indicate the measured value optically or acoustically (display, voice answer output, printer, typewriter), and (2) Procedures which provide machine readable outputs (punched card, paper tape, magnetic tape, magnetic disk, digital telemetering, direct input into digital computer). This paper describes examples and discusses the trend of development.

Photochemistry of 1, 3-Butadiene: Details of the Primary Processes and Mechanism of Photopolymerization, I. Haller and R. Srinivasan, *Journal of Chemical Physics* **40**, 1992-1997 (April 1, 1964).

The photolysis of 1, 3-butadiene in the vapor phase was studied in the presence of inert gases such as krypton, diethyl ether, and cyclohexane. In every instance, an increase in the pressure of the added gas led to a decrease in all of the volatile products. A consideration of the radiative lifetime of the first singlet excited state of 1, 3-butadiene suggests that the observed pressure dependence cannot be attributed to a quenching reaction from that state. It seems likely that all of the volatile products in the vapor phase photolysis arise from a vibrationally excited ground state molecule of 1, 3-butadiene that is formed by the internal conversion of the electronically excited singlet state.

The formation of a polymer in the gas-phase photolysis was found to have an induction period and to depend on the square of the number of photons that were absorbed. In all probability, the polymer is formed in the photolysis of a volatile product(s) of the primary photodecomposition.

Photoelastic Coatings on Flat Rotating Axisymmetrical Parts, W. E. Nickola, *Experimental Mechanics* **4**, 99-109 (April, 1964).

Body forces generated in photoelastic coatings bonded to rotating metallic parts affect the deformation in the parts. This effect becomes considerable when the coating thickness approaches that of the part. As a result, the observed photoelastic strain pattern is not truly indicative of the strains that would be present in an uncoated part. This interaction is considered analytically and experimentally for the case of a flat circular disk with a central hole when the coating covers the entire disk area and (a) coatings of equal thickness are bonded to both sides of the test part, and (b) the coating is bonded to only one side of the test part. Correction factors are derived which are applicable to problems where the strain field is axisymmetrical. The applicability of the derived correction factors in the vicinity of stress concentrations in the rotating part is considered.

Polynomials Root Determination for Engineers, A. J. Sykas, *Electro-Technology* **33**, 109-116 (April, 1964).

The determination of the roots of a polynomial is one of the essential problems of applied analysis in engineering. This paper presents a unique approach to the problem. Exact algebraic equations are supplied for determining the roots of third and fourth degree polynomials. For the fifth to the ninth degree polynomials, compatible pairs of methods are recommended. The Bernoulli or Graeffe methods are used to approximate the root followed by the Bairstow or Newton method to refine the root. Polynomials above the ninth degree should be solved with the aid of computers. The Muller and Resultant programs are recommended for these higher order polynomials.

A Precise Technique for the Design of Transistorized Schmitt Triggers, R. A. Jensen, *Electronic Design* (in two parts) Part I: **12** (March 30, 1964); Part II: **12** (April 6, 1964).

Predictions of triggering voltage levels of Schmitt triggers designed by conventional methods—which assume that the triggering and saturation levels of each stage are identical—are often unreliable. Analysis shows that the triggering levels

and saturation levels can, in fact, be quite different. A new design procedure allows accurate selection of triggering levels, and, in addition, incorporates a slight modification of the basic circuit which further simplifies the design. Experiments verify the analysis and design procedure, showing excellent agreement between target parameters and those of the actual circuit.

Preparation and Properties of Thin Films of Molybdenum Oxide, I. Ames and L. V. Gregor, *Electrochemical Technology* **2**, 97-100 (March/April, 1964).

Thin films of molybdenum oxide have been prepared by sublimation from a hot Mo tube through which oxygen was passed and by direct thermal evaporation of solid MoO_3 pellets. The film thicknesses ranged from 30 to 10,000Å and test capacitors were made with such films as the dielectric. The physical properties of the films were determined. Indications were made with such films as the dielectric. The physical properties of the films were determined. Indications were that they are semi-insulators composed of partially reduced MoO_3 having resistivities ranging from 10^6 to 10^8 ohm-cm.

Propagation of Axisymmetric Waves in a Circular Semi-infinite Elastic Rod, R. K. Kaul and J. J. McCoy,* *Journal of the Acoustical Society of America* **36**, 653-660 (April, 1964).

The Mindlin-McNiven equations for axially symmetric waves are used to determine the radial strains in a circular, semi-infinite, isotropic, elastic rod for both pure and mixed end conditions when a constant pressure is suddenly applied to its end. Using double-integral transforms, the solution is obtained in terms of three Fourier integrals, each one representing one mode of propagation. These integrals are too complex to be evaluated exactly and, therefore, an asymptotic solution valid for large distance of travel is obtained for the head of the pulse by using the method of steepest descent. The results predict the existence of edge resonance and further demonstrate its influence on the strain field.

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Quadrupole Coupling Constant, eqQ/h, of Fe³⁺ in Several Rare-Earth Iron Garnets, W. J. Nicholson and Gerald Burns, *The Physical Review* **133**, A1568-A1570 (March 16, 1964).

Using the Mössbauer effect, values of eqQ/h of Fe^{3+} have been obtained at each of two sites in several rare-earth iron garnets. The measured values of eqQ/h were compared with values obtained using a point-charge lattice sum calculation. For the octahedral (a) site there was reasonable agreement between the measured and calculated values of eqQ/h indicating that an ionic model is reasonably valid. However, the measured values of eqQ/h at tetrahedral (d) sites were larger than those estimated. This difference is attributed to a small amount of covalent bonding which is also evident in the values of the (d) site internal field and isomer shift.

Role of the Intermetallic Compounds in Determining the Superconducting Transition Temperature of Superimposed Metal Films, H. L. Caswell, *Physics Letters* **10**, 44-45 (May 15, 1964).

A number of experiments have been reported on the critical temperature, T_c, of film sandwiches of superimposed normal and superconducting metals. The presence of the normal film is found to lower the T_c of the sandwich below that of the pure superconductor. The phenomenon has been considered theoretically with the model being that of two discrete film layers in intimate contact. The validity of this model has been questioned by Rose-Innes and Serin for binary systems which form intermetallic compounds. Van Gurp has compared film sandwiches of the two binary systems, In-Al which reportedly forms no intermetallic compounds and In-Mg which forms several intermediate alloy phases. However, in these systems, oxidation effects are extremely important. For example, Miles and Smith found the T_c depression in In-Al film sandwiches to depend on the length of time the sample had been exposed to atmospheric air. Thus, Van Gurp's experiments are confused by oxidation effects and difficult to interpret.

The binary systems, Pb-Cu, Pb-Ag and Pb-Au, provide a better opportunity to evaluate the importance of intermetallic compound formation since they are not as susceptible to oxidation effects. All three systems have very restricted solid solubilities and only one (Pb-Au) forms any intermediate alloy phases. With the Pb-Au system, two intermetallic compounds have been reported in thin films: $AuPb_3$ and $AuPb_2$. Moreover, T_c data are available on composite films of Pb-Ag and an Pb-Cu. Therefore, to obtain a rather definitive answer to the role of intermetallic compound formation, it was only necessary to obtain T_c data on film sandwiches of lead and gold.

Selected Area X-Ray Diffraction Studies of Surface Damage in Sliding on Single-Crystal Copper, D. D. Roshon, Jr., *Journal of Applied Physics* **35**, 1262-1269 (April, 1964).

Selected area x-ray diffraction was employed to study the localized structural changes resulting from sliding of a hemispherical copper stylus on the (001) face of a copper single crystal. Although a relatively large (0.25 mm) x-ray beam was used, significant structural deformations were resolved. Features observed included deformation of boundary regions by rotation from slip, crystal bending in areas of pileup, the microcrystalline Beilby layer, a preferentially oriented transition region, and transferred crystalline particles. The observed deformations exhibited a dependence on sliding direction.

Sensory Feedback Analysis of Stereotelevision Pursuit Tracking, J. D. Gould and K. U. Smith,* *Journal of Applied Psychology* **48**, 152-160 (June, 1964).

A stereotelevision system, capable of presenting binocular cues for remote depth perception, has been developed for research on problems of optical design and for sensory feedback studies in space science. Preliminary experiments evaluated a color-separation system, which was found to be faulty for research. Detailed visual acuity and stereoscopic acuity tests with a binocular-separation system disclosed that a very adequate and reliable 3-dimensional system can be devised for laboratory studies of remote binocular vision. A specific experiment tested the utility of a nondirectional auditory cue in aiding visual pursuit tracking in depth. Results indicated that the effectiveness of the auditory cue varies as a function of the speed of the target course.

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Set-Theoretic Foundations for Syntactic Description, W. S. Cooper, *Janua Linguarium* **34**, (1964).

In those areas of descriptive linguistics which call for a rigorous treatment of syntactic structure, mathematical

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foundations are needed. Set theory is recommended as the appropriate branch of mathematics for the foundations of syntax. Grammars may be viewed as mathematical definitions within the formalism of set theory. An exposition of elementary set theory is given, and a number of grammars are stated to show its application to descriptive linguistics.

Simple Basis Set for Molecular Wavefunctions Containing First- and Second-Row Atoms, Enrico Clementi, *Journal of Chemical Physics* 40, 1944-1945 (April 1, 1964).

The self-consistent field functions for the ground state of the first- and second-row atoms (from He to Ar) are computed with a basis set in which two Slater-type orbitals (STO's) are chosen for each atomic orbital. The reported STO's have carefully optimized orbital exponents. The total energy is not far from the accurate Hartree-Fock energy given by Clementi, Roothaan, and Yoshimine for the first-row atoms and unpublished data for the second-row atoms. The obtained basis sets have sufficient flexibility to be a most useful starting set for molecular computations, as noted by Richardson. With the addition of $3d$ and $4f$ functions, the reported atomic basis sets provide a molecular basis set which duplicate quantitatively most of the chemical information derivable by the more extended basis set needed to obtain accurate Hartree-Fock molecular functions.

Simplified Approach to the Ground-State Energy of an Imperfect Bose Gas. III. Application to the One-Dimensional Model, E. H. Lieb* and Werner Liniger, *The Physical Review* 134, A312-A315 (April 20, 1964).

The study of the integrodifferential equation proposed previously for the evaluation of the ground-state energy of an imperfect Bose gas is continued. It is applied here to the one-dimensional delta-function gas where the exact result is known for all values of the coupling constant γ. The results are: (i) For small γ, the equation gives the correct first two terms in an asymptotic series; (ii) a numerical solution of the equation shows that the maximum relative error occurs for $\gamma = \infty$ in which case it is 19%; (iii) for $\gamma = \infty$ the exact two-particle distribution function can be compared with that given by the equation. The agreement is quite good.

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Single Crystal Growth of LaF₃, P. F. Weller and J. A. Kucza, *Journal of Applied Physics* 35, 1945-1946 (June, 1964).

Single crystals of LaF₃ have been grown using the Czochralski technique. Crystal clarity and perfection were strongly dependent on the amount of oxide impurity present. Trivalent rare earth doping was easily achieved, and divalent doping was also possible with easily reduced rare earths such as europium and samarium.

Solidification of Iron-Carbon Alloys of Nearly Eutectic Composition, G. Koves and L. F. Mondolfo, *Journal of The Iron and Steel Institute* 202, 424-426 (May, 1964).

A study of the freezing of high-purity iron-carbon alloys on both sides of the eutectic was conducted by measuring the undercooling for nucleation and relating it to the resultant structures.

It was found that the structures were strongly dependent on nucleation, but practically independent of composition, and that the same treatment produced very similar struc-

tures in both hypo- and hypereutectic alloys. In the samples melted under vacuum in absence of impurities any cementite present nucleated austenite at 10-20°C undercooling. In the absence of cementite the freezing started with the formation of austenite at higher undercooling. In both cases graphite formed eventually at the grain boundaries of the austenite, in the form of small flakes with a definite eutectic appearance.

In samples in which the surface was exposed to air before or during melting some compound formed, which nucleated flake graphite at 0-5°C undercooling, producing the typical structure of cast irons, with primary graphite flakes in a matrix of ferrite or pearlite. It was concluded therefore that in the freezing of cast irons primary flake graphite is nucleated by impurities.

Some Flexible Information Retrieval Systems Using Structure Matching Procedures,† G. Salton* and E. H. Sussenguth, Jr., *AFIPS Conference Proceedings, Spring Joint Computer Conference* 25, 587-597 (1964).

The comparison between stored information identifications and requests for information is one of the principal tasks to be performed in automatic information retrieval. In many retrieval systems it has been found necessary or expedient to use complicated constructs for the identification of information. A complete identification for a document or an item of information is often represented by a graph, consisting of nodes and branches between nodes, to identify respectively the key words and relations between key words. The matching of such information graphs with graphs representing requests for information is a relatively complicated operation, particularly since the request structure can be made to match the information structure only partially and incompletely. An efficient topological structure-matching procedure, which does not depend on a specific ordering of the nodes, nor on the presence or absence of certain specified substructures, is described. The procedure is applied to the matching of document graphs with request graphs, and to a retrieval system based on the comparison of syntactically analyzed document excerpts with a stored phrase dictionary.

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Some New Geometries for Which Laplace's Equation in Three Dimensions is Soluble, R. Ball,* D. Bartlett,** R. Bayer, and F. Partovi,*** *Journal of Mathematics and Physics* 18, 144-157 (June, 1964).

It is sometimes possible to use inversion through a sphere in conjunction with the separation of variable technique to solve Laplace's equation for boundaries which are not conveniently treated by the separation of variable technique alone. The use of the inversion technique is facilitated if the inverted forms of coordinate systems for which Laplace's equation is separable are known. In this paper, expressions are derived for the inverted forms of the prolate spheroid, oblate spheroid, and parabolic coordinate systems and their forms have been classified in terms of the parameters involved. The use of the inversion technique to solve Laplace's equation in conjunction with the classification is discussed and examples are given for some interesting geometries.

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Some Observations on Conduction through Thin Tantalum Oxide Films, C. L. Standley and L. I. Maissel, *Journal of Applied Physics* **35,** 1530-1534 (May, 1964).

The electrical properties of several tantalum oxide diodes with various metal counterelectrodes have been studied. The devices were prepared on sputtered tantalum by anodizing to the desired oxide thickness (100-200 Å) and evaporating the second metal electrode in vacuum. The devices show a work function dependence on the second metal electrode that also appears to be affected by the manner in which the original tantalum was prepared. The temperature behavior of this and several other oxide diode systems follows a Schottky relation fairly well, with deviations at low temperatures and thinner oxide layers, as expected.

Storage Requirements for a Data Exchange, I. De' n'vis and G. Davison, *IBM Systems Journal* **3,** No. 1, 2-13 (1964).

A computational procedure is derived analytically to evaluate the input/output buffer storage requirements in a data exchange. Validity of the analysis is substantiated by comparing—in a typical instance—the analytical results with those obtained by simulation.

A Study of the Desorption of Stearic Acid from Platinum and Nickel Surfaces Using Ellipsometry, W. T. Pimbley and H. R. MacQueen, *Journal of Physical Chemistry* **68,** 1101-1106 (May, 1964).

Isothermal desorption experiments were performed for the desorption of many monolayers of stearic acid from both a nickel and a platinum surface. The experiments were performed under ultrahigh vacuum conditions and at a number of different temperatures. An ellipsometer was used to measure the amount of adsorbed stearic acid at any given time. Desorption constants obtained from the isothermal curves were examined for their temperature dependence by plotting them on an Arrhenius plot. The resulting binding energies of the bottom layer to the metal surface were 36.4 kcal/mole to nickel and 30.5 kcal/mole to platinum. The binding energy of the outer layers was 44.1 kcal/mole for desorption from either metal. This energy compares well with the sublimation energy for stearic acid. A theory is presented for isothermal multimolecular desorption. Many features of the experimental results compare well with the predictions of the theory. However, the rate of desorption of the bottom one or two layers is much higher than the theory would indicate. The probable cause and implications of this discrepancy are discussed.

A Synopsis of Magnetic Memories, Hsu Chang, *Proceedings of the INTERMAG Conference* **T-159,** 5-2-1 to 5-2-4 (1964).

Magnetic memories abound in shapes and in materials. The present paper considers the major physical phenomena underlying the operations of the magnetic elements, the circuitry and the transmission line array. Our purpose is to formulate a few ground rules for memory design and to determine the ultimate limitations. Some future improvements are also indicated.

The Synthesis and Polymerization Studies of Some Higher Homologues of 9-Vinylcarbazole, Jorge Heller, D. J. Lyman, and W. A. Hewett, *Die Makromolekulare Chemie* **73,** 48-59 (1964).

9-Allylcarbazole, 9-Δ^3-butenylcarbazole, 9-Δ^4-pentenylcarbazole and 9-Δ^5-hexenylcarbazole were synthesized and their polymerization with Ziegler-Natta catalyst systems studied. 9-Allylcarbazole could not be polymerized and 9-Δ^3-butenylcarbazole could only be polymerized with extreme difficulty. However, 9-Δ^4-Pentenylcarbazole and 9-Δ^5hexenylcarbazole could be polymerized at conversions of about 55%. These results are interpreted in terms of steric hindrance about the vinyl group. No evidence of complexing due to the basic nitrogen atom was noted. Of the catalyst systems used only Et_2AlCl-$\gamma TiCl_3$ was found to be effective in the polymerization. As judged by x-ray diffraction and insolubility the polymers were highly crystalline.

Systems Simulation with Digital Computers, K. Blake and G. Gordon, *IBM Systems Journal* **3,** No. 1, 14-20 (1964).

The general nature of digital simulation of a system is discussed. A machine-independent examination of the associated programming problem is conducted and illustrated by means of an example. Finally, the nature and application of simulation languages are noted.

Theory of Hypochromism, R. K. Nesbet, *Molecular Physics* **7,** 211-221 (March, 1964).

The explanation of hypochromism recently proposed by Bolton and Weiss is examined critically, and a more detailed theory is derived from the semi-classical radiation formalism. The theory is applied to compute the relative hypochromism for several positions of two ethylene molecules, and results are compared with a previous derivation from the static exciton theory. The present results are approximately three orders of magnitude larger, and are comparable to the large hypochromism observed in polynucleotides for similar intermolecular distances. The formula used by Bolton and Weiss is found to be erroneous, in that a resonance line width is misinterpreted to be equivalent to a molecular band width parameter, but the correct formula changes the results of Bolton and Weiss only by a factor $\pi/2$. The present theory is shown to be equivalent to classical dispersion theory, but it does not require the usual dipole approximations. There is a clear conflict with static exciton theory, which also is derived from semi-classical radiation theory and is equivalent to the usual theory of molecular spectra. Thus the status of the latter theory must also be questioned.

A Theory of Nonlinear Networks—I, R. K. Brayton and J. K. Moser,* *Quarterly of Applied Mathematics* **22,** 1-33 (April, 1964).

This report describes a new approach to nonlinear RLC-networks which is based on the fact that the system of differential equations for such networks has the special form

$$L(i)\frac{di}{dt} = \frac{\partial P(i,v)}{\partial i}, \qquad C(v)\frac{dv}{dt} = -\frac{\partial P(i,v)}{\partial v}.$$

The function, $P(i,v)$, called the mixed potential function, can be used to construct Liapounov-type functions to prove stability under certain conditions. Several theorems on the stability of circuits are derived and examples are given to illustrate the results. A procedure is given to construct the mixed potential function directly from the circuit. The concepts of a complete set of mixed variables and a complete circuit are defined.

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Tunnel Diode Delay-Line Memory, H. H. Harris, Jr. and W. D. Pricer, *IEEE Transactions on Electronic Computers* **EC-13,** 269-272 (June, 1964).

This paper describes a memory system wherein bits of information are stored serially in time on electrical delay lines. The simplicity and speed of the basic storage cell makes large high-speed stores of this sort feasible. The paper stresses the basic principles of operation. A brief description of one such system model built to demonstrate these principles is included.

The Vapor Pressure of Silicon Tetrachloride and Germanium Tetrachloride Below Their Melting Points, P. Balk and D. Dong, *Journal of Physical Chemistry* **68,** 960-962 (April, 1964).

Saturation vapor pressures have been determined for solid and undercooled liquid $SiCl_4$ from 174.5° and 182.7°K to the melting point (204.3°K), and for solid and undercooled liquid $GeCl_4$ from 186.8 and 197.8°K to the melting point (221.6°K). The experimental points fit equations of the form $\log p = -a/T + b$, and values of the constants a and b are given. The entropies of the solids at the melting points have been calculated from the data. The data for solid $GeCl_4$ relate in all probability to the metastable β-phase.

Vibration Frequencies of Tapered Bars and Circular Plates, H. D. Conway,* E. C. H. Becker, and J. F. Dubil, *Journal of Applied Mechanics* **31,** 329-331 (June, 1964).

Calculations are made of the values of the transverse vibrational resonant frequencies for truncated-cone cantilever beams for a number of geometries, the boundary conditions being clamped/free, clamped/simply supported, and clamped/clamped. After noting an analogy which exists between the free vibration of cones and linearly tapered plates for the special case when Poisson's ratio = 1/3, data are also given for the resonant axisymmetrical frequencies of clamped tapered circular plates. Some data for partially tapered plates are also computed. Aside from their value for design purposes, these data can be used as test cases for assessing the accuracy of various approximate methods of solution.

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Zener Tunneling in Semiconductors with Degenerate Band Structure, J. B. Krieger, *Solid State Communications* **2,** 153-155 (June, 1964).

The theory of tunneling between a degenerate and a non-degenerate band system is investigated. The wave function for the former, in the presence of the electric field, shows that at the appropriate branch point of the energy function the electron can make a transition between degenerate bands. These wave functions are used to calculate the valence-conduction band tunneling rate, in a uniform electric field, for Kane's four-band model.

Letters to the Editor

Active Imaging, W. A. Hardy, *Nature* **202,** 277-278 (April 18, 1964).

Double-Diffusion in GaAs, P. Gansauge and W. V. Münch, *Zeitschrift für Naturforschung* **19a,** 516-517 (April, 1964).

Dynamics of Reactive Collisions: The H + H_2 Exchange Reaction, M. Karplus, R. N. Porter, and R. D. Sharma, *Journal of Chemical Physics* **40,** No. 7, 2033-2034 (April, 1964).

Harmonic Generation in Injection Lasers, A. W. Smith, M. I. Nathan, J. A. Armstrong, A. E. Michel and K. Weiser, *Journal of Applied Physics* **35,** No. 3 (Part 1) 733 (1964).

Impurity Atom Distribution from a Two Step Diffusion Process, D. P. Kennedy and P. C. Murley, *IEEE Proceedings* **52,** 620 (May, 1964).

On Reciprocity Theorem, G. J. Fan, *Proceedings of the IEEE* **52,** No. 5, 626 (May, 1964).

Paramagnetische Elektronenresonanz von Fe^{3+} in $LaAlO_3$ (Electron paramagnetic resonance of Fe^{3+} in lanthanum aluminate), E. Brun,* J. E. Drumheller,* K. A. Müller and F. Waldner,* *Helvetica Physica Acta* **37,** No. 3, 210 (1964).

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Resonance Relaxation of Pt^{3+} in Al_2O_3, U. Höchli* and K. A. Müller, *Helvetica Physica Acta* **37,** No. 3, 209 (1964).

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