

Technical Papers by IBM Authors Published Recently in Other Journals

Alphabets and Codes, H. Zemanek, *Elektronische Rechenanlagen* 7, No. 5, 239-258 (1965).

Five international codes, five IBM-codes and the code of the Soviet Union are described and compared by means of two tables, one ordered by bit-strings and one ordered by graphics (numerics, letters, and syntactics).

Atomic Bethe-Goldstone Equations. I. The Be Atom, R. K. Nesbet, *Physical Review* 155, No. 1, 51-55 (March, 1967).

The nonrelativistic electronic energy of Be(¹S) is computed by a generalization of the method of Brueckner, through the variational solution of generalized Bethe-Goldstone equations. These equations describe clusters of two, three, or four electrons interacting with the remainder of an *N*-electron system. The three- and four-particle terms are found to be very small, but the sum of three-particle terms is nearly 0.001 atomic units (a. u.). The computed correlation energy is -0.0921 a. u., or 98.1% of the difference between experimental total energy and computed Hartree-Fock and relativistic energies.

Atomic Bethe-Goldstone Equations. II. The Ne Atom, R. K. Nesbet, *Physical Review* 155, No. 1, 56-58 (March, 1967).

The nonrelativistic electronic energy of Ne(¹S) is computed by the variational solution of generalized Bethe-Goldstone (BG) equations. The sum of all two-particle net energy increments (pair correlation energies) is -0.3822 atomic units (a.u.), or 97.3% of the empirical correlation energy. The three- and four-particle net energy terms expected to be most important are computed and found to be smaller than 0.001 a.u. The computed pair correlation energies are analyzed in terms of symmetries induced in the BG equations, and are found to be represented well within the accuracy of the present calculations by the somewhat smaller number of parameters needed to characterize the *L* and *S* eigenstates of all possible eight-particle subsystems of the ten-electron Hartree-Fock reference state.

An Automated X-Y Dimensional Stability Measuring System for Printed Circuit Substrates, F. E. Grace and R. G. Kiwimagi, *IEEE Transactions on Parts, Materials, and Packaging PMP-2*, No. 4, 99-107 (December, 1966).

A system is described for measuring length (width) changes in printed-circuit substrates under environmental (temperature/humidity) changes. A fixture for samples 20 in. long is also described. Data are given for temperature coefficient and humidity coefficient of epoxy-glass substrates 0.010 in. and 0.020 in. thick, both bare and partially covered with an etched copper pattern. Two approximate mathematical models are discussed. One is static and linear; the other is time-dependent and nonlinear, but treated as a linear expansion.

Avalanching in GaAs p- π -p Structures, K. Weiser, M. Drougard and R. Fern, *Journal of Physics and Chemistry of Solids* 28, No. 2, 171-183 (February, 1967).

A reversible, electric breakdown at fields between 2 and 3×10^6 V/cm is observed in *p*-type GaAs structures consisting of a high resistivity layer, approximately 1μ thick, flanked by low resistivity regions. The breakdown is accompanied by light emission which takes place outside the high resistivity layer since the electrons produced by the breakdown process are swept into the adjacent low resistivity regions before they have a chance to recombine. A study of light intensity vs electric field suggests an avalanche breakdown characterized by an ionization constant for holes which depends exponentially on the inverse electric field. These *p*- π -*p* structures are prepared by zinc diffusion into manganese doped (*p*-type) GaAs, and a mechanism is suggested for the formation of the high resistivity layer. The *I-V* characteristics before breakdown are essentially ohmic up to several volts suggesting the absence of space charge limitation for the current in such thin layers.

Beziehungen zwischen Schallspektrum, Mithörschwelle und der Erregung des Gehörs (Correlations between sound spectrum, masked threshold, and the stimulation of the auditory)*, D. Maiwald, *Acustica* 18, No. 2, 69-80 (1967).

The masked thresholds of pure tones masked by noise are measured as a function of bandwidth, center frequency, and sound pressure level of the noise. The shape of the excitation pattern caused by the noise in the ear can be deduced from these masked thresholds. Variations of the bandwidth of the noise only affect the excitation pattern as long as the bandwidth is larger than the critical band value at the given center frequency. If the bandwidth decreases below this value the excitation pattern, initially of trapezoidal shape, changes into an asymmetrical triangular shape; a further decrease of bandwidth at constant sound pressure level causes no further changes. The excitation patterns of narrow-band noise of various center frequencies can be brought into coincidence by horizontal displacement if the critical band function is used as abscissa. Narrow-band noise generated by sufficiently steep filters produces almost the same excitation pattern as a pure tone of the same center frequency and equal level. The excitation caused by narrow-band noise, however, fluctuates around an average value according to the random fluctuations of the sound, whereas the excitation of a pure tone is constant. In both cases the lower slope of the excitation pattern has a steepness of approximately 27 dB/Bark. This steepness is independent of the center frequency of the sound and depends only very little on the sound pressure level.

* Work performed at the Institut für Nachrichtentechnik der Technischen Hochschule Stuttgart

Bicyclo [2.1.1] hexane. Preparation and Photochlorination, R. Srinivasan and F. I. Sonntag, *Journal of the American Chemical Society* 89, No. 2, 407-410 (January 18, 1967).

A simple method for the preparation of bicyclo[2.1.1]hexane, which is based on the mercury (¹⁹⁹Pt) sensitized isomerization of 1,5-hexadiene, is described. Photochlorination of bicyclo[2.1.1]hexane in the gas phase, in solution in carbon tetrachloride or trifluorotrichloroethane, or as pure liquid, led to more than 95% of a single monochloride in good yield. Evidence to show that this compound is 2-chlorobicyclo[2.1.1]hexane is presented. Further chlorination gave 2,2-dichlorobicyclo[2.1.1]hexane and *trans*-2,3-dichlorobicyclo[2.1.1]hexane as products.

A Binder-Type Plate for Charge-Transfer Electrophotography, D. W. Chapman and F. J. Stryker, *Photographic Science and Engineering* 11, No. 1, 22-29 (February 1, 1967).

A Zn CdS binder-type plate, developed for charge-transfer electrophotography, could have significant advantages over both zinc oxide coated papers and amorphous selenium plates in that it does not require dark adaptation, it is reusable, its photographic performance is comparable to that of selenium, and it should be more economical to make than selenium plates. Environmental tests indicate that, in its present status, the plate is insensitive to storage at high temperature and relative humidity, but suffers from a reversible reduction in charge acceptance when cycled repetitively at high relative humidities.

Block-Stochastic Matrices and Associated Finite-State Languages, W. Kuich and K. Walk, *Computing* 1, No. 1, 50-61 (1966).

Finite automata are considered whose transition matrix is block-stochastic. The block-stochastic structure defines an equivalence relation among states of the automata. The implications of this relation are investigated, especially with respect to the languages accepted in the states of the automata.

Brazing Strong, Reliable Joints, J. A. Ferrante, *Tool and Manufacturing Engineer* 58, No. 2, 47-49 (February, 1967).

Brazing with copper in a hydrogen atmosphere is an effective way of joining steel parts that must later be heat treated. Joint design, fit tolerances, surface finish, type of steel, and furnace atmosphere are factors that will affect the quality of a finished joint.

Complete Multi-Configuration Self-Consistent Field Theory, A. Veillard and E. Clementi, *Theoretica Chimica Acta* 7, No. 2, 133-143 (February, 1967).

The two-configuration self-consistent field formalism previously presented is extended and the CMC SCF LCAO MO (complete multi-configuration self-consistent field LCAO MO) technique is presented. The single Slater determinant for a $2n$ electron system is replaced by a combination of determinants built from two sets of MO's, one containing n orbitals; the second, $(\omega - n)$ orbitals. All the possible double excitations from the (n) set to the $(\omega - n)$ set are considered. The orbitals as well as the linear combination of determinants are simultaneously optimized making use of the self-consistent field technique.

Complete Sets of Functions of Two and Three Binary Variables, V. Kudička and P. Oliva, *IEEE Transactions on Electronic Computers* EC-15, No. 6, 930-931 (December, 1966).

A catalog of all nonredundant complete sets of functions of two and three binary variables is presented in the form of a table.

Computer Application for Selecting Damping Materials, Parts I and II, D. M. Preiss, W. C. Rodgers and D. W. Skinner, *Rubber Age* 99, No. 1, 76-82 (January 1967); 99, No. 2, 62-66 (February 1967).

A computer program for using elastomers in damping applications is described. The program contains the damping characteristics for twenty-three elastomers. Masses, spring constants, initial velocities, displacements, and equilibrium positions of the impacting members are used as input to the program. The output describes the dynamic response of the system as a function of time.

Computer Simulation of Stepping-Motor Performance, J. R. Dailey, *Electro-Technology* 79, No. 3, 60-64 (March, 1967).

Conventional analog computer techniques are compared to the Pactolus and DSL/90 digital computer programs as methods for piecewise analysis of stepping-motor performance.

On Connecting Modules Together Uniformly to Form a Modular Computer, E. G. Wagner, *IEEE Transactions on Electronic Computers* EC-15, No. 6, 864-873 (December, 1966).

A modular computer may be informally defined to be a device consisting of a large (or infinite) number of identical circuit modules connected together in some uniform manner. This paper is concerned with making the concept of "connected together in a uniform manner" mathematically precise. Uniformity of connection in a modular device is first defined in terms of the linear graph whose vertices correspond to the modules and whose edges correspond to the cables connecting them. It is shown that the class of graphs satisfying the definition is precisely the class of group-graphs; that is, the vertices correspond to the elements of a group G , and there is a finite subset G_0 of G ($1 \in G_0$) such that $\{g, g'\}$ is an edge of the graph if, and only if, there exists g_0 in G_0 such that $g' = gg_0$. It is then shown that restricting the group G to be Abelian restricts the patterns of simultaneous activity which may occur within the computer.

A Continued Fraction Algorithm for the Computation of Higher Transcendental Functions in the Complex Plane, I, Gargantini and P. Henrici,* *Mathematics of Computation* 21, No. 97, 18-29 (January, 1967).

This report deals with the numerical evaluation of a class of functions of a complex variable that can be represented as Stieltjes transforms of non-negative real functions. The considered class of functions contains, among others, the confluent hypergeometric functions of Whittaker and the Bessel functions. The method makes it possible, in principle, to compute the values of the function with an arbitrarily small error, using one and the same algorithm in whole complex plane cut along the negative real axis. Detailed numerical data are given for the application of the algorithm to the modified Bessel function $K_0(z)$.

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Cyclic Codes in Multiple Channel Parallel Systems, K. Y. Sih and M. Y. Hsiao,* *IEEE Transactions on Electronic Computers* EC-15, No. 6, 927-930 (December, 1966).

The well-known cyclic error-correcting codes are used so far only for serial systems; that is, systems having a single channel with information transmitted one bit at a time. In data-processing equipment and communication systems, information is often transmitted serially by characters and parallel by bits within a character. That is, there are several channels in parallel. Error

correction in the existing multiple channel systems has been restricted to the use of block codes with the block length equal to the number of channels. The use of cyclic codes will allow the length of a code word many times greater than the number of parallel channels. This offers simple mechanization and, at the same time, reduces the redundancy of the system.

In this note we present a method of design and implementation of cyclic codes in multiple channel systems. The codes have the same algebraic structure as in the serial systems. The method is based upon a serial-to-parallel transformation of linear sequential circuits, in which the transfer matrix of the circuit plays a key role.

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Data Management Concepts for DOS/360 and TOS/360, A. R. Cenfetelli, *IBM Systems Journal* 6, No. 1, 22-37 (1967).

The data management function is discussed in the specific context of DOS/360 and TOS/360, the disk and tape operating systems for intermediate System/360 configurations. Explained are the processing routines of the data management facilities, collectively referred to as the input/output control system. Techniques that keep the routines small in size, efficient in operation, and simple to use are emphasized.

Dielectrically Isolated Silicon with a Sharp Impurity Gradient, V. Y. Doo and D. K. Seto, *Electrochemical Technology* 5, No. 3-4, 87-89 (March-April, 1967).

Sharp impurity gradient at the $N - N^+$ or $P - P^+$ interface and low collector resistance are required for high-frequency transistors. $N - N^+$ or $P - P^+$ impurity profiles in the dielectrically isolated silicon produced by using methods known today suffer severe gradation because of the subsequent heating during the oxidation and polycrystalline silicon deposition. A new method, etch epitaxial refill (EER), which gives sharp impurity gradient and low collector resistance after isolation is described and the results of applying it are discussed.

Discrete-State Feedback—A Route to Minimum Control, R. H. Thomas and P. P. Tong, *Instrumentation Technology* 14, No. 4, 59-61 (April, 1967).

Discrete-state feedback takes place in a non-continuous and time-independent manner. More specifically the feedback occurs only when the state variable under consideration experiences a prescribed change or reaches a predetermined value. This differs from continuous and sampled-data feedback. Discrete-state feedback emphasizes the concept of minimum control and is attractive for digital machines because the control function is essentially a digital sequential process.

A logical method (flow chart) is described which will assist the control engineer in deciding whether discrete-state feedback is the technique to use for a particular application. A printed circuit motor for a high-speed incrementor is used as a design example and the reader is shown step-by-step how to utilize the technique.

Dynamic Mechanism Reliability by Monte Carlo Methods, F. R. Van Wagner, *Eighth Annual ASQC West Coast Reliability Symposium*, pp. 71-83, (February 18, 1967).

The Monte Carlo method provides a way of evaluating a complex reliability formula which would defy ordinary analytic ap-

proaches in all but a handful of trivial cases. The formula itself, derived by a technique called conditional convolution, gives the exact probability that a randomly constructed mechanism can perform a given task N times with R or fewer failures. Two computer programs, one a general-purpose Monte Carlo simulator, have been developed to handle the computations. They have been applied many times by IBM engineers to design-reliability problems with proven success.

Equivalent DC Sputtering Yields of Insulators, P. D. Davidse and L. I. Maissel, *Journal of Vacuum Science and Technology* 4, No. 1, 33-36 (January-February, 1967).

Insulators can be sputtered by applying a radio frequency potential to an electrode behind the dielectric target. This technique can be used successfully for the deposition of high-quality films at high rates. However, this technique cannot be used for absolute measurements of sputtering yields because of the spread in energies of the bombarding ions. This paper describes how these yields can be studied by simultaneously sputtering with the insulators other materials with known dc sputtering yields.

Estimating Flight Time for Optimum Trajectories, R. L. Duty, *IEEE Transactions on Aerospace and Electronics Systems* AES-3, No. 2, 179-185 (March, 1967).

Various methods are presented for estimating the flight time for vehicles that fly an optimum trajectory. A realistic example is considered in order to display the inherent accuracy of each of these methods. Numerical integration methods are found to be the most accurate. Simple formulas are derived for the case where a less accurate estimate is acceptable. All of these methods require less computation than would be required in order to solve the overall optimization problem. Thus any one of these methods can be applied to an on-board guidance scheme or control system that requires a real-time estimate of the time-to-go.

An Experimental Investigation of a Mixed-Font Print Recognition System, C. N. Liu and G. L. Shelton, Jr., *IEEE Transactions on Electronic Computers* EC-15, No. 6, 916-925 (December, 1966).

This paper discusses an experimental study of a mixed-font print recognition system. With a program-controlled CRT scanner input, using 96 N -tuple recognition measurements with ternary minimum distance decision, the system reported is capable of reading a variety of type styles at a performance level which is quite acceptable for fair to good quality print. Performance is marginal for poor quality print.

Function and Design of DOS/360 and TOS/360, G. Bender, D. N. Freeman and J. D. Smith, *IBM Systems Journal* 6, No. 1, 2-21 (1967).

The functions of disk and tape operating systems for System/360 configurations with as little as sixteen thousand bytes of main storage are discussed. The two related systems are designed to provide a range of services that include input/output control, stacked-job control, symbolic device assignments, and library maintenance. A set of language translators, a set of sort/merge programs, and various other programs go far toward minimizing the effort required of program preparation. Design objectives, system definitions, and functional capabilities are stressed. The design of the control program is discussed in some detail.

Ein Funktionsschema des Gehörs zur Beschreibung der Erkennbarkeit kleiner Frequenz- und Amplitudenänderungen, (A functional model of the ear for explaining the detectability of small changes in frequency and amplitude)*, D. Maiwald, *Acustica* **18**, No. 2, 81-92 (1967).

A functional model is suggested for explaining the behavior of the ear in detecting small changes of a sound. According to this model the ear does not process the changes of sound spectrum directly. Rather, the stimulating sound produces an auditory excitation pattern $L_E(z)$, [L_E = excitation level, z = critical band function], and all changes of the sound cause alterations of the excitation level as a function of time. In the functional model the excitation pattern is scanned by a large number of identical detectors each detecting temporal changes, $\Delta L_E(z_i)$, of the excitation level at a fixed locus z_i . Additional detectors for recognizing frequency changes are not necessary since variations of the center frequency of a sound also influence the excitation level $L_E(z_i)$ due to the selectivity of the spectrum-excitation-transformation. Therefore small changes in amplitude as well as in frequency can be detected by the single type of detector which reacts upon changes of the excitation level, i.e., variations of amplitude only.

The conceptions on which the fundamental model is based are checked by several experiments. The results of the measurements indicate that simultaneous changes of a sound in frequency and in amplitude clearly influence each other in the detecting process of the ear. Thus the assumption is supported that the ear does not use any separate pitch detectors, at least in the region of the threshold for small changes. Furthermore it is confirmed by experiments that the decisive factor for the detection of small frequency changes is the maximum slope of the excitation pattern. In the case of pure tones this slope is directly given by the selective qualities of the spectrum-excitation-transformation. Moreover it can be deduced from the experimental results that always those sections of the excitation pattern $L_E(z)$ are decisive for the detection of sound changes which show the greatest changes of level.

* Work performed at the Institut für Nachrichtentechnik der Technischen Hochschule Stuttgart.

A High Speed Associative Memory, A. W. Bidwell and W. D. Pricer, *Digest of Technical Papers, 1967 International Solid-State Circuits Conference*, pp. 78-79 (February, 1967).

This paper describes a simple associative memory cell as used in a high speed 8-word experimental model with 15 nsec interrogate delay and in an experimental time sharing system of 64 words.

High-Speed Wavelength Selection in the Laser Cavity, M. A. Habegger, *Applied Physics Letters* **10**, No. 3, 103-105 (February 1, 1967).

The performance and limitations of a nonmechanical wavelength selector are reported. This device, when placed in an argon laser cavity, can switch laser oscillation from one wavelength to another in a time of the order of $1 \mu\text{sec}$.

Internal Data Management Techniques for DOS/360, D. H. Ricour and V. Mei, *IBM Systems Journal* **6**, No. 1, 38-48 (1967).

A technique for individual preassembly and linkage of input/output program sections, which reduces overall assembly time, is described. Also discussed are two techniques used in generating

channel programs for direct-access devices. One of the techniques is designed for random addressing of records, the other for indexed sequential addressing. The developmental work that led to these techniques was heavily influenced by the objective of effectively minimizing the amount of main storage required for the input/output control functions in DOS/360, the disk operating system for System/360 configurations with intermediate amounts of main storage.

Laser Pulse Distortion in a Nonlinear Dielectric, R. J. Joenk and R. Landauer, *Physics Letters* **24A**, No. 4, 228-229 (February 13, 1967).

The velocities of the envelope and phase are derived for a laser pulse propagating in a nonlinear dielectric with intensity dependent index of refraction and an estimate made of the frequency shift due to the nonlinearity.

Low Cost General Purpose Computer for Missile Guidance, W. N. Carroll and F. F. Jenny, *Electronics* **40**, No. 5, 171-176 (March 6, 1967).

The article describes the performance of a general purpose digital computer which alters the historical economic advantage that analog, hybrid, and incremental computers have enjoyed in missile guidance applications. Through the use of monolithic integrated circuits, mass produced high speed core memories, low cost packaging techniques, and an optimized organization, the computer promises to provide greater performance, flexibility, and reliability at equal or lower cost than traditional approaches.

Luminescence from GaP Containing Silicon, M. R. Lorenz and M. H. Pilkuhn, *Journal of Applied Physics* **38**, No. 1, 61-63 (January, 1967).

An emission line in GaP of previously unexplained origin peaking at about 1.96 eV (6300 Å) at 77°K was studied in electroluminescence of forward biased $p-n$ junctions and in photoluminescence. We attribute this band to the presence of Si and establish its dependence on Si concentration. The peak energy position of the 1.96 eV band is dependent on the identity of the dominant shallow donors thereby indicating that the deep center is an acceptor. The results indicate that Si substitutes at Ga sites and acts as a shallow donor. At high electron concentrations Si occupies also P sites where it is a compensating acceptor with a level about 0.25 eV above the valence band. The dependence of current and light intensity on voltage was studied. The 1.96 eV line has an external quantum efficiency at 77°K of up to 1.4×10^{-5} but is rapidly quenched with increasing temperature.

Das magnetische Feld einer unsymmetrischen Parallelbandleitung mit magnetischem Rückschluss, (The magnetic field of unsymmetrical striplines with magnetic keepers), W. Jutzi, *Archiv der elektrischen Uebertragung* **21**, No. 4, 190-196 (1967).

The magnetic field of slotted unsymmetrical striplines with a magnetic keeper is investigated taking into account a finite conductivity of a very thick groundplate. The strips are divided into a sufficient large number of substrips, so that in every substrip the current density may be assumed to be constant. The magnetic field of a thin substrip is represented in closed form at dc and at very high frequencies. Between these limiting cases the frequency

dependence is described with easily computable integrals. It is shown how the keeper increases the magnetic field under the strips and reduces its frequency dependence. A set of linear equations with the coupling impedances of the substrips yield the current distribution on the strips. Finally the magnetic fields of all substrips are superposed.

Measurement of Picosecond Laser Pulse Widths, J. A. Armstrong, *Applied Physics Letters* **10**, No. 1, 16-18 (January 1, 1967).

The special symmetry properties of second-harmonic generation at the surface of a GaAs crystal are used in a technique which measures the shape of the fast pulses from a mode-locked Nd-glass laser. The pulses studied were found to have a full width at half power of between 4 and 6 picoseconds. The technique is capable of measuring pulse widths at least as short as 4×10^{-13} sec.

The Measurement of Protective Film Thickness on Silicon Wafers by Reflectance Spectrophotometry, E. A. Corl, *Instrument News* **17**, No. 3, 14-15 (March, 1967).

The surfaces of silicon semiconductor devices must be protected against harmful substances in the atmosphere which may cause their operating characteristics to deteriorate. A film of silicon dioxide generated by thermal oxidation of the bulk silicon or by pyrolytic decomposition of silanes is generally used as a passivation immediately adjacent to the silicon-oxide interface. This film is also used as a mask against diffusants during fabrication of the device and as electrical insulation from metal films connecting active portions of interconnecting leads, and subsequently to package leads. A thicker layer of silicon dioxide is produced by steam oxidation after the completion of necessary diffusions within the several layers of the wafer. The resulting oxide layer prevents contamination from reaching the surface of the silicon during operation. Holes are etched through the oxide by conventional photo-lithographic techniques to provide contact to the devices such as diodes, transistors, resistors, etc., in the silicon.

Measuring Current Gain in Power Transistors, K. W. Smith, *Electro-Technology* **79**, No. 2, 56-60 (February, 1967).

This article presents techniques for measuring the common emitter current gain of power transistors from dc to frequencies of several megacycles. The selection of impedances which will properly terminate the device input and output over this frequency range is discussed in detail. It is shown that the collector of a power transistor must be terminated in an impedance of only a few ohms if accurate measurements are to result. A method of establishing the error introduced in the measurement of h_{fe} due to incorrect selection of terminating impedances is illustrated.

Microscopic Free Energy and Order Parameters of Antiferroelectrics, P. B. Miller and P. C. Kwok, *Solid State Communications* **5**, No. 1, 57-60 (January, 1967).

A microscopic free energy function for antiferroelectrics has been derived as a power series in a complete set of order parameters which are the thermal averages of normal coordinates whose wave vectors form a group G . Furthermore it has been shown that the wave vectors of the non-zero order parameters at all the extrema of the free energy form subgroups of G and that there will always be a net polarization in the antiferroelectric phase. The general discussion is illustrated by application to the antiferro-electric transition of PbZrO_3 .

Multilayer Boards by Computer, W. D. Markovitz, *Electronic Products* **9**, No. 9, 92-94 and 96 (February, 1967).

Many companies are now using computers to generate the wiring patterns for multilayer printed circuit boards. This paper describes some details of the process.

Nondestructive Readout in Thick Magnetic Film Devices, H. H. Zappe, *IEEE Transactions on Magnetics Mag-3*, No. 1, 2-5 (March, 1967).

To study the nondestructive readout properties of thick magnetic film devices, sense voltages are computed for triangular interrogate word pulses. Eddy currents are assumed to be the exclusive damping mechanism. For a given pulse rise time one can obtain a maximum signal peak value with a given optimum film thickness, and the read signal of an optimized film can be approximated by simple analytical functions. In an attempt to describe the nondestructive readout stability, a relation is developed between pulse widths, angle of rotation of the magnetization, and reversibility threshold.

Nonlinear Oscillations in a Distributed Network, R. K. Brayton, *Quarterly of Applied Mathematics* **24**, No. 4, 289-301 (January, 1967).

The oscillations of small amplitude in a lossless transmission line terminated with a nonlinear circuit are studied by perturbation theory. The equations describing this system are reduced to a difference-differential equation with one delay. A general procedure is given for equations of this type for finding the expansion of the oscillation to any order in terms of the coefficient of the fundamental frequency. The frequency-amplitude relations are obtained to second order and compared with results found on the computer. Both the autonomous and forced cases are studied. It is indicated in the forced case that the frequency-amplitude relation gives approximately the range of "locking in."

Nonlinear Scattering of Electrons by Laser Beam, P. T. Chang, *Physics Letters* **24A**, No. 2, 130-132 (January, 1967).

Direct observation of nonlinear scattering of electrons by a laser beam has been reported, but the probability of reflection appeared much higher than what was predicted by the Kapitza and Dirac formula. Since it is well known that the intensity of a laser beam has a Gaussian distribution, it can be shown that energy conservation is preserved if this distribution is taken explicitly into account in the calculation.

Numerical Evaluation of Wiener Integrals, A. G. Konheim and W. L. Miranker, *Mathematics of Computation* **21**, No. 97, 49-65 (January, 1967).

A systematic study of quadrature formulae for the Wiener integral $\int F[x]w(dx)$ of the type $\int F[\theta(u, \cdot)]w(du)$ is presented. The Cameron and Vladimirov quadrature formulae, which are the function space analogues of Simpson's Rule, are shown to fit into this framework. Numerical results are included.

Optical and Electrical Properties of Epitaxial and Diffused GaAs Injection Lasers, M. H. Pilkuhn and H. Rupprecht, *Journal of Applied Physics* **38**, No. 1, 5-10 (January, 1967).

GaAs injection lasers were prepared by an epitaxial solution growth method and their properties compared with those of diffused junctions. The optical gain factor β was up to a factor of 7 higher for the epitaxial diodes at 300°K. This resulted in threshold current densities as low as 26,000 A/cm² (3.8×10^{-3} cm length) at 300°K. At 77°K, gain factor and loss numbers were similar for the two laser types. The spontaneous line-width of the epitaxial lasers was unusually large (~ 300 Å at 77°K) and increased with decreasing junction voltage. The internal quantum efficiency of epitaxial diodes drops from 100% at 4.2°K to 40% at 300°K. The vertical beam spread was found to be between 20°–30° half-width at 77°K as well as at 300°K. Diffused diodes frequently show a delay between the current pulse and the stimulated emission of up to 30 nsec, dependent on the current value at higher temperatures. No such delay was observed in epitaxial lasers.

Optical Reader is not Affected by Light Intensity Variations, N. D. Kline, *Electronic Design* 15, No. 4, 112–113 (February 15, 1967).

A circuit is described which will produce an output voltage directly proportional to the contrast ratio of the input voltage. The circuit can be used in mark sensing machines or in applications where the output is compared to a preset threshold for switching purposes or where the output is compared to select the channel with the maximum output voltage or contrast ratio to aid in distinguishing erasures.

Picosecond Silicon Monolithic Current-Switching Circuit Using P-N Junction Isolation and Diffused Resistors, B. P. F. Wu, C. Y. Chen and V. A. Dhaka, *Digest of Technical Papers, 1967 International Solid State Circuits Conference*, pp. 66–67 (February, 1967).

The circuit delay of a digital silicon monolithic circuit can be calculated from its component design and circuit layout. Current-switching circuits using *p-n* junction isolation, diffused resistors, and multilayer interconnections have been fabricated. The measured circuit delay ranged from 320 to 540 picoseconds and agreed with the designed values of 300 and 520 picoseconds, respectively.

Polarizability of a Two-Dimensional Electron Gas, F. Stern, *Physical Review Letters* 18, No. 14, 546–548 (April 3, 1967).

The response of a two-dimensional electron gas to a longitudinal electric field of arbitrary wavevector and frequency is calculated in the self-consistent field approximation. The results are used to find the asymptotic screened Coulomb potential and the plasmon dispersion for a plane of electrons imbedded in a three-dimensional dielectric.

Post Depositional Structures in the Lias, South Wales, F. J. Wobber, *Journal of Sedimentary Petrology* 37, No. 1, 166–174 (March, 1967).

References to bedding surface irregularities in the British Lias limestones as being of secondary origin are reviewed in light of recent studies in South Wales. Protuberances on both top and bottom of some limestone units are the products of loading, vertical stresses created by weight of overburden after burial, and interstratal sliding partly due to local subsidence; some structures are further distorted by localized, multi-directional, compactional stresses. Four descriptive limestone groups have been

identified and post depositional processes contributing to their formation analyzed. Many of the structures described from the Lias of Britain occur in similar paleozoic sediments of North America, and have yet to be described.

Properties of a Model for Parallel Computations: Determinacy, Termination, Queueing, R. M. Karp and R. E. Miller, *SIAM Journal of Applied Mathematics* 14, No. 6, 1390–1411 (November, 1966).

This paper gives a graph-theoretic model for the description and analysis of parallel computations. Within the model, computation steps correspond to nodes of a graph, and dependency between computation steps is represented by branches with which queues of data are associated. First, it is shown that each such computation graph *G* represents a unique computation, determined independently of operation times. Next, methods of determining whether such a computation terminates and of finding the number of performances of each computation step are developed. The maximal strongly connected subgraphs of *G* and the loops within these subgraphs play a central role in this analysis. For example, use is made of the result that either every computation step within a strongly connected subgraph of *G* is performed an infinite number of times, or none is. Finally, necessary and sufficient conditions for the lengths of data queues to remain bounded are derived.

Rapid Potentiometric Determination of Fluoride at High Concentrations, J. M. Hogan and F. Tortorici, *Analytical Chemistry* 39, No. 2, 221–223 (February, 1967).

The development of a rapid and reliable method for the determination of fluoride has been the objective of numerous investigations. In the proposed method, fluoride is precipitated with lead nitrate and a known concentration of HCl. The liquid portion is separated by filtration, and the excess chloride determined potentiometrically.

Real-Time Systems in Perspective, J. D. Aron, *IBM Systems Journal* 6, No. 1, 49–67 (1967).

The more important characteristics of real-time systems are listed, discussed in an historical context, and illustrated by remarking on relevant features of typical applications. Because the intent of the paper is to provide a general survey, no attempt is made at a truly rigorous definition of the term "real-time." The point of view taken is a functional one, viz., that the distinguishing properties of most real-time systems stem directly from the distinctive needs of five different classes of applications: control, command and management information, time-shared computing, remote batch computing, and data acquisition. A number of general references are included for the reader who is interested in more detail on the various aspects of real-time systems.

Residual Strains in Phosphorus-Diffused Silicon, M. L. Joshi, C. H. Ma* and J. S. Makris, *Journal of Applied Physics* 38, No. 2, 725–734 (February, 1967).

An x-ray line-broadening method is used to determine the residual strain level in a single-crystal silicon slice diffused with high amounts of phosphorus (surface concentration $> 10^{21}$ atoms/cm²). The strain level was found to be higher than that from the Prussin model. This is shown to be due to insufficient penetration of the diffusion-induced dislocations inside the diffused layers. Moreover, the strains along $\langle 220 \rangle$ directions were found to

be considerably higher than those along other directions. This is interpreted as additional broadening along the Burgers vector direction.

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Rolle und Bedeutung formeller Sprachen bei der industriellen Automation (Use of formal languages in the industrial automation process), H. Zemanek, *Elektrotechnik und Maschinenbau* **83**, No. 6, 463ff (1966).

Considered are formal languages as a means for describing industrial manufacturing processes. The historical background and the main principles for designing formal languages are outlined. Some of the existing formal languages for computing processes (ALGOL, FORTRAN, COBOL) and for Automatically Programmed Tools (APT) are discussed.

SCEPTRE Gives Designers New Power, S. R. Sedore and J. R. Sents, *Electronic Design* **15**, No. 6, 230-234 (March 15, 1967).

The article outlines the progress which has been made recently in the development of automatic transient analysis programs. Electronic equipment has become so complex that the analysis of its operation cannot be accomplished manually. Digital computers have become powerful tools for resolving such problems, but the proper use of a digital computer is also a complex problem. The circuit analysis program, SCEPTRE, bridges the gap between the design engineer and the computer.

Semiotics and Programming Languages, H. Zemanek, *Communications of the ACM* **9**, No. 3, 139-143 (1966).

The term pragmatics and the notion are traced back in history: the definitions of Morris for the semiotic dimensions are given and the contribution of the "Wiener Kreis" is described. Relationships of semiotics to other aspects of language theory are treated. A definition of the notion of a language and a programming language in particular is tried and the reasons for artificial formal languages are given. The borderlines between the semiotic aspects are traced and the different possible fields in pragmatics of programming languages are outlined.

Some Electrical Properties of the Semiconductor β -Ga₂O₃, M. R. Lorenz, J. F. Woods and R. J. Gambino, *Journal of Physics and Chemistry of Solids* **28**, No. 3, 403-404 (1967).

The wide-band gap semiconductor β -Ga₂O₃ has an electron mobility of the order of 100 cm²/V-sec at room temperature. Single crystals grown under reducing conditions have about 2×10^{18} free carriers, apparently due to anion vacancies.

Some Theory of Sampling When the Stratification is Subject to Error, T. Dalenius* and S. P. Ghosh,** *Technometrics* **9**, No. 1, 1-13 (February, 1967).

In this paper we present sampling theory pertinent to the following type of sample design. Each one of the B boxes is shaken and classified into one of L strata on the basis of the auditory observation made concerning the quality of the content. A sample of boxes is selected from each stratum, and an accurate observation is made by inspecting the content of each box selected

for the sample. The efficiency of this design will depend upon the accuracy of the auditory observation, and also on the costs involved.

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Stability of Palladium Oxide Resistive Glaze Films, E. H. Melan, *Microelectronics and Reliability* **6**, No. 1, 53-65 (February, 1967).

Process variables that affect the resistivity and TCR of the Pd-Ag glass resistor system are, for a fixed electrode system: composition, firing temperature and time, and substrate material. While the greatest changes occur via composition variations, particularly Ag and glass, substantial changes to R_s and TCR can be made by varying the firing cycle or substrate material. For the latter, certain physical and thermal constraints may preclude a wide choice of base materials. Determining the effect of process latitude on device stability becomes the next objective.

Stability of electrical parameters was determined through large-scale, long-term tests involving a matrix of 14 firing processes and 19 environmental conditions of temperature, humidity and load. Results for 3200 test hours indicated resistor drift to be within ± 1 per cent under ambient humidity conditions and up to 90°C and 6 W/in² for most processes. Distributional drift behavior shows a progressive widening—both negative and positive—of ΔR with time. Accelerated testing done at elevated temperatures shows drift to be primarily positive, with a decreasing rate of change with time, and exhibiting three acceleration regions. Humidity tests show some moisture susceptibility when compared with lower RH controls but still of a relatively small magnitude. Various encapsulants may serve to inhibit moisture. The effects of resistor adjustment by sand abrasion and various compositions on stability were also evaluated. TCR was found to be essentially invariant under the test conditions described.

Standing Waves in Self-Trapped Light Filaments, R. G. Brewer and C. H. Townes,* *Physical Review Letters* **18**, No. 6, 196-199 (February, 1967).

Intense light tends to be trapped in very small filaments in an optical material. It is shown here that under some conditions of sufficiently high intensity, light waves of approximately equal intensity travel in the backward and forward directions in these filaments, and the resulting standing waves produce visible spatial beats. This effect allows a rather direct detection of substantial changes in the index of refraction within the trapped filaments.

* MIT.

Study of Electroabsorption Using Differential Photocurrent Response, K. G. Ashar and R. L. Anderson,* *Physical Review* **154**, No. 3, 721-730 (February 15, 1967).

A method is devised to study the tunneling-assisted photon absorption process (Franz-Keldysh effect) in semiconductor junctions, making use of the differential photocurrent response. This method has advantages over the differential-transmission method in the region of high absorption coefficient. Measurements were made using this technique on GaAs, Ge, and Si p - n junctions. The results on GaAs and on Ge are in qualitative agreement with theory and with published results of transmission measurements. No theory is available corresponding to the results of silicon.

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System Performance Evaluation: Survey and Appraisal, P. Calingaert,* *Communications of the ACM* 10, No. 1, 12-18 (January, 1967).

The state of the art of system performance evaluation is reviewed and evaluation goals and problems are examined. Throughput, turnaround, and availability are defined as fundamental measures of performance; overhead and CPU speed are placed in perspective. The appropriateness of instruction mixes, kernels, simulators, and other tools are discussed, as well as pitfalls which may be encountered when using them. Analysis, simulation and synthesis are presented as three levels of approach to evaluation, requiring successively greater amounts of information. The central role of measurement in performance evaluation and in the development of evaluation methods is explored.

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Systems Aspects of Solid-State Differential Amplifiers, R. H. Thomas, *ISA Transactions* 6, No. 1, 25-30 (January, 1967).

An equation for determining the effect of amplifier-circuit configuration on overall system accuracy and performance is derived. A model of a solid-state differential amplifier suitable for use in systems design is developed. Interpretation of the commonly available amplifier specifications in terms of the model parameters is presented. Included are some representative values for the model parameters. The differential amplifier model and accompanying equations derived in this paper permit the system engineer to consider a differential amplifier as another component in the total system.

3-D Imagery and Holograms of Objects Illuminated in White Light, R. V. Pole, *Applied Physics Letters* 10, No. 1, 20-22 (January 1, 1967).

Described is a method of obtaining holograms of 3-D objects illuminated in white light. First, a 3-D scene, illuminated in white light, is photographed through a fly's eye lens. If this photograph is projected through the same lens it yields a real 3-D image of the object directly. However, by using coherent light for projection, this real image can be used to make a hologram, which in turn yields both a real and a virtual image of the object.

Tracer Controlled Milling for Short-Run Parts, R. S. Gwynn, *The Tool and Manufacturing Engineer* 58, No. 1, 65-67 (January, 1967).

A simple line drawing, a Masterline Tracer and a vertical milling machine are combined for the automatic production of prototype and short-run parts. Particular emphasis is placed on machining irregular shaped parts.

Tracer Evaluation of Hydrogen in Steam-Grown SiO₂ Films, P. J. Burkhardt, *Journal of the Electrochemical Society* 114, No. 2, 196-201 (February, 1967).

Silicon wafers were oxidized in capsules at 1000°C with 1 atm of tritium-tagged steam. The oxide films formed were investigated by conventional tritium counting techniques. The hydrogen profile suggested a complementary error function type indiffusion of water, giving a C_0 of 4×10^{19} molecules of H₂O per cm³. The profile had a minimum value at around 600 Å oxide thickness. The location of this value was independent of

original oxide thickness. Following this minimum, the concentration again increased as the Si/SiO₂ interface was approached. The concentration of hydrogen near this interface was greater for the thinner oxide films. This observation led to the conclusion that either a hydrogen-containing intermediate is formed by the reaction between water and silicon and that the concentration of this intermediate is dependent on the oxidation rate or that a transition region exists in the oxide film which permits segregation of the diffusant near the Si/SiO₂ interface. Thermal biasing experiments followed by surface charge measurements and autoradiograms showed that mobile positive charge was present in oxide near the Si/SiO₂ interface. However, this mobile charge was not hydrogen or a hydrogen-containing species. Out-diffusion experiments yielded an activation energy of 15.7 kcal/mole for the tritium species.

Transient Magnetic and Electric Fields Above a Conducting Ground Plane of Arbitrary Thickness, W. Liniger and S. Schmidt, *IEEE Transactions on Magnetics* MAG-2, No. 4, 727-732 (December, 1966).

The time-dependent Maxwell equations without displacement current terms are solved above, within, and below a doubly infinite slab of finite conductivity and arbitrary thickness D with a prescribed current in an infinitely long wire above and parallel to the slab. Closed analytic expressions for the magnetic and electric field above the ground plane are obtained by transform methods in terms of a Laplace transform variable representing time. For finite D the results in actual time are computed by numerical inversion of the Laplace transform; for $D = \infty$ they are given analytically to within numerical quadratures. Asymptotic expressions valid for large time and/or large lateral distance from the wire are obtained both for $D < \infty$ and $D = \infty$. A summary of numerical results is given.

Travelling Solvent Defects on Silicon Wafers, E. Biedermann, *Journal of the Electrochemical Society* 114, No. 2, 207-208 (February, 1967).

A special surface defect, which is observed occasionally on Silicon wafers after deposition of an epitaxial Si-layer has been identified as being caused by small impurity pellets which, liquid at the temperature of the epitaxial process, travel over the wafer surface under the influence of the incidental temperature gradients thereon. Electron microprobe analysis showed the pellets to contain the elements Fe, Cr, and Ni in about the ratio of stainless steel 70:20:8. Similar surface defects can easily be produced by seeding a pure Si wafer with small grains of other metals such as Cu, Ag, Cr, Ni, Pd, or Pt and heating the wafer in an inert atmosphere to slightly above the respective eutectic point with silicon.

The Tunneling Cryotron—A Superconductive Logic Element Based on Electron Tunneling, J. Matisoo, *Proceedings of the IEEE* 55, No. 2, 172-180 (February, 1967).

This paper discusses the operation of a new superconductive logic element. In geometry, the element resembles the in-line cryotron and like the in-line cryotron exhibits gains of greater than unity when biased. The gate, however, is a Josephson junction. The two states, zero-voltage and "resistive," of the junction are both superconducting states, one being a pair tunneling state, the other a single-particle tunneling state. The transition from one state to the other takes place in less than 800 psec (the resolving time of the apparatus). If used in a flip-flop circuit in a current steering mode, current transfer times are calculated to be less than 200 psec.

Two Statistical Evaluation Criteria for Predicting Performance of Microelectronic Circuits, D. B. McKay, *Semiconductor Products and Solid State Technology* 10, No. 3, 55-58 (March, 1967).

Two statistical design techniques—the Monte Carlo method and the direct calculation method—are described as they relate to microelectronic circuit design parameters (transistor V_{BE} and Beta variations, resistor values, etc.). The method for implementing these two techniques is reviewed for a number of sample circuits. A technique known as "tracking" is also included in mathematical form for a simple transistor circuit. Two generalized program flow charts are included as a guide for predicting and verifying dc design techniques applied to ac performance.

Unusual Aspects of Indigenous Microflora as Determined in Men Undergoing Simulated Space Conditions, D. Shorestein, A. E. Prince, * J. D. Gatts,** and P. E. Riely, *Preprints of Scientific Programs 1967 Annual Meeting of Aerospace Medical Research*, pp. 307-308 (April 10, 1967).

In studies conducted at the Aerospace Medical Research Laboratories at Wright-Patterson Air Force Base, Dayton, Ohio to determine the indigenous microflora of men and the changes occurring under altered conditions of environment and personal hygiene protocols, several groups of organisms previously not considered to be major portions of the normal flora were isolated in high numbers and with great frequency.

Corynebacteria, once considered to be a minor organism on the skin, was found to predominate over, or at least be of the same order of magnitude as the Staphylococci. Many strains not able to be identified by existing classifications were isolated and our own schema for separation of these organisms were established. These results could lead to important considerations in clinical bacteriology.

E. coli of the potentially dangerous enteropathogenic types were recovered in greater numbers than were to be expected and in certain subjects shifts in the type of coli were noted to a point where over 50% of the coli isolated were of enteropathogenic types. The spread of these organisms to areas not normally host to them was observed under certain experimental conditions.

By use of special culturing techniques obligate anaerobic organisms of the genus *Peptococcus* were recovered with regularity from certain body areas and their indigenous natures seemed apparent although a majority of the literature does not indicate the significance or common nature of their occurrence.

By performance of both qualitative and quantitative studies, differences and similarities were discovered which would not have been apparent by use of only one approach. This was particularly evident in studies to determine the bilateral symmetry of the microbial populations on the body—in particular, on the groin.

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Variable Preset Counter Uses Inexpensive Relays, J. O. Clancy, *Electronic Design* 15, No. 4, 113 (February 15, 1967).

Relay counters are used to stop automatic production equipment when consecutive rejects are detected. Most of these counter circuits have a fixed count and require relays with multiple coils and contacts. The circuit shown here has a selector switch to vary the count or to disconnect the output relay and uses inexpensive single-coil relays with a form-C contact.

A Vestigial-Sideband FM Modem, E. Hopner, R. W. Calfee and L. P. West, *Telecommunication Journal* 34, No. 2, 55-56 (February 15, 1967).

An experimental vestigial-sideband FM modem has been developed that is capable of 4800-baud operation over readily available leased telephone lines, while also allowing 1200-baud binary double-sideband FM operation over switched networks, the standard recommended for international data transmission by the CCITT. Analog signals, which would be required for facsimile document transmission and other applications, can also be transmitted with the proposed modem. The vestigial-sideband FM process is described, with details of the three-level coding that allows the high data rate over a limited bandwidth. Test results are cited which verify the high-speed capability.

Where and How Tapes Give N/C Welder Total Flexibility, R. A. Goodrich, *Production* 59, No. 2, 128-129 (February, 1967).

A numerically controlled welder capable of welding materials from 0.001-in. foil to 0.500-in. stock, and holding table position tolerances to ± 0.003 in. is described. The hybrid, magnetic electrode, force-resistant automatic welder can be operated manually, semi-automatically, or automatically.

Zener Diodes Convert Signals from Digital to Analog, P. P. Tong, *Electronics* 40, No. 4, 112 (February 20, 1967).

If high accuracy and high resolution are not required, digital commands can be converted into equivalent analog signals by summing the voltages of the back-biased zener diodes. This zener conversion circuit produces a high output voltage at low impedance and is much simpler than similar circuits using operational amplifiers.

Letters

Changes in GaAs Electroluminescent Diodes Induced by Continuous Operation, W. N. Jacobus, *Solid-State Electronics* 10, No. 3, 260-262 (March, 1967).

Detection of Strain in Evaporated Films by Wavefront Reconstruction, P. J. Magill and T. Young, *Journal of Vacuum Science and Technology* 4, No. 1, 47-48, (January-February, 1967).

Function-Method Approach to Work Sampling, G. P. Thilgen and J. F. Procopio, *Journal of Industrial Engineering* 18, No. 3, 15-16 (March, 1967).

Grundlagen der MOS-Transistoren (Fundamentals of MOS transistors), W. von Münch, *Verhandlungen der Deutschen Physikalischen Gesellschaft* 2, No. 1, 59 (1967).

Measurement of Diffused Semiconductor Surface Concentrations by Infrared Plasma Reflection, E. E. Gardner, W. Kappallo and C. R. Gordon, MIT. *Applied Physics Letters* 9, No. 12, 432-434 (December 15, 1966).