

Technical Papers by IBM Authors Published Recently in Other Journals

Adaptive Direct Digital Control with Multi-Parameter Adjustment, R. M. Bakke, *The International Federation on Automatic Control, Teddington Symposium*, pp. 5.2-1 to 5.2-10 (September, 1965)

An adaptive control scheme has been developed for the adjustment (i.e., tuning) of parameters in Direct Digital Control (DDC) algorithms.

This paper presents an extension of this adaptive control scheme to the multi-parameter adjustment problem. Multi-parameter adjustment is developed. The theoretical base of the identification scheme is presented. Practical limitations on the implementation of this adaptive control scheme into a DDC algorithm are discussed.

Algorithm for Diagonalization of Large Matrices, R. K. Nesbet, *Journal of Chemical Physics* **43**, No. 1, 311-312 (July 1, 1965).

This note describes a computational algorithm intended to be efficient for very large matrices. Several properties make the method advantageous for large n : the time required to compute a single eigenvector is proportional to n^2 , not n^3 as in most standard diagonalization methods; the unit process requires only one row of H at a time, facilitating buffered block transfer of very large matrices ($n > 250$) from auxiliary memory in a computer system; the eigenvalue convergence is second order; and the lowest eigenvalue converges monotonically. The proposed method combines the second-order matrix diagonalization algorithm of Lowdin with the classical iterative method for solving linear equations of Seidel, used by Boys in a first-order matrix diagonalization algorithm.

Analysis of Real Time Multiprogramming, Wei Chang and Donald J. Wong, *Journal of the Association for Computing Machinery* **12**, No. 4, 581-588 (October, 1965).

The problems associated with a real time message processing system in the multiprogramming environment are described. The basic philosophy of multiprogramming is compared with that of sequential processing in order to put the concepts in their proper perspective. A mathematical model was developed based on the theory of priority queues. The queue size and its variability within the CPU Ready List, the Real Time List and the Nonreal Time List can then be computed with the enclosed formulation. In turn, the core requirement for the central processor can be determined.

Anisotropy Control of Ni-Fe Films Through Sequenced-Field Deposition, W. R. Beam and W. T. Siegle, *IEEE Transactions on Magnetics* **MAG-1**, No. 1, 66-67 (March, 1965).

Anisotropy of nickel-iron films of 82, 74, and 66 percent nickel compositions was controlled by time-sequenced application of orthogonal fields during deposition. Resulting anisotropy values are in agreement with simple M -induced anisotropy principles. Coercive forces show small but definite decrease with anisotropy constant. Dispersion angle is proportional to the reciprocal of the anisotropy constant. The technique is suitable for production of low- H_c films. It permits nonanomalous inverted films to be produced and allows the study of other anisotropy sources.

The Anomalous Codeposition of Iron-Nickel Alloys, H. Dahms and I. M. Croll, *Journal of the Electrochemical Society* **112**, No. 8, 771-775 (August, 1965).

The dependence of the anomalous codeposition of iron-nickel alloys on the pH at the cathode surface is investigated. An equation is derived to evaluate the surface pH as a function of bulk pH rate of hydrogen evolution, buffer concentration, and diffusion conditions. The results obtained on rotating disk electrodes show that anomalous codeposition is due to a suppression of nickel discharge and that suppression occurs only when the surface pH is high enough to cause hydroxide formation. A type of mechanism is proposed by which the adsorption of ferrous hydroxide suppresses the deposition of nickel but permits a high rate of iron discharge. Experimental results which support this mechanism are discussed. This type of mechanism could be of general importance for other systems exhibiting anomalous codeposition.

Anticlastic Curvature of Strips of Variable Thickness, H. D. Conway* and K. A. Farnham, *International Journal of Mechanical Sciences* **7**, No. 7, 451-458 (July, 1965).

The effect of bevelling the edges on the anticlastic deformations of the cross sections of otherwise uniform thickness elastic strips or tapes subjected to pure bending is investigated. Bevelling on the concave or convex sides and on both edges of the strips is considered. It was found that a relatively small amount of bevelling on the concave sides of bent strips greatly reduced the anticlastic deformations.

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Application of Adaptive Threshold Elements to the Recognition of Acoustic-Phonetic States, James E. Dammann, *Journal of the Acoustical Society of America* **38**, No. 2, 213-223 (August, 1965).

The relation of acoustic-phonetic states to the problem of speech recognition is discussed. It is suggested that a first step toward understanding the dynamics of the speech signal could be made by recognizing a small number of acoustic phonetic classes. Adaptive threshold elements are proposed as a means of recognizing these classes and a method of utilizing the adaptive threshold elements in a decision procedure is presented. The means employed to gather the data representing the classes consists essentially of taking amplitude samples from a bank of 15 filters at 10-msec intervals. Samples obtained in this manner are used as input for the adaptive-decision procedure, which is simulated in a general-purpose computer. Samples representative of each class are used to train the adaptive-decision procedure, and the capability to generalize to new samples is observed. For one speaker, generalization results of 92%-correct sample classification were achieved, and generalization from one speaker to another was demonstrated. It further was shown that the selection of an output code can significantly affect the generalization and sequences of recognized samples can represent dynamic changes through words.

Applying a Multiplexed Operational Amplifier to Low-Frequency Signal Monitoring, J. W. McCullough, *Electronic Products* (Eastern Region Edition) **8**, No. 4, 53 (September, 1965).

An approach to monitoring low-level, low-frequency electronic signals is described. A single operational amplifier multiplexed between data channels is substituted for the separate multiple amplifiers normally used in data collection applications. Source impedance of each channel is designed to control the gain and frequency response of separate transducers. Design procedures are given both for the transducer circuits and the multiplexer configuration.

Approximate Controlability for Distributed Linear Systems, W. L. Miranker, *Journal of Mathematical Analysis and Applications* **10**, No. 2, 378-387 (April, 1965).

The problem of controlability of distributed linear systems is described in terms of the flow of convex sets in function space. Controlability is then characterized in terms of the separability of the convex sets by a hyperplane. Since for flows governed by partial differential equations, the set of nonreachable points in the function space may be everywhere dense, conditions for approximate control, wherein the system is required only to come into a given neighborhood of a target state, are established.

An Approximation Technique for Suboptimal Control, R. C. Durbeck, *IEEE Transactions on Automatic Control* **AC-10**, No. 2, 144-149 (April, 1965).

This paper presents a new technique for generating an approximation to the minimum performance functional V

for optimization of dynamic systems. Convergence of the technique is shown and the results from two example systems are given. The resultant approximation V is shown to be useful over a significant region in state space for (1) generating a near optimal control law, (2) determining regions of stability, and (3) defining useful bounds associated with the system performance.

Automatic Fact Retrieval, W. S. Cooper, *Science Journal* **1**, No. 4, 81-86 (June, 1965).

In recent years much attention has been directed to the possibility of using electronic computers for information retrieval. By the term "information retrieval" is meant the process of retrieving a needed piece of information from a large fund of mostly irrelevant information. In less abstract terms, it is the process a scientist or other scholar must perform when he has to scan through a stack of books and articles before he comes at last upon the information which is of interest to him. The conventional methods of searching the literature are often extremely tedious and time consuming. With the advent of the large scale digital computer the question has naturally arisen whether it might be possible to automate some or even all of the conventional retrieval processes.

Basic Properties of Fluid Mechanic Elements, H. H. Glaettli, *Proceedings of the First International Conference on Fluid Logic and Amplification*, Cranfield, England, pp. A2-13 to A2-20 (September, 1965).

It is shown that elementary expressions based on simple assumptions can be used to evaluate important properties of pure fluid devices. Such properties are: operating pressure, operating power, and response time. Only a very few constants enter the picture: they vary simply over a limited range and can easily be determined experimentally. Elimination of the average flow velocity by introducing the Reynolds number shows immediately that minimum operating pressure and minimum operating power increase with decreasing size. The same is true for the minimum response time. The maximum values on operating power and response time decrease with decreasing size. The reason being that there exists, in addition to the requirement of a minimum Reynolds number, another limitation: a maximum operating pressure which is independent of size. A minimum size is determined by the crossover of minimum and maximum operating power. A lower limit for the response time can be estimated by considering the free jet amplifier as an idealized model for pure fluid amplification. This allows comparison of different designs or different types of amplifiers by their figures of merit. Such a figure of merit states how far behind the ideal behavior an actual amplifier is, and can be applied independent of the geometry involved.

Brazing Stronger, More Reliable Steel Joints, J. A. Ferrante and J. T. Swails, *Proceedings of the ASTM 1965 Annual Engineering Conference*, Paper No. 749, pp. 1-20 (April, 1965).

This paper discusses how the quality, uniformity, and strength of copper-hydrogen brazed steel joints can be upgraded by proper control of component dimensions and ma-

terial and/or choice of furnace atmosphere during brazing. Also presented is a review of the mechanisms of copper-hydrogen brazing. Information on components includes data on static loading, fatigue, and the reliability of machined holes vs pierced holes.

Broadening of Impurity Bands in Heavily Doped Semiconductors, T. N. Morgan, *The Physical Review* **139**, No. 1A, A343-A348 (July 5, 1965).

The shapes of deep-lying bands of impurity states broadened by fluctuations in the local Coulomb potential are calculated for the case of randomly distributed ions in a semiconductor and are shown to determine the shapes of the spectral lines emitted by electrons or holes captured in these bands. The distribution function for the local potential is described in terms of its Laplace transform, and expressions for its first few moments, $\bar{E}$, $\langle (E - \bar{E})^2 \rangle$, etc., are calculated for screened Coulomb potentials. An approximate form is given for this function and is shown to be reasonably accurate for materials having a high degree of compensation or a large screening length. From the results of this analysis it is shown that the shapes of impurity emission lines can be used to aid in the identification of the nature of the states and transitions involved. In particular, the width of a line is determined principally by the product of the ion density and the screening length in the luminescent region, while the sense of its skewness depends on the signs of the dominant ion and of the carrier which is captured. Numerical examples are given for GaAs diodes containing approximately 10^{18} ions/cm³.

Burst Measurements in the Time Domain, W. W. Lang, *Proceedings of the Fifth International Congress on Acoustics*, Liege, Belgium, pp. J66-1 to J66-4 (September, 1965).

A study has been made to identify the parameters that are most appropriate for characterizing burst-like events. A set of such parameters has been defined. Methods for measuring the values of these parameters in the time domain with three different types of instrumentation have been developed.

Calculation of the Hall Effect in Ionic Solutions, Harold L. Friedman,* *Journal of Physical Chemistry* **69**, No. 8, 2617-2628 (August, 1965).

The theory of electrical conductance in ionic solutions recently reported by the author has been extended to apply to the transport in combined electric and magnetic fields. Calculations are made with the "brownian" model, essentially the model used in the Debye-Hückel-Onsager conductance theory. General expressions and numerical results are obtained for the ideal and limiting-law terms of the Hall conductance. The calculations indicate that the effect is large enough to be measurable, at least for solutions of the more mobile ions. For symmetrical electrolytes the limiting-law term opposes the ideal term in the Hall conductance, while for unsymmetrical electrolytes it may either aid or oppose the ideal term.

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Calorimeter with Peltier Compensation and with Multiple Sample Bulbs for Measuring Heats of Solution, Harold L. Friedman* and Yung-Chi Wu, *Review of Scientific Instruments* **36**, No. 8, 1236-1240 (August, 1965).

A calorimeter has been constructed for measuring heats of solution of salts in various solvents near room temperature and at large solvent/salt ratio. The instrument consists of a sealed tantalum vessel housing an externally driven stirrer and suspended in an evacuated submarine immersed in a constant temperature bath. The heat of stirring is compensated by a Peltier cooling device. Up to four samples of salt can be dissolved in an experiment without opening the calorimeter. A germanium resistance thermometer is used to compare the temperature change produced by the dissolving salt with that produced by electrical heating.

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Chemically Deposited Cobalt-Phosphorus Films for Magnetic Recording, Y. Moradzadeh, *Journal of the Electrochemical Society* **112**, No. 9, 891-896 (September, 1965).

Thin magnetic films of cobalt-phosphorus chemically deposited from a modified Brenner bath are reported in this paper. Detailed data are presented to demonstrate the role of deposition conditions on thickness, phosphorus content, and magnetic properties of the films. The films are much thinner than have been reported previously and exhibit a coercivity range of approximately 80 to 900 Oe with a coercivity-thickness relation $H_c = -2/5$. This is similar to that reported by Fisher and Chilton for much thicker films. Some of the variables which control the magnetic properties of the deposited film are shown to be: film thickness, bath pH, hypophosphite concentration, and bath temperature; the first two are the dominant factors and overshadow any influence that the codeposited phosphorus may have. An account of the apparatus used for precise and automatic control of the bath pH is given. Well-adherent, mirror-like films which are suited for conventional high-density magnetic recording, as well as Kerr magneto-optical readouts, are obtained.

Circuits Using Fluid Dynamic Components, H. H. Glaetli, *Proceedings of the First International Conference on Fluid Logic and Amplification*, Cranfield, England, pp. D4-41 to D4-52 (September, 1965).

Two circuits, a binary full adder and a binary counter, are described. The adder unit can be used as a serial adder or (without additional amplifiers) in a parallel adder. The counter unit (based on a proposal by R. W. Warren) may be cascaded directly. Test procedures for both circuits are explained. A four-stage adder is connected as an oscillator in order to determine the minimum carry propagation time per stage required for sufficient amplification to maintain the signal level. In the case of a multistage counter, it is important to distinguish between the minimum resolving time for counting and the maximum speed for frequency dividing. A test arrangement to determine both capabilities is described, and test results including typical pressure diagrams are given for geometrically similar elements of various sizes.

It is shown that geometric similarity and constant Reynolds number are not sufficient to maintain mechanical similarity when Mach numbers higher than 0.1 to 0.3 or cavitation effects are involved: the Mach number, for instance, increases automatically when the size of the element operated at constant Reynolds number and with the same gas is decreased. This behavior is by principle, and usually necessitates a different design for small elements, which also means that there may be a maximum size for certain devices, above which they can no longer be operated successfully without changing to another fluid. Typical curves showing how the gain of mono- and bi-stable elements may change with size of constant Reynolds number as a function of size are given. High signal restoring power is a further interesting aspect of the adder circuit and is illustrated separately.

Closed-Loop Stepping Motor Application, T. R. Fredriksen, *Machine Design* 37, No. 22, 202-213 (September 16, 1965).

Due to its digital behavior, the stepping motor has become a widely used device particularly in open-loop control systems. However, only a fraction of the potential performance of a stepping motor is utilized in such application. In addition to the normal open-loop oscillatory characteristics, severe restrictions exist as to stepping rate and load inertia. This paper presents a new approach to stepping-motor control based on digital feedback. It is shown that the closing of a minor loop around the synchronous inductor motors results in substantially improved stepping rates, completely removing the load-inertia restrictions. As a closed-loop device, the stepping motor is ideally suited for positional control systems.

Coherence Properties and Photon Correlation, H. Morawitz, *The Physical Review* 139, No. 4A, A1072-A1075 (August 16, 1965).

An intensity-correlation experiment is proposed to test the second-order coherence of laser light from a cw-operated laser based on the Glauber formalism. The calculation utilizes the known form of the density matrix for radiation from a randomly excited source such as a discharge tube which is equivalent to filtered black-body radiation, and represents the laser radiation field by a coherent state. The intensity correlation calculated exhibits the standard Hanbury Brown-Twiss term and an extra term due to intensity interference between the Fourier components of the thermal field and the laser mode.

A Comparison of Block and Recurrent Codes for the Correction of Independent Errors, C. V. Freiman and J. P. Robinson, *IEEE Transactions on Information Theory* IT-11, No. 3, 445-449 (July, 1965); *Proceedings of the First IEEE Communications Convention*, Boulder, Colorado (June, 1965).

Expressions for mean time to uncorrectable errors are rigorously derived for e -tuple error-correcting block codes and Type A e -tuple error-correcting recurrent codes when used in a memoryless binary symmetric channel with small probability of bit error p . It is shown that, if these codes are to

perform equally well independent of p , it must be true that $e = \epsilon$ and

$$(e + 1) \begin{bmatrix} n_A - 1 \\ e \end{bmatrix} = \begin{bmatrix} n_B - 1 \\ e \end{bmatrix}$$

where n_B is the block length of the block code and n_A is the error span of the recurrent code. Optimum single error-correcting block and recurrent codes are then compared in detail. It is shown that for equivalent performance the recurrent code requires slightly more redundancy, but significantly less storage in the coding circuitry as determined by n_A and n_B .

A Computer-Aided Linkage Analysis System, F. Bitonti, D. Cooper, D. Frayne, and H. Hansen, *IBM Systems Journal* 4, No. 3, 200-223 (1965).

An experimental system for the kinematic analysis of two- and three-dimensional mechanical linkages is outlined. The structure of the programmed system, the input language, and the method of storage allocation are described. The class of problems treated by the system is discussed in brief, as are the basic vector equations used in obtaining solutions for position, velocity, acceleration and force of linkage elements.

Computer-Assisted Cam Manufacture, J. J. Harvey, *Tool & Manufacturing Engineer* 55, No. 2, 76-77 (August, 1965).

Master and low-volume cams are produced to ± 0.0002 in. radial tolerance in less time and for less cost by utilizing a computer and a numerically controlled jig bore. Polar coordinate cam data is processed through the computer. The computer program interpolates the given data, if desired, to reduce the increment between movements, calculates movements along dwells, and converts input data to rectangular coordinate output. The output in the form of punched tape is used to produce the cam on the numerically controlled jig bore.

Computer Automated X-Ray Stress Analysis—A Versatile Test Method, G. Koves, *Annals of Reliability and Maintainability* 4, pp. 597-603 (1965).

This paper describes an x-ray diffraction test method in which both the measurement and evaluation steps are highly automated, making this high-precision technique available as a practical quality tool. The evaluation procedure is completely computer automated using a FORTRAN program and an IBM 7090 Data Processing System. The test method combines the depth and accuracy of the x-ray technique with the high speed and simplicity essential for a quality control procedure.

Cr³⁺ Fluorescence in Garnets and Other Crystals, Gerald Burns, E. A. Giess, B. A. Jenkins, and Marshall I. Nathan, *The Physical Review* 139, No. 5A, A1687-A1693 (August 30, 1965).

The results of a study of the sharp-line fluorescence of Cr³⁺ in a number of crystals is presented. The host crystals were

several diamagnetic garnets, a spinel, and emerald. The results are used to discuss two aspects of the sharp-line energy levels. First, some of the dynamical aspects are considered. The measurements of the temperature dependence of the sharp no-phonon R -line positions, linewidths, and efficiencies are in reasonable agreement with the existing theory. The theory assumes a simple form for the interaction of the Cr^{3+} energy levels with the phonons and uses a Debye density of states. The phonon-assisted radiation is also discussed. Second, some of the static aspects of the energy levels are considered. The splittings between the no-phonon R lines along with splittings of the ground states of the Cr^{3+} in the same crystals are compared with the predictions of existing theories. Here the agreement is very poor. The experimental data show the difference between the Cr^{3+} energy levels when odd terms, in addition to usual crystal-field terms, exist. The data also indicate some large nonlinearities between the energy-level splittings and the crystal field.

Crystal Fields at Rare-Earth Ions, Gerald Burns, *The Journal of Chemical Physics* **42**, No. 1, 377-390 (January 1, 1965).

The object of this paper is to find out why the calculated rare-earth crystal-field parameters do not agree with those determined experimentally. As is well known, in explaining the $4f$ spectra in the rare-earth compounds, one needs relatively few crystal-field constants, V_n^m 's. These V_n^m 's have been measured for many rare-earth ions in LaCl_3 , ethylsulfates and other lattices. One can study the V_n^m 's in a given lattice as the nuclear charge is varied (starting from Ce, $Z = 58$ to Yb, $Z = 70$). For a given n and m one finds that the V_n^m 's vs Z vary fairly smoothly. However, when the crystal fields are calculated using an ionic model one cannot get good agreement with the V_n^m 's. In general, neither the magnitude nor the Z dependence of the V_n^m 's can be reproduced. The calculated crystal-field parameters are written as: $(1 - \alpha_n) \langle r^n \rangle A_n^m$, where α_n is the shielding factor (the outer $5s^2 5p^6$ electrons to some extent shield the inner $4f$ electrons from the crystal field), $\langle r^n \rangle$ is the expectation value of r^n over the $4f$ electrons, and A_n^m is a lattice sum over the charges in the lattice that produce the crystal field. To try to determine why the agreement is bad, the effect of the lattice in altering the values of α_n and $\langle r^n \rangle$ was calculated. However, the principal trouble appears to come from the A_n^m values. $A_n^m \approx 1/R^{n+1}$, where R is the distance between the rare-earth ion and the charges in the lattice that produce the crystal fields. For the important $n = 4$ and 6 lattice sums one gets very rapid convergence. The A_n^m sums are usually calculated assuming the lattice can be replaced by point charges, point dipoles, etc., at the nucleus of the ions surrounding the rare-earth ions. Thus, R is taken as the various internuclear distances. However, for lattice sums that depend on such high powers of R , one must consider the extended nature of the charge distribution of the ions surrounding the rare earths. Another way of stating the trouble is: Since the distance between the observer (rare-earth ion) and the charge distribution is not large compared to the extent of the charge distribution it is not a good approximation to replace the charge distribution by point moments. From numerical examples it is easy to see, for $n = 4$ and 6 , that most of the contribution to the A_n^m sums comes from the parts of the surrounding ions that are closest to the rare-earth ions. Thus it becomes difficult to calculate the A_n^m 's accurately. However, using this idea, agreement is obtained with the dependence of the

V_n^m 's on Z and some of the inter-relationships between the different n terms.

For the lattices usually used as hosts one cannot calculate the A_2^0 sum because of its sensitivity to the x-ray data and charge distribution parameters. However, by using nuclear quadrupole resonance data to eliminate calculating the actual lattice sum, one gets good agreement between the measured V_2^0 's and $(1 - \alpha_2) \langle r^2 \rangle A_2^0$.

Damping Characteristics of Elastomers, D. M. Preiss and D. W. Skinner, *Rubber Age* **97**, No. 5, 58-68 (August, 1965).

Authors of a number of articles in recent literature have attempted to provide the design engineer with guides for selecting high damping materials. Such viscoelastic or rubber-like materials include: plastics, resins, adhesives, and rubbers. The information given is generally useful for most of these materials, but not for rubber.

This paper presents the information obtained from an experimental program conducted to determine the static and dynamic mechanical properties of the viscoelastic materials commonly used as engineering materials. Various formulations are examined as to their resilience, mechanical properties and damping characteristics to help the engineer set up guides to choosing the right elastomer.

Decision Making in Incompletely Known Stochastic Systems, J. Raviv, *International Journal of Engineering Science* **3**, No. 2, 119-140 (July, 1965).

This paper is a study of decision making in a discrete-state, discrete-time system whose state transitions constitute a Markov chain with unknown stationary transition matrix $\mathbf{P}$. The states of the system cannot be observed. The decision at each stage is based on observables whose conditional probability distribution, given the state of the system, is known.

We consider a class of problems in which the successive observations can be employed to form estimates of P , with the estimate at time n , $n = 0, 1, 2, \dots$, then used as a basis for making a decision at time n . The estimates and the corresponding decisions must have the property that as $n \rightarrow \infty$, the decision based on the estimate of P tends to the optimal decision rule which would be used throughout if P were known.

Dependence of Superconducting Energy Gap on Transport Current by the Method of Electron Tunneling, James L. Levine, *Physical Review Letters* **15**, No. 4, 154-156 (July 26, 1965).

The variation of superconducting energy gap with transport current has been measured in tin and indium near the transition temperature. Thin films and a compensated geometry were used to eliminate diamagnetic effects. The energy gap, measured by a tunneling technique, was found to decrease quadratically with increasing current in semiquantitative agreement with calculations based on the Ginzburg-Landau theory.

Design Considerations for a 25-nsec Tunnel Diode Memory, D. J. Crawford, R. L. Moore, J. A. Parisi, J. K. Picciano, and W. D. Pricer, *Computer Design* 4, No. 9, 30-42 (September, 1965).

The design factors for a practical ultra-high speed "scratch pad" memory are described. Information is stored in an array of tunnel diodes interconnected with driving and sensing circuits in a manner to specifically minimize cycle time. The design features modular construction of both the storage array and the associated circuits, practical component tolerances and compact construction. A fully populated system now under construction contains 64 words of 48 bits each complete with address circuits and I/O data circuits. The memory is designed to operate at a 25-nsec cycle time. Special features of interest are miniature printed circuit transformer construction, high-speed driving techniques and rapid regeneration of interrogated information.

Design Principles of Non-Destructive Read Thin Magnetic Film Memories with Read Cycle Time of 15 Nanoseconds, G. Kohn, W. Jutzi, Th. Mohr and D. Seitzer, *Proceedings of the INTERMAG Conference*, pp. 8.3-1 to 8.3-5 (1965).

A new NiFe film memory element with closed magnetic flux structure is introduced. The interaction of the film switching process and a well-defined eddy current relaxation in high conducting layers are the basis for a non-destructive read operation. Design principles of a very high-speed memory comprising an all-evaporated film and strip-line array and the necessary drive and sense circuits are discussed in suitable detail. Cross sectional model tests showing read cycle time of 15 nsec and write cycle times of 60 nsec are reported.

Dislocation Reactions in Silicon Web-Dendrite Crystals, S. O'Hara and G. H. Schuttke, *Journal of Applied Physics* 36, No. 8, 2475-2479 (August, 1965).

The origin and reactions of dislocations in silicon web-dendrite crystals are discussed. In particular, x-ray topographs are compared with etching results. Dislocations having $[2\bar{1}1]$ axes or $\langle 110 \rangle$ type axes have been characterized. In the former case, normal edge and 20° dislocations are seen; however, an apparently new dislocation with a $[2\bar{1}1]$ axis and $[101]$ type or $[110]$ type of Burgers vector has also been observed. Dislocations having a $[110]$ axis and $[110]$ Burgers vector have been identified and associated with the Cottrell-Lomer reaction. The presence of multiple twin planes parallel to the growth direction of the web, accompanied by regions of very high dislocation density near the dendrites, increases the probability of certain dislocation reactions.

Dispersion Analysis as Applied to Speech Spectra, J. E. Dammann, *Proceedings of the Fifth International Congress on Acoustics*, Liege, Belgium, pp. A54-1 to A54-4 (September, 1965).

In attempts to determine the structure of the speech signal it is difficult for the analyst to view the situation from a

purely objective point of view. That is, he ordinarily must use subjective notions of the structure of language phenomena. The dispersion analysis method is an attempt to expose some of the speech structure without making any *a priori* assumptions about that structure. The data is simply taken and transformed by a general method called dispersion analysis.

The results presented in the paper are the first from the application of dispersion analysis to speech and must be regarded only as indications of what further study may show. The dispersion analysis method does not appear to provide one with a "God's truth" picture of what is happening in speech, but it does appear to provide one with some interesting views of its phonetic character and dynamic aspects.

The Eddy Current Resetting Magnetic Field of Switching Thin Magnetic Films in Different Conducting Surroundings, Wilhelm Jutzi, *Proceedings of the INTERMAG Conference*, pp. 8.2-1 to 8.2-6 (1965).

NDRO of thin magnetic films is accomplished using the resetting magnetic field of eddy currents generated by the stray fields in suitable conducting surroundings. The amplitudes of the resetting field as a function of time are compared for a single film over a thin and very thick conducting groundplate, between a conducting foil and a very thick conducting groundplate, and for two coupled films sandwiching a conducting foil over a very thick conducting groundplate. The computed results are compared with measurements.

Effect of Fast Cooling on Diffusion-Induced Imperfections in Silicon, M. L. Joshi, *Journal of the Electrochemical Society* 112, No. 9, 912-916 (September, 1965).

Misfit dislocations in phosphorus-diffused silicon are shown to suffer rearrangement on fast cooling. These dislocations extend in specific direction, and act as centers of phosphorus precipitates. There are also other areas of precipitation where the particles are of irregular shape and size. The motion of dislocation network in the depths of the diffusion profile is mainly by glide, although a less dominant climb motion is observed.

Effects of Low-Energy Electron Irradiation on Si-Insulated Gate FET's, A. J. Speth and F. F. Fang, *Applied Physics Letters* 7, No. 6, 145-146 (September 15, 1965).

Several effects of 5 kV electron irradiation on N-channel silicon insulated-gate field effect transistors are described. After a total exposure of about 2×10^{-5} Coul/cm² on an FET with a fixed positive gate bias, the gate threshold voltage shifts to a stable value. This shift is linearly dependent upon the gate bias voltage during exposure. The shape of the transconductance vs gate bias characteristic is preserved. The effect is explained as due to an induced positive charge layer in the SiO₂ near the SiO₂-Si interface.

Energy of Walls in Thin Magnetic Double Permalloy (Ni-Fe) Films, J. C. Slonczewski and S. Middelhoek, *Applied Physics Letters* 6, No. 7, 139-140 (April 1, 1965).

In double films, consisting of two Permalloy layers separated by a non-magnetic layer, Néel walls and quasi-Néel walls occur. The energy of a Néel wall/quasi-Néel wall combination is calculated as a function of the thicknesses of the magnetic layers and the intermediate layer. The resulting energy is compared with the energies of Bloch, Néel and cross-tie walls in single films.

Electroluminescence near Band Gap in Gallium Phosphide Containing Shallow Donor and Acceptor Levels, L. M. Foster and M. Pilkuhn, *Applied Physics Letters* 7, No. 3, 65-67 (August 1, 1965).

Diodes which are doped with shallow donors and acceptors, partially compensating one another in both the n and p regions, give rise to bright green emission. This green emission is more efficient at room temperature than the so-called "A-line emission" which is commonly observed in weakly doped diodes. The peak energy of the green emission varies with the donor binding energy. At 77°K, large peak shifts with applied voltage have been observed. Data concerning this peak shift, the intensity-voltage dependence, and the linewidth-voltage dependence are presented and interpreted through photon assisted tunneling.

Electron-Spin-Resonance Investigation of Chromium Ions in NaCl, Benjamin Welber, *The Physical Review* 138, No. 5A, A1481-A1483 (May 31, 1965).

The electron-spin-resonance spectrum of Cr ions in NaCl is examined. After x irradiation, a spectrum is identified belonging to ions of Cr^+ ($3d^5$) in sites of cubic symmetry. The g value, fine structure, and hyperfine splitting are determined, and compared with the corresponding values in the case of NaF. In addition, the unirradiated crystals yield a spectrum attributed to Cr^{2+} ($3d^4$) ions in noncubic sites of several types.

Enumeration of Strongly Connected Sequential Machines, C. E. Radke, *Information and Control* 8, No. 4, 377-389 (August, 1965).

Recently, attention has been given to the problem of counting the number of equivalence classes of finite automata. The enumeration problem for strongly connected sequential machines has remained unsolved. This paper develops a recursive solution from which the number of strongly connected, complete sequential machines can be determined for an arbitrary state set, input set, and output set.

The Etching and Polishing Behavior of Ge and Si with HI, A. Reisman and M. Berkenblit, *Journal of the Electrochemical Society* 112, No. 8, 812-816 (August, 1965).

Studies of the etching and vapor polishing behavior of Ge with HI as a function of temperature, linear gas stream velocity, etch rate, and etchant concentration indicate that

temperature is the most significant parameter affecting the smoothness of the etched surfaces. A less pronounced effect is the occurrence of microscopic pitting above a critical etchant concentration. The other parameters did not appear to affect surface characteristics. Less detailed studies of the HI etching of Si have been used to define practical conditions for the vapor polishing of Si. A qualitative analysis of the requirements for a usable vapor polish and the experimental conditions necessary to quantitatively define the kinetic of solid-gas etching reactions are presented.

Excitation of Molecular Nitrogen by Electron Impact, H. F. Winter, *The Journal of Chemical Physics* 43, No. 3, 926-932 (August 1, 1965).

Relative cross sections for excitation of the triplet series of molecular nitrogen have been obtained. The cross sections have a maximum within a few volts of threshold as expected for electron exchange collisions. In particular, the $C^3\pi_u$ state has a sharp maximum within a few tenths of a volt of threshold and then decays sharply.

The $A^3\Sigma_u^+$ state has an increasing slope through the Franck-Condon region and then is a strictly linear function of energy for about $1\frac{1}{2}$ volts. It subsequently reaches a maximum and starts to decay. This leads to the postulate that the region of increasing slope is caused by the continual excitation of new vibrational levels and the excitation function of a given vibrational level may be linear to near threshold. This interpretation is shown to be consistent with the experimental data.

Fabrication and Assembly Operations—Part V: Production Order Sequencing, A. B. Calica, *IBM Systems Journal* 4, No. 3, 225-240 (1965).

The sequencing of several project networks on limited facilities is discussed under the assumption that the projects and resources have already been specified by a higher scheduling function. A priority function is proposed which uses both the local and global properties of the project network. The resulting schedule is then converted into a network on which useful alterations can be made.

Fabrication and Assembly Operations—Part VI: Parameter Values for Sequencing Control, S. Gorenstein, *IBM Systems Journal* 4, No. 3, 241-249 (1965).

The document adapts the sequencing control reported in Part V of this paper to individual plant requirements and goals. A regression model is used to relate measures of plant performance to certain control parameters. This relationship is periodically re-computed using statistical analysis of operational data. A pertinent decision rule is derived by optimal control theory.

Fabrication and Assembly Operations—Part VII: Adaptive Control in Production Planning, S. Shapiro, *IBM Systems Journal* 4, No. 3, 250-255 (1965).

This paper discusses a control method for reducing the operating costs of a production system by continual modifica-

tion of the planning operations. The method improves resource allocations by adjusting the mathematical model of the production system to actual system performance. The results of some preliminary experimental work with a simulated fabrication shop are presented.

Ferroacoustic Resonance and Acoustical Birefringence in Gadolinium-Iron-Garnet, B. Lüthi, *Applied Physics Letters* 6, No. 12, 234-236 (June 15, 1965).

The so-called linear magneto-acoustical birefringence effect has been measured for the first time in gadolinium iron garnet. Measurements and important constants deduced from them are presented.

Die Gegengekoppelte Doppelstufe mit Transistoren und ihre Eigenwerte, (Transistor Feedback Double Stage and its Eigenvalues), Dieter Seitzer, *Archiv der Elektrischen Uebertragung* 19, No. 6, 301-308 (June, 1965).

Wideband transistor amplifiers with cutoff frequencies beyond 100 Mc/sec are often based on feedback circuits. The shunt-series feedback and the series-shunt feedback involving two amplifier stages have the same forward circuit for the amplification without feedback. Gain and eigenvalues of this forward circuit are evaluated and, by means of the feedback formula and the root locus technique, the properties and especially the eigenvalues of the closed loop are determined. A diagram is presented relating the calculated open-loop gain and its poles to the unknown closed-loop poles.

Generalized Commuting Properties of Measure Preserving Transformations, R. L. Adler, *Transactions of the American Mathematical Society* 115, No. 3, 1-13 (March, 1965).

In this paper we discuss the following: Let G be the group of measure preserving transformations on a measure space (X, B, m) . Associated with a given $T \in G$ is a sequence $C_n(T)$, $n = 0, 1, 2, \dots$ of subsets of G defined inductively by

$$C_0(T) = \{S: S \in G, S = I \text{ a.e.}\}$$

$$C_n(T) = \{S: S \in G, STS^{-1}T^{-1} \in C_{n-1}(T)\}.$$

It is clear $C_n(T) \leq C_{n+1}(T)$. If there exists N such that $C_N(T) = C_{N+1}(T)$ then $C_n(T) = C_{n+1}(T)$ for all $n \geq N$; and, in this case, we define $N(T) = \min \{N: C_N(T) = C_{N+1}(T)\}$, otherwise we set $N(T) = \infty$. $N(T)$ is a spatial isomorphism invariant for measure preserving transformations. $N(T)$ is computed for transformations with pure point spectrum and Anzai's skew product transformations.

Gold as a Recombination Centre in Silicon, J. M. Fairfield and B. V. Gokhale, *Solid-State Electronics* 8, No. 8, 685-691 (August, 1965).

The recombination of holes and electrons through gold centres in silicon involves two recombination energy levels, a donor and an acceptor, and four capture probabilities. By

comparing the low-level photoconductivity decay of gold-doped silicon samples with a theoretical expression derived from a transient solution of the recombination problem, we have determined the following values for these probabilities:

Acceptor level:

$$\alpha_n = 1.65 \times 10^{-9} \text{ cm}^3/\text{sec}$$

$$\alpha_p = 1.15 \times 10^{-7} \text{ cm}^3/\text{sec}$$

Donor level:

$$\beta_n = 6.3 \times 10^{-8} \text{ cm}^3/\text{sec}$$

$$\beta_p = 2.4 \times 10^{-8} \text{ cm}^3/\text{sec}.$$

These results have been used to calculate, under high-level conditions, minority carrier lifetimes, which have then been compared with such lifetimes determined empirically from diode storage time measurements. Good agreement has been found, indicating that diode storage times can be successfully predicted.

GPSS III—An Expanded General Purpose Simulator, H. Herscovitch and T. Schneider, *IBM Systems Journal* 4, No. 3, 174-183 (1965).

Significant improvements in the modeling capability and storage flexibility of the General Purpose Systems Simulator are described in this paper. Increased versatility and ease of use as well as new debugging aids are also discussed. The additions and changes to the simulator are illustrated by examples.

Heats of Mixing of Electrolytes Having Common Ions,† Y. C. Wu, M. B. Smith,* and T. F. Young,** *Journal of Physical Chemistry* 69, No. 6, 1868-1872 (June, 1965).

Heats of mixing of 24 pairs of 1 m aqueous solutions of 1-1 electrolytes having an ion common to the pair have been measured at 25°C. Heats of mixing of NaCl and Na₂SO₄, each in an aqueous solution of unit ionic strength, have also been determined. The effect of the substitution of one common ion for another has been investigated for given homoionic pairs. The maximum effect observed is about 3 cal/mole of electrolyte. The heats of mixing of HCl with the alkali metal chlorides differ from the heats of mixing of LiCl with the same respective electrolytes by approximately a constant amount, ca. 13 cal/mole of solute.

† Work done at George Herbert Jones Chemical Laboratory, University of Chicago.

* Ethel Petroleum Corp, New Orleans.

** Argonne National Laboratory.

Heats of Mixing of Electrolytes of the 1-1 Charge Type,† Y. C. Wu, M. B. Smith,* and T. F. Young,** *Journal of Physical Chemistry* 69, No. 6, 1873-1876 (June, 1965).

Heats of mixing of eight pairs of 1 m aqueous solutions of 1-1 electrolytes not having an ion common to the pair have been measured at 25°C. The average of the absolute values of the molal heats of mixing is somewhat larger than the average of the absolute values of the heats of mixing of

pairs of the same electrolytes so grouped that there is a common ion within each pair. The thermochemical relation between the heats of cross mixing and the heats of common-ion mixing (the cross-square rule) has been tested by application to four systems. The rule fits the data remarkably well. The purely thermodynamic, and hence exact, relation between heats of dilution and heats of cross mixing has been pointed out and its application illustrated. Work with relatively dilute solutions is not in accord with the Brønsted principle of specific ionic interaction.

† Work done at George Herbert Jones Chemical Laboratory, University of Chicago.

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Improper Solutions Under Existence Assumptions: An Example, J. H. Eaton, *IEEE Transactions on Automatic Control* AC-10, No. 2, 186-189 (April, 1965).

A pursuit problem is considered in which a pursuer X and target Y are points in an n -dimensional Euclidean space E^n . The pursuer is assumed to have knowledge of the control (and hence trajectory) to be used by the target and is to choose a control to minimize the pursuit time. The target, wishing to delay interception as long as possible, desires to choose a control which maximizes the pursuit time. It is shown that if the target assumes the existence of an optimal control (i.e., a control for which the least upper bound of the pursuit time is attained), he can be led to a choice of control which will result in an interception in less time than if he applied no control at all.

Infrared Dielectric Properties of Cadmium Fluoride and Lead Fluoride, J. D. Axe, J. W. Gaglianella and J. E. Scardefield, *The Physical Review* 139, No. 4A, A1211-A1215 (August 16, 1965).

Infrared reflectivity measurements have been made on samples of cubic CdF_2 and PbF_2 between 10 and 150μ at room temperature. The data have been analyzed by the use of reflectivity dispersion relations to obtain infrared dielectric properties of these substances as well as their optic-mode frequencies (transverse and longitudinal, TO and LO). For CdF_2 we find $\omega_{\text{TO}} = 202 \text{ cm}^{-1}$; $\omega_{\text{LO}} = 385 \text{ cm}^{-1}$; $\epsilon_s = 8.09$. For PbF_2 , $\omega_{\text{TO}} = 102 \text{ cm}^{-1}$; $\omega_{\text{LO}} = 337 \text{ cm}^{-1}$; $\epsilon_s = 27.4$.

Integrated Transmission Lines for Magnetic Thin Film Memories, T. D. English and J. J. McNichol, *Proceedings of the INTERMAG Conference*, pp. 11.6-1 to 11.6-6 (April, 1965).

The pulse transmission properties of integrated strip lines are examined for a structure that has been proposed for application in a large capacity, high-speed magnetic film memory. The lines are vacuum deposited onto an insulated ground plane and are characterized by low impedances. Previous analyses such as those given by Eastman and Chang, McQuillan, and Harloff examine the effects of skin depth losses in lines which are assumed to be perfectly terminated. In general, this type of analysis is insufficient for lines which are lossy and which have resistive terminations. The present analysis considers skin-effect losses in the ground plane and in the strip conductors separately and also includes

the effect of reflections from resistive terminations. The influence of heavy magnetic loading of the transmission line due to the presence of magnetic film devices is examined in detail. A computer program, similar to the one described by Bertin, has been used to obtain numerical results for the pulse response of the transmission lines. Data are presented which demonstrate the influence of line geometry and material properties.

Internal Strain in Elastically Strained Germanium and Silicon. II. General Relations, Transverse and Longitudinal Case, A. Segmüller and H. R. Neyer, *Physics of Condensed Materials* 4, 63-70 (1965).

The general relations between the internal strain vector and the strain tensor are used to derive the conditions for internal strain in the diamond structure. Both the transverse and longitudinal internal strains have been measured, and the results of Part I improved. The experimental results on germanium and silicon are in good agreement with the theory of internal strain.

Interstitial-Substitutional Diffusion in a Finite Medium, Gold into Silicon, G. J. Sprokel, *Journal of the Electrochemical Society* 112, No. 8, 807-812 (August, 1965).

A differential equation describing interstitial-substitutional diffusion is derived. Boundary conditions are selected pertinent to diffusion into a finite medium. Laplace's transformation is used to solve the differential equation. The result is plotted as a relation between dimensionless quantities. The quantities D_1 and C_{01} can be calculated from the intercept and the initial slope, respectively. The theory is applied to the diffusion of gold into silicon wafers of varying thickness.

Investigation of the Effect of O_2 , N_2 , and H_2O on Nickel Thin Films, J. F. Freedman, *Journal of Applied Physics* 36, No. 3 (Part 2), 694-696 (March, 1965).

The role of oxygen, nitrogen, and water vapor adsorbed during the evaporation process was investigated for nickel films grown on room-temperature glass substrates. A change in pressure from 10^{-10} to 10^{-7} Torr oxygen caused a marked shift in the resonance field and the perpendicular anisotropy (i.e., the anisotropy resulting from the rotation of the magnetization out of the plane of the film). This shift could be accounted for by an increase in internal stress from $5 \times 10^9 \text{ dyn/cm}^2$ at 10^{-10} Torr to $2 \times 10^{10} \text{ dyn/cm}^2$ at 10^{-7} Torr. The wall-motion coercive force also increased with increasing pressure, ranging from 50 to greater than 200 Oe. Samples made in pressures as high as 1×10^{-5} Torr nitrogen appeared identical (as determined by the measurements) to films made in residual vacuum of 10^{-10} Torr. The presence of water vapor caused a slight increase in internal stress and H_c when the pressure changed from 10^{-10} to 10^{-5} Torr. The effect appears to be related to an internal oxidation phenomenon.

These experiments clearly demonstrate the role of impurity atoms in determining the stress-sensitive magnetic properties of films and emphasizes the need for controlling the partial pressures of gases during evaporation, and not just the total pressures.

Long-Wave Lattice Dynamics of the Fluorite Structure, J. D. Axe, *The Physical Review* **139**, No. 4A, A1215-A1220 (August 16, 1965).

A simple shell model is used to calculate expressions for the long-wavelength vibrational eigenfrequencies and elastic constants of the fluorite (CaF_2 type) lattice. The concept of effective charge is introduced and expressions analogous to the Szigeti relations for lattices with diatomic unit cells are given. These and other relations between the acoustic and optical properties derived for the dipole shell model are in better agreement with the measured properties of the alkaline-earth fluorides than are those derived for a rigid-ion model. The large deviation from the Cauchy relation $C_{12} - C_{11}$ seems to be largely explainable in terms of the shell-model correction to the internal strain.

Low-Temperature Thermal Conductivity of Ferromagnetic Insulators Containing Impurities, P. Erdős, *The Physical Review* **139**, No. 4A, A1249-A1262 (August 16, 1965).

The spinwave thermal conductivity of ferromagnetic insulators with magnetic scattering is investigated. The role of magnon-magnon interactions is clarified. The magneto-elastic coupling is treated by the Green function technique.

Luminescence and Recombination through Defects in p-n Junctions, T. N. Morgan, *The Physical Review* **139**, No. 1A, A294-A299 (July 5, 1965).

We have developed simple expressions for the recombination current occurring in the space-charge region of a p-n junction at high temperatures. The current passing through a defect state in the forbidden gap is shown to vary approximately exponentially with applied voltage as $I \propto \exp(eV/\beta kT)$, where $\beta = 1, 2, > 2$ depending on the bias voltage relative to two "kink" voltages V_k and V_a . The energy eV_k is given approximately by twice the energy of the center as measured from midgap, while V_a is determined by the gap energy and carrier effective masses and by the ratio of the capture cross sections of the center for holes and electrons. These effects are shown to explain the kinks appearing in curves of light intensity versus voltage for electroluminescent diodes. When used to analyze emission peaks from copper-doped GaAs junctions they provide values for the cross-section ratios and identify the center producing the 0.97 eV emission as a donor lying in the upper half of the energy gap.

Magnetic Properties of the Gallium Iron Garnet System, B. Lüthi and T. Henningsen,* *Proceedings of the International Conference on Magnetism*, Nottingham, England, pp. 668-671 (September, 1964).

We investigated the magnetic properties of the yttrium gallium iron garnet system, $\text{Y}_3\text{Ga}_x\text{Fe}_{5-x}\text{O}_{12}$ with x varying from 0.8 to 1.9. The magnetization curves could be well-fitted to a molecular field theory, taking only $a-d$ interactions for the iron ions into account. Extrapolation of our results gives a disappearance of ferrimagnetism for $x \sim 2.6$ in this system. A 90% preference for substitution of the tetrahedral

d sites by gallium ions was found roughly over the whole concentration range. Furthermore, transverse ferroacoustic resonance measurements gave values for the first cubic anisotropy constant K_1 . These experimental values were compared with results from the so-called single ion anisotropy theory, using parameters deduced from a ferromagnetic resonance experiment in yttrium iron garnet and from an electron paramagnetic resonance experiment of Fe^{3+} in yttrium gallium garnet. The discrepancy between these two approaches is discussed. Our experimental values are better explained with the parameters deduced from the ferromagnetic resonance experiment.

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Magnetomechanical Applications Utilizing Silicon Iron, O. I. Chirino and C. W. Jordan, Jr., *IEEE Transactions on Component Parts* **CP-12**, No. 1, 11-16 (March, 1965).

This paper discusses the processing and use of iron-silicon alloys in electromechanical applications. These materials are more commonly used in electromagnetic applications such as transformer and motor laminations, relays, and solenoids.

Resistance to mechanical stress is provided by applying hard carburized or carbonitrided cases to only those areas subjected to mechanical stress. Thus, a single part provides both magnetic softness and resistance to abrasion and impact. The process used to produce grain orientation in M6 electrical steel precludes the use of subsequent case hardening treatments. In this instance, hard inserts can provide similar resistance to impact and abrasion.

The magnetic properties of these materials are of prime importance to assure functional performance. This paper describes special annealing practices which provide properties that allow maximum performance from materials of the previously mentioned types. The common industry practice of specifying magnetic properties by using core loss values is of particular interest. In electromechanical applications, these values are not sufficient to guarantee magnetic performance; therefore, properties such as maximum permeability and coercive force must be determined. This entails the selection of materials and practices that will give proper performance. The methods used in selecting suitable materials and the required testing procedures are also covered in this paper.

Mathematische Darstellung der Wirkungsweise von Instrumenten für die Trägheits-Navigation (Mathematical Models of Inertial Sensors), Friedrich G. Unger, *Elektrotechnische Zeitschrift* **86**, No. 16, 534-539 (August 6, 1965).

Mathematical models of inertial sensors are differential equations, transfer functions, block diagrams, and the combination of a vector and a matrix. These models are derived for gyros and accelerometers, including the important error sources. The inputs to inertial sensors are the vector of linear acceleration and the vector of angular rate ω . These two vectors can be combined into one vector $\mathbf{X}$. The output of the sensors is derived as a function of these input vectors.

Measurement of Photoinduced Discharge Currents and Voltages, L. F. Shew, *IEEE Transactions on Instrumentation and Measurement* IM-14, No. 3, 160-166 (September, 1965).

An apparatus has been developed for monitoring the instantaneous surface potential of photoconductive insulators during illumination. In addition, instrumentation methods have been evolved for measuring the effective photoinduced discharge current, transit time, and mobility of charge carriers in such materials. The device has proved useful and convenient for qualitative evaluation of the photoinduced discharge characteristics of electrophotographic paper and plate materials under dynamic conditions. It also provides means for precise quantitative measurement for theoretical study of the photoconductive properties of such media.

Circuit analysis and theory of operation of the apparatus are described. Discussions are given on the accuracy and usefulness of the techniques presented for monitoring the effective photoinduced discharge current to yield insight into the electrical and optical properties of photoconductive insulators. Test data are shown and discussed.

Metastable Co-Au Alloys: Example of an Amorphous Ferromagnet, S. Mader and A. S. Nowick, *Applied Physics Letters* 7, No. 3, 57-59 (August 1, 1965).

By co-evaporation of Co and Au onto a substrate at 80°K amorphous structures have been obtained which are ferromagnetic. They transform into a crystalline structure upon heating to 420°K. The magnetization decreases with increasing Au concentration and reaches zero at Co + 75% Au.

1965 Survey of Commercial Semiconductor Photosensitive Devices, Parts 2 and 3, R. D. Kaus, *Electronic Industries* 24, No. 8, 83-94 (August, 1965); 24, No. 9, 82-88 (September, 1965).

The relative merits of photoconductors, photovoltaic diodes, phototransistors, and *pnpn* light-activated devices are discussed. Comparative data on the properties of the most common photosensing materials are presented. Terminology and figures of merit used in evaluating the various devices and materials are defined.

Nitrogen Analogs of Sesquifulvalene. III. Theoretical Correlation of Excited-State Properties, E. M. Evleth, Jr., J. A. Berson,* and S. L. Manatt,** *Journal of the American Chemical Society* 87, No. 13, 2908-2913 (July 5, 1965).

The experimental energies and intensities of the electronic absorption bands of a series of nitrogen analogs of sesquifulvalene are compared with the results of three kinds of theoretical treatment. Although the Hückel theory and its variant, the ω -method, are satisfactory in correlating much of the data, they fail to account for the major observed difference in behavior between the members of the 2- and 4-series, namely, the occurrence of two strong, long wave length bands in the 2-series but of only one in the 4-series. Treatment of the data by first-order perturbation theory, using the series of anions phenylcyclopentadienide, phenylindenide, and phenylfluorenone, gives better results. The

transition energies are correlated with the values calculated from perturbation theory with a correlation coefficient of 0.953; the value of the resonance integral β , obtained from the slope of the correlation, is -47.6 kcal/mole.

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On Dynamic Program Relocation, W. C. McGee, *IBM Systems Journal* 4, No. 3, 184-199 (1965).

A general statement of the problem of dynamic program relocation is presented as an aid in describing specific relocation principles. The main purpose of the paper is to review a number of typical methods of meeting the expanding need for dynamic program relocation. Although no attempt is made at evaluation, the methods are discussed in the context of selected computer systems for tutorial concreteness.

One-Dimensional, Many-Body Calculation with a Correlated Gaussian Wave Function, T. R. Koehler, *The Physical Review* 139, No. 4A, A1097-A1100 (August 16, 1965).

A two-parameter many-body correlated Gaussian wave function is used to calculate the expectation value of the Hamiltonian for N one-dimensional particles interacting through the one-dimensional analog of an atomic potential. Using a potential equal to four times the Slater-Kirkwood He-He potential, we calculate the optimum average interparticle separation, the ground-state energy, and the velocity of sound of the system as a function of particle mass. It is found that the correlated Gaussian always gives an improvement in energy compared with an uncorrelated Gaussian.

On the Determination of Stationary Spatial Coherence, J. V. Cornacchio and R. P. Soni, *Il Nuovo Cimento*, Series X, 38, 1169-1177 (August, 1965).

A solution is presented for the spatial coherence, μ , over an arbitrary plane aperture in terms of observable quantities. It is assumed that the aperture illumination is quasi-monochromatic and spatially stationary. Fourier transform methods are used to obtain a closed-form solution of the integral equation relating the spatial coherence, μ , the far-field intensity, I , and the aperture intensity, I_a . The solution is expressed as a product of the Fourier transform of I and a function depending on I_a . The special case of uniform aperture intensity yields particularly simple results. In this case, μ is given by knowledge of only the Fourier transform of I and a factor capable of a very simple geometric interpretation in terms of the aperture area. Some general properties of μ are observed, and then related to characteristics of the aperture and far-field intensity distributions. Applications of the results to the problem of measuring the spatial coherence are discussed. Finally, in order to illustrate the usefulness of the results, μ is obtained for a specific far-field intensity distribution.

On the Role of Linguistics in the Teaching of English,† P. S. Rosenbaum, *Harvard Educational Review* 35, No. 3, 332-348, (Summer, 1965).

The problem of "which linguistic description," which has plagued educators for twenty-five years, is investigated in

terms of the oft suggested criterion of correctness. It is demonstrated that a necessary condition which any linguistic description must meet, if it is to claim correctness, is that it be formulated in terms of a theory which offers some explicit measure of the adequacy of linguistic descriptions. An examination of the forms of linguistic description currently available reveals that only the transformational version of generative linguistic descriptions satisfies the necessary condition. Insofar as the criterion of correctness or validity is taken seriously, the question of "which linguistic description" is answered. A range of educational situations in which the results of transformational research might be utilized is mentioned. This range includes the content of the English curriculum in general, the evaluation of certain traditional criteria employed in the evaluation of composition, and a possible explanation for the continuing lack of correlation between instruction in grammar and improved performance in the literate skills.

† Work performed while author was at MIT. Supported by Joint Services Electronics Program (Contract DA 36-039-AMC-03200 E), National Science Foundation (Grant GP-2495), National Institutes of Health (Grant MH-04737-05), National Aeronautics and Space Administration (Grant NSG-496), and U. S. Air Force (ESD Contract AF 19(628)-2487).

On the Solution Set of a Linear System with Inaccurate Coefficients, W. Oettli, *SIAM Journal, Numerical Analysis, Series B* 2, No. 1, 115-118 (1965).

The variation of the solution of the linear $(n \times n)$ -system $Ax = b$ is studied when the coefficients a_{ij} and right-hand sides b_i are assigned intervals of variation of the length $2 \Delta a_{ij}$ and $2 \Delta b_i$, respectively.

Optical Properties of Divalent Rare-Earth Metals and Alkaline-Earth Metals, W. E. Müller, *Physics Letters* 17, No. 2, 82-83 (July 1, 1965).

Reflectances of the four elements Sr, Ba, Eu, and Yb were measured in the energy range from 0.3 to 5 eV. It is shown that bcc Ba and Eu are very similar on the one hand, and fcc Sr and Yb on the other. In recent high-pressure experiments by other authors, this close similarity of corresponding metals was also found. These experimental results suggest nearly identical band structure of the outer electrons in Ba, Eu and Sr, Yb, respectively. The observed structure in the reflectance curve was assigned to s - p interband transitions of conduction electrons. No $4f$ electrons of rare earths are involved in this energy range.

Optimal Programming of Lot Sizes, Inventory and Labor Allocations, Bernard P. Dzielinski and R. E. Gomory, *Management Science* 11, No. 9, 874-890 (July, 1965).

The economic lot size programming problem as studied originally by A. S. Manne and later by B. P. Dzielinski, C. T. Baker and A. S. Manne, is the problem of making economic lot size, inventory and work force decisions in a multi-production process. When several thousand distinct items are involved, the large number of equations that result from the linear programming formulation makes computation infeasible. Also, a large number of variables are involved because of inclusion of alternative set-up sequences

for each item. In this paper, the application of the Dantzig and Wolfe decomposition principle and a method for creating alternative set-up sequences as they are needed by means of a computation of the Wagner and Whitin type is described as a method for overcoming the computational difficulty.

A digital computer program has been developed using these methods. The results of some experiments where production was planned for a large number of distinct items are described.

Parameter Estimation for a Generalized Gamma Distribution, E. W. Stacy and G. A. Mihram,* *Technometrics* 7, No. 3, 349-358 (August, 1965).

It is fairly commonplace in reliability analyses to encounter data which is incompatible with the exponential, Weibull, and other familiar probability models. Such data motivates research to enlarge the group of probability distributions which are useful to the reliability analyst.

In this paper, we examine a three-parameter generalization of the gamma distribution and derive parameter estimation techniques for that distribution. Those techniques, in the general case, depend upon method-of-moments considerations which lead to simultaneous equations for which closed form solutions are not available. Graphic solution is proposed and aids to the computations are provided. Major concepts in the paper are summarized by means of a numerical example.

Details are given for the special case in which only the scale parameter is unknown. Three unbiased estimators for that parameter are derived along with their variance formulas. Minimum variance considerations are discussed by application of the Cramér-Rao Theorem.

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Photochemical Rearrangement Reactions of 2-*n*-Propylcyclopentanone, R. Srinivasan and Sheldon E. Cremer, *Journal of Physical Chemistry* 69, No. 9, 3145-3147 (September, 1965).

Photolysis of 2-*n*-propylcyclopentanone in the vapor phase at about 140° with 3130 Å radiation gave rise to carbon monoxide, ethylene, propylene, 1-pentene, a C_7 hydrocarbon, cyclopentanone, and *trans*-4-octenal. The production of carbon monoxide, along with C_2 , C_3 , and C_7 hydrocarbons, and the formation of *trans*-4-octenal represent well-known primary processes in cyclic ketones. However, the formation of cyclopentanone and propylene in equivalent amounts represents the first observation of the Norrish type II process in an alicyclic ketone. The quantum yield for this process has been determined to be 0.08. The reaction was essentially unaffected by adding oxygen or by carrying it out in the liquid phase. Photolysis of 2-(*n*-propyl-2, 2- d_2) cyclopentanone showed, as in other instances, the specific nature of the hydrogen atom that underwent intramolecular transfer.

PL/I: A New Programming Language, R. A. Sibley, *ACM Proceedings of the 20th National Conference*, pp. 543-563 (August, 1965).

After a discussion of the procedures and motivations that have, to date, accompanied its development, a survey of the

characteristic features of PL/I, a new programming language, will be presented. Those readers who are familiar with the language may wish to move on to the section where primary implementation considerations are explored. Finally, an experimental implementation of a PL/I compiler is covered in some detail. This last discussion includes a brief description of a special-purpose programming system that was used in this experimental work.

Polarization Effects in the Two-Photon Excitation of Anthracene Fluorescence, W. L. Peticolas, R. Norris* and K. E. Rieckhoff, *Journal of Chemical Physics* **42**, No. 2, 4164-4169 (June 15, 1965).

The polarization of the fluorescence of anthracene has been measured after two-photon excitation with ruby laser light. The anthracene molecules were rigidly held in a 2×10^{-3} M solution in EPA glass at liquid-nitrogen temperatures. For comparison, the polarization of the fluorescence was measured from one-photon excitation at approximately twice the laser frequency. The measured polarization of the two-photon excited light is in satisfactory agreement with the polarization as calculated from the Goepfert-Mayer process involving a transition through an intermediate state. It is in disagreement with the polarization calculated in terms of the process recently suggested involving the A^2 term in the Hamiltonian. Thus the measurement of the polarization of the two-photon fluorescent light appears to be one way of experimentally estimating the relative contribution of these two second-order processes.

The concentration and intensity independent quantity δ , which is the ratio of the cross section to the laser flux, was found experimentally to be 0.9×10^{-21} cm²-sec/atom-photon for anthracene molecules in a dilute glass.

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Potential Applications of Magnetic Rare Earth Compounds, S. Methfessel, *IEEE Transactions on Magnetics* **MAG-1**, No. 3, 144-155 (September, 1965).

Chemistry and physics of the rare earth elements and their compounds are in a rapidly expanding state of development. Many new materials with interesting magnetic properties have recently become available. The potential of lanthanon compounds as magnetic materials in electrical engineering is evaluated by comparing the basic properties of lanthanons and transition metals. The lanthanides show certain unique properties resulting from the localization of their magnetic 4f levels. Unfortunately, their Curie temperatures are relatively low. The probability of finding ferromagnetic lanthanide compounds with high Curie temperatures is explored. A survey of magnetic properties of metallic and nonmetallic lanthanide materials indicates possible applications for which they can compete favorably with other materials.

Preemptive Priority Queues, Wei Chang, *Operations Research* **13**, No. 5, 820-827 (September-October, 1965).

Customers of different priorities arrive at a counter in accordance with a Poisson process. The customers are served by a single server in order of priority and for each priority in order of arrival. Preemptive discipline is assumed. Three service policies are considered: (i) preemptive-resume, (ii) preemptive-repeat-identical, and (iii) preemptive-repeat-dif-

ferent. The time-dependent solutions for these priority systems are very complicated. However, the problem can be simplified in case of stationary solutions. In this paper, a step-by-step method is proposed to find the stationary distributions of the queue sizes, the waiting times, and the busy periods of each priority class.

Preparation of Alkali-Free Silicate Glasses, Brian Sunners and Bernt Narken, *Ceramic Bulletin* **44**, No. 8, 620-624 (September, 1965).

Increasing electronic applications for glass have brought about the need for better control of impurities. A method is described for the preparation of alkali-free glass containing less than 10 ppm sodium. Further purification of this glass by electrolysis has been shown to reduce the sodium concentration to ≤ 2 ppm. Analyses by flame photometric and neutron activation methods are included to demonstrate these results.

Prevention of Oxidation in a Glow Discharge Environment with Sputtered Permalloy Films as an Example, Eric Kay, *Journal of Electrochemical Society* **112**, No. 6, 590-594 (June, 1965).

Problems associated with the elimination of significant amounts of oxygen inclusions in sputtered thin films grown in a plasma environment are discussed. In particular, data are presented to show that a plasma environment can easily be produced in which the concentration of ground state, excited and ionic oxygen containing species is sufficiently low so that no discernible effects on the magnetic properties of sputtered Permalloy films due to anti-ferromagnetic inclusions can be detected. Experimental evidence is also given to show that neither the energy of bombarding ion species at the cathode nor the inevitable electron bombardment of the substrate need influence the inducement of a truly uniaxial anisotropy into the NiFe film provided independent temperature control of the film during its growth can be achieved. A comparison between dc and asymmetric ac is well as substrate biasing with respect to the plasma is made with particular reference to the substrate environment.

Probes Designed for Testing Miniature Semiconductor Devices, F. Masterson, *SCP and Solid State Technology* **8**, No. 8, 52-56 (August, 1965).

The field of semiconductors has been achieving significant advancements in design, miniaturization and mechanization. Two- and three-element probes, described herein, are representative of new manufacturing equipment used in a mechanized system to test the electrical parameters of miniature diodes and transistors. Mass-produced semiconductor devices are tested in a circuit configuration which assures their successful functioning in computer operation.

On a Problem Concerning a Central Storage Device Served by Multiple Terminals, M. V. Menon, *Journal of the Association for Computing Machinery* **12**, No. 3, 350-355 (July, 1965).

A storage or processing device with a fixed number of cells is considered. If a chance-mechanism selects which of

M persons is to transmit an element of message to the device, the probability is found that the device will be filled without a complete message having been introduced into it. This probability should be useful in determining the "optimum" number of persons who can use the device. The problem is treated as one in an M -dimensional random walk.

A Reed-Switch Pulse Generator, R. H. Westerlund, *EEE* 13, No. 9, 69-71 (September, 1965).

The reed-switch emitter is a pulse-generating device with an output capable of driving solid-state circuitry. The length of each pulse is controlled by the opening and closing of a reed switch, which in turn is controlled by a magnetic field. The reed-switch emitter is discussed and the various methods of controlling pulse durations of reed-switch emitters are presented.

Remarks on Linear Magneto-Resistance and Magneto-Heat-Conductivity, S. Shtrikman* and H. Thomas, *Solid State Communications* 3, No. 7, 147-150 (July, 1965).

The question of the possible existence of an electrical resistivity, or heat conductivity, which changes linearly with an applied magnetic field is considered. It is concluded that although both effects are forbidden in nonmagnetic crystals, namely crystals whose point group contains the time reversal operation explicitly, it is allowed in all magnetic crystals which allow piezomagnetism.

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Resistive Intermediate State for Thin Superconductive Films of Tin, T. D. English, Jr., and L. A. Finzi,* *Journal of Applied Physics* 36, No. 3 (Part 2), 1191 (March, 1965).

An experimental study of the resistive transition state of vacuum-deposited films of tin has been performed in the temperature range extending from 3.7° to 2.0°K for various values of normally applied magnetic field H . In general, the relationship between the current I through the film and the voltage drop V across the film is not linear. However, over a broad range of the variables T , H , and I , the voltage drop V can be expressed in terms of the voltage drop V_n which occurs when the sample is completely normal

$$V = V_n \left(1 - \exp \left\{ - \frac{a[H - b(T_c - T)]}{T_c - T} \right\} \right);$$

for $T < T_c$, $b(T_c - T) < H$,

where T_c is the zero-field transition temperature. The constants have been found to be: $a = 0.12^\circ\text{K/G}$ and $b = 64 \text{ G/}^\circ\text{K}$.

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Reverberation Chamber Measurements of the Acoustic Power of Pure Tone Sources, K. S. Nordby and G. C. Maling, *Proceedings of the Fifth International Congress on Acoustics*, Liege, Belgium, pp. J65-1 to J65-4 (September, 1965).

Pure tone sound fields were studied to determine their rms equivalent sound pressure levels. When several modes are excited (above 1 kc/sec), the pressure maxima have a gaussian distribution (SD 1 dB). The rms equivalent SPL is approximately 2 dB below the mean value of the distribution. Theory and measurements are compared.

Reversible Photo Transfer of Electrons Between Rare Earth Ions in CaF_2 , B. Welber, *Journal of Chemical Physics* 42, No. 12, 4262-4264 (June 15, 1965).

This paper describes the observation of a charge transfer phenomenon occurring between divalent and trivalent ions incorporated into the CaF_2 lattice. It is shown that, in one of the two cases considered, the phenomenon is reversible at 4°K.

Segregation of a Nonvolatile Impurity during Normal Freezing in an Off-Stoichiometric Melt under Constant Component Pressure, M. R. Lorenz, *Journal of Applied Physics* 36, No. 9, 2908-2909 (September, 1965).

The effect of segregating a nonvolatile impurity during normal freezing in an off-stoichiometric melt under constant component pressure is examined. A modified normal freeze equation is derived relating the impurity concentration in the solid to the fraction of original melt solidified for any off-stoichiometric melt composition. The correction term in the modified equation becomes significant for segregation coefficients of the order of unity and melt compositions appreciably off stoichiometry.

Self-Correcting Memory, G. C. Randa and C. V. McNeil, *Electronic Design* 13, No. 18, 28-31 (August 30, 1965).

A memory system with self-correcting ability, designed for a digital-guidance computer, achieved a reliability factor of 0.999. This reliability has been made possible by combining the self-correcting feature with the duplex, or redundant, concept. The design is flexible enough to permit operation either in the duplex, or redundant, mode, or in the serial, or simplex, mode, depending upon the nature of the mission.

Shrinking the Man-Computer Interface, W. F. Hubbarth, *Control Engineering* 12, No. 8, 63-66 (August, 1965).

As space systems evolve, increased utilization of a general purpose computer is required to meet mission objectives. The digital computer is becoming the prime data handling

means and will be used for every phase of space mission as the basis of navigation, guidance, system monitoring, crew monitoring, and scientific data processing. Effective utilization of this general purpose system requires that the crew members be provided with an appropriate interface to accomplish the aims of the mission. Design concepts are presented for the man/computer interface with emphasis on key parameters. Examples of this interface are given.

Signal Velocity in a Region of Resonant Emission, N. S. Shiren, *Physical Review Letters* **15**, No. 8, 341-343 (August 23, 1965).

Experimental and preliminary theoretical results are reported on the signal velocity of microwave ultrasonic pulses propagating through a phonon maser amplifier. For all levels of amplification, up to a maximum of 12.5 dB/cm, the velocity was found to be the same, within $\pm 1\%$ as in the absence of the maser interaction. This result is thus quite different from that observed in absorption where the pulse velocity decreases in the region of resonance.

Some Objections to Levin's "Deviation," R. J. Scholes, *Lingua* **13**, 189-192 (1965).

This article examines some specific and general questions regarding the classification of grammatical deviances into deviance by order and deviance by class membership.

Some Results on Tests for Poisson Processes, P. A. W. Lewis, *Biometrika* **52**, Parts 1 and 2, 67-77 (June, 1965).

It is shown that a test proposed by Barnard for Poisson processes, using certain distribution-free statistics, is not consistent against renewal alternatives. However, empirical evidence is given which suggests that a modification of this test due to Durbin results in relatively powerful tests of the Poisson hypothesis. A simple test based on Durbin's modification is described, and its asymptotic relative efficiency with respect to the asymptotically most powerful test against the alternative of a renewal process with gamma-distributed intervals is given.

Space-Variant Image Formation, A. Lohmann and D. Paris, *Journal of the Optical Society of America* **55**, No. 8, 1007-1013 (August, 1965).

The application of optical transfer theory to the process of image formation requires that the image-forming system be linear and space invariant. In a space-invariant system, the point image retains its shape while the point source explores the object plane. The purpose of this paper is to investigate image-forming systems which are linear but space variant. Such systems may exceed performance limitations which are inherent in linear space-invariant systems. A method for experimentally determining space variance is devised. The degree of space invariance is defined and evaluated for several examples of space-variant systems.

Stresses in a Thin Slab with Different Elastic Properties from that of the Substrate Due to Distributed Normal and Shearing Forces on the Surface of the Slab, T. C. Ku, S. C. Kingsley and J. H. Ramsey, *International Journal of Engineering Science* **3**, No. 1, 93-107 (May, 1965).

This paper presents a general solution for the state of stress in a thin slab and the semi-infinite substrate under any given boundary loading at the surface of the slab. Under the assumptions that (1) the slab and substrate adhere perfectly to each other, (2) they are each individually homogeneous, isotropic, and linearly elastic, and therefore (3) they may be governed by the equations of elasticity, the solution is obtained in Fourier integral form. Numerical results are presented for two special cases in which the boundary loadings consist of (1) uniformly distributed uni-directional shearing force, and (2) elliptically distributed uni-directional shearing force, respectively. The area of loading is a circle of radius a on the surface of the slab. The slab and the substrate are referred to the (r_1, z_1, θ_1) and (r_2, z_2, θ_2) coordinate systems, respectively.

Struktur und Energie von Blochlinien in dünnen Ferromagnetischen Schichten (Structure and Energy of Bloch Lines in Thin Ferromagnetic Films), Ernst Feldtkeller* and Harry Thomas, *Physics of Condensed Materials* **4**, 8-14 (1965).

For circular Bloch lines in ferromagnetic thin films the structure and the energy have been calculated. The radius of the region in which the magnetization is tilted considerably out of the film plane, depends only weakly on the film thickness and has the order of 100 Å for 80/20 nickel-iron films. This region is surrounded by a circularly magnetized region. The transitions to the noncircular configuration of the walls and domains takes place at an essentially higher radius.

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Studies of Trace Metal Metabolism: The Electron Paramagnetic Resonance of Manganese in Ribonucleic Acids,† B. A. Calhoun, J. Overmeyer and F. W. Sunderman,* *Proceedings of the Society for Experimental Biology and Medicine* **119**, 1089-1093 (August-September, 1965).

In an attempt to elucidate the intramolecular bonding of trace metals in ribonucleic acids, measurements have been made of the electron paramagnetic resonance (EPR) spectra of 36 samples of RNA isolated from human and rat tissues. The EPR pattern of manganese was readily detected in all of the samples of RNA. The resonance patterns indicate that manganese is present in RNA in a divalent state and suggest that manganese is located at the center of a distorted octahedron of oxygen atoms. From the intensity of nominally forbidden resonances, the crystal field splitting parameter D was estimated to be 0.02 cm^{-1} .

†These investigations have been supported in part by a grant to the University of Florida from the American Cancer Society.

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Ueber Neuere Untersuchungen an Wandstrahlelementen und ihre Anwendung in Logischen Schaltungen (On Recent Investigations of Wall-Reattachment Elements and their Application in Logic Circuits), J. Bahr and H. H. Glaettli, *Elektronische Rechenanlagen* 7, No. 3, 137-147 (1965).

In the first section, apart from some introductory remarks and a survey of the most important types of elements, the paper contains the results of recent basic investigations on the logical, highly effective monostable element with three outputs. In the second part, numerous examples of applications are shown and fundamental indications for the layout of circuits are given.

Ultrasonic Maser Amplification by Stimulated Phonon-Photon Double Quantum Emission in MgO, N. S. Shiren, *Applied Physics Letters* 7, No. 5, 142-144 (September 1, 1965).

In multilevel spin systems with nearly equal level spacings the double quantum process is especially favorable for the case in which one quantum is a phonon and the other a photon. Through utilization of this mechanism large maser amplification (~ 23 dB/cm) of microwave ultrasonic waves has been achieved. Population inversion of the $S_z = \pm 1$ ($\Delta M = 2$) levels of Ni^{2+} or Fe^{2+} in MgO was achieved by adiabatic rapid passage through the $\Delta M = 1$ transitions. The ultrasonic wave, at frequency ω_2 , was started after termination of the field sweep; the saturating rf at frequency ($\omega_1 - \omega_2$) used for passage was left on during the traversal of the ultrasonic pulse. The interaction is most easily calculated in the coordinate system rotating at ω_1 , since the transition appears there as a single quantum $\Delta M = 2$ transition at frequency ($\omega_1 - \omega_2$). The effect may thus be considered as a two-level rotary maser in analogy with rotary saturation. The theoretical gain is half that expected in direct $\Delta M = 2$ transitions at $2\omega_2$.

A Uniqueness Theorem for the Displacement Boundary-Value Problem of Linear Elastodynamics, by M. E. Gurtin* and R. A. Toupin, *Quarterly of Applied Mathematics* 23, No. 1, 79-81 (April, 1965).

The classical uniqueness theorem for the displacement problem of linear elastodynamics rests on the assumption that the elasticity tensor is positive semidefinite. In this paper it is shown that uniqueness follows from the weaker condition that the acoustic tensor for each direction of propagation be positive semidefinite.

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The Use of Magnesium Alloys in Aerospace Electronic Technology, R. A. Munroe, *Electronic Packaging and Production* 5, No. 8, 77-86 (August, 1965).

Although many mechanical designers are familiar with some properties of magnesium alloys, these alloys are seldom used by electronic packaging specialists. Probably most electronic applications in existence are forced upon de-

signers by the single fact that the use of any other metal exceeds desired weight objectives. The choice of magnesium alloys as an afterthought to reduce weight, coupled with obviously poor corrosion protection, has led many designers to believe that magnesium is not serviceable in aerospace environments. The paper describes in a broad manner when and how to use magnesium. Because most designers are familiar with aluminum alloys, direct comparisons are made between magnesium and aluminum alloys, thus giving the reader a ready frame of reference. Fabrication techniques, thermal properties, mechanical properties, corrosion, and aerospace applications are discussed.

Vacuum Deposited Molybdenum Films, R. A. Holmwood and R. Glang, *The Journal of the Electrochemical Society* 112, No. 8, 827-831 (August, 1965).

Vacuum evaporation of molybdenum with an electron bombardment source on oxidized silicon wafers produces films whose properties depend on the condensation temperature. At 600°C or above, the films have resistivities comparable to molybdenum wire, satisfactory adhesion, and tolerable stress. They are potentially useful as interconnections for silicon devices and monolithic circuits. All films are polycrystalline with (110) fiber texture. Other crystallite orientations appear above 500°C, while simultaneously the intrinsic film stress becomes decreasingly tensile and, at 625°C, compressive. Film stress and preferred orientation are considered to result from the interaction of lattice defects during the entire growth process and not merely from lattice distortions at the film substrate interface.

Letters

Correlation Between Axial Field Parameters of Fe^{3+} and Cr^{3+} in Oxide Crystals, K. A. Müller, *Helvetica Physica Acta* 38, No. 4, 358 (1965).

Detection of Striae in GaAs by Chemical Etching, T. S. Plaskett and A. H. Parsons, *Journal of the Electrochemical Society* 112, No. 9, 954-955 (September, 1965).

Elektron-Spinwellen-Streuung in Gadolinium (Electron Spinwave Scattering in Gadolinium), B. Lüthi and H. Rohrer, *Helvetica Physica Acta* 38, No. 4, 353 (1965).

Energy Level of the First Excited Singlet State of 1, 3-Butadiene, R. Srinivasan and F. I. Sonntag, *Journal of the American Chemical Society* 87, No. 16, 3778 (August 20, 1965).

Effect of Mobility Distribution on the Measurement of Ion Concentrations with Extended Collectors, R. E. McCurry, *Journal of Applied Physics* 36, No. 8, 2599-2600 (August, 1965).

Fault Planes in Steam-Oxidized Silicon, F. J. Wilhelm and M. L. Joshi, *Journal of Applied Physics* **36**, No. 8, 2592-2593 (August, 1965).

Ferroakustische Resonanz und akustische Doppelbrechung in Gadolinium-Eisen-Granat (Ferroacoustic Resonance and Acoustical Birefringence in Gadolinium Iron Garnet), B. Lüthi, *Helvetica Physica Acta* **38**, No. 4, 353 (1965).

Hydrodynamik und Zweiter Schall von Spinwellensystemen (Hydrodynamics and Second Sound in Spin-wave Systems), P. Erdös, *Helvetica Physica Acta* **38**, No. 4, 352 (1965).

Image Formation and Multiplicative Noise, A. Lohmann, *Journal of the Optical Society of America* **55**, No. 8, 1030-1031 (August, 1965).

Optical Gain and Losses of Epitaxial and Diffused GaAs Injection Lasers, M. Pilkuhn, H. Rupprecht and J. Woodall, *IEEE Journal of Quantum Electronics* **QE-1**, No. 4, 184 (July, 1965).

Paramagnetic Resonance and Relaxation of Ag^{2+} and Pd^{3+} in MgO and CaO, P. Wysling,* K. A. Müller and U. Höchli, *Helvetica Physica Acta* **38**, No. 4, 358 (1965).

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Resonant Excited States in the Dynamic Jahn-Teller Effect, J. C. Slonczewski, *Helvetica Physica Acta* **38**, No. 4, 359 (1965).

Wärmeleitfähigkeit ferromagnetischer Isolatoren bei tiefen Temperaturen (Thermal Conductivity of Ferromagnetic Insulators at Low Temperatures), P. Erdös, *Helvetica Physica Acta* **38**, No. 4, 352 (1965).