

Technical Papers by IBM Authors Published Recently in Other Journals

About Two Microstructural Features of Electrodeposits, R. Weil* and W. N. Jacobus Jr., *Plating, Journal of the American Electroplaters' Society* **53**, No. 1, 102-106 (January, 1966).

Two features of the microstructure of certain electrodeposits from bright plating baths, namely striations and crevices, were studied. The striated structure was found to consist of alternate bands of columnar and more impeded, fine crystallite growth. Crevices on the surface of bright, but not specular deposits were either regions of very small crystallites or depressed grain boundaries. Both structural features appeared to be caused by nonuniform codeposition of foreign substances.

* Stevens Institute of Technology.

Admissible Solutions of Linear Systems with Not Sharply Defined Coefficients, W. Oettli, W. Prager* and J. H. Wilkinson,** *Journal of SIAM, Numerical Analysis, Series B* **2**, No. 2, 291-299 (1965).

The compatibility of a complex vector ξ with the linear system $A\xi = b$ is discussed from the point of view of mathematical programming, when all that is known concerning the typical element of A is that it is represented in the complex plane by a point of a circular disc with given center a_{ij} and radius Δa_{ij} .

*Present address: University of California, La Jolla.

** National Physical Laboratory, Teddington, Middlesex, England.

Approximation in the Metric of $L^1(X, \mu)$, T. J. Rivlin and B. R. Kripke,* *Transactions of the American Mathematical Society* **119**, No. 1, 101-122, (July, 1965).

This is a detailed study of least first power approximation with especial attention to the uniqueness problem. The presentation is unified by the systematic exploitation of a basic characterization result.

*University of California, Berkeley.

Automatic Simplification of Mathematical Expressions—The FORMAC Algorithm, R. G. Tobey, R. J. Bobrown, S. N. Zilles, *AFIPS Conference Proceedings, Proceedings of the Fall Joint Computer Conference* **27**, pp. 37-53 (November, 1965).

The simplification of symbolic mathematical expressions is an essential process in the manipulation of such expressions. The role of simplification in the experimental FORMAC programming system is presented in this paper. In addition, the approach taken in implementing the FORMAC automatic simplification algorithm is described. Some possibilities for automatic simplification are explored, and a broad sketch of the techniques employed by the FORMAC algorithm for automatic simplification is presented.

Automatic Programs in Circuit Analysis and Design, S. R. Sedore, *Electronic Design* **14**, No. 1, 96-99 (January 4, 1966).

This article surveys the computer techniques used to perform dc, ac, and transient analysis of electronic circuits. Some problems currently being faced by the developers of analysis programs are mentioned.

Automatic Telephone Intercept System, G. F. Abbott and R. L. Bence,* *Telephone Engineering & Management* **69**, No. 23, 43-49 (December, 1965).

The magnitude, complexity, and sophistication of the telephone system is largely taken for granted today. Direct-distance dialing places any one of 72 million telephones at the finger-tip of the customer. Although most telephone services are revenue-producing, one essential element which yields no income to a telephone company is its automatic intercept system. A mechanized intercept system developed through the collaboration of IBM and Southwestern Bell Telephone is described in this paper.

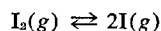
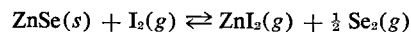
* Southwestern Bell Telephone Co., St. Louis.

Bound-Electron-Lattice Coupling and Vibronic Spectra, W. E. Bron, *The Physical Review* **140**, No. 6A, A2005-A2014 (December 13, 1965).

The radial extent of the coupling between the bound electronic states of a defect ion in a crystal and the vibrations of the lattice ions is investigated. An electrostatic-coupling model is used to evaluate the electron-lattice interaction. It is found that those electronic transitions which involve a change in configuration are coupled primarily to the vibrations of ions in the immediate vicinity of the defect. Consequently, if there exist local or pseudolocalized vibrations, the resultant vibronic spectra are dominated by transitions to vibrational modes which have high local amplitude. In contrast, it is found that, in general, electronic transitions within a configuration are coupled to nonlocalized vibrations as well as to the localized vibrations. In the special case of the transition $^5D_0 \rightarrow ^7F_0$ of Sm^{2+} , the coupling is primarily to nonlocalized vibrations, so that the vibrations resemble those of ions of the undisturbed lattice. The observed vibronic structure accompanying this transition of Sm^{2+} in the alkali halides is presented. A comparison is made of sm^{2+} : KBr between the singularities in the phonon density of states as observed in the vibronic structure, and those predicted from the published dispersion curves of KBr obtained from neutron-scattering data. The agreement is found to be very good. The vibronic structure accompanying the same transition of Sm^{2+} in the alkaline-earth halides is also discussed.

Bourdon Gauge Determination of Equilibrium in the ZnSe(s)-I₂(g) System, T. O. Sedgwick and B. J. Agule, *Journal of the Electrochemical Society* **113**, No. 1, 54-57 (January, 1966).

Bourdon gauge measurements of samples of I₂(g) plus ZnSe(s) have been made in the temperature range 900–1200°K and over a fourfold range in pressure. The pressure vs temperature behavior of the system can be described satisfactorily by the equilibria,



The standard enthalpy and entropy of the first reaction between 900–1200°K were calculated using the second law with the result; $\Delta H^\circ = 23.1$ kcal, $\Delta S^\circ = 21.1$ e.u. The standard heat of formation, ΔH°_{298T} , and entropy, S°_{298} , of ZnSe(s) were found to be 44.2 kcal and 15.4 e.u., respectively.

Die charakteristische Matrix des gegengekoppelten Vierpols (The Characteristic Matrix of a Two-Port Network with Feedback), D. Seitzer, *Archiv der elektrischen Uebertragung* **20**, No. 1, 19-26 (January, 1966).

It is shown that a two-port network with substantial feedback can be described by an illustrative equivalent model. The matrix belonging to that equivalent model is called the characteristic matrix of the two-port. The characteristic matrix of a two-port with feedback is calculated in a way which is valid, at the same time, for all types of feedback. The characteristic matrix is based on the impedance mismatch at the input and output of the two-port considered. Therefore, it is especially suitable for describing high-speed transistor circuits.

The Conduction Properties of Ge-GaAs_{1-x}P_x n-n Heterojunctions, L. L. Chang, *Solid State Electronics* **8**, No. 9, 721-728 (September, 1965).

n-type Ge has been grown epitaxially on GaAs_{1-x}P_x substrates of 4×10^{17} cm⁻³ donors at 360°C. The substrates have (111) orientation and a composition range of $x = 0, 0.1$ and 0.3 . Junctions made with $x = 0$ or 0.1 exhibit diode behavior that can be interpreted by the metal-semiconductor emission theory modified to take into account the effects of both electron tunnelling and voltage distribution between the semiconductors. The barrier heights have been found to be 0.62 V and 0.54 V for the A- and B-surfaces of substrates with $x = 0.1$, and 0.50 V and 0.43 V correspondingly with $x = 0$. The apparent barriers at zero bias are smaller than these values by about 0.2 V due to tunnelling reduction. For substrates with $x = 0.3$, various measurements tend to suggest a structure of back-to-back diodes. The effect of interface states, as likely produced by the relatively large lattice mismatch in this case (>1 per cent), is believed to be responsible for this structure.

Considerations for the Short-Term Stability of Frequency Multipliers, R. Van Blerkom and S. L. Anema, *IEEE Transactions on Aerospace and Electronic Systems* **AES-2**, No. 1, 36-47 (January, 1966).

The effects of frequency multiplication circuits on the short-term stability of an oscillator system are analyzed. The short-term stabilities of real components such as varactor multipliers are compared to the short-term stability of an ideal "frequency multiplier" which maintains its stability of the basic oscillator. In addition, it is shown that positive feedback like that used in a synchronized oscillator, while useful for tracking, degrades short-term stability.

The Degree of Approximation of Certain Functions of Two Variables by a Sum of Functions of One Variable, T. J. Rivlin and R. J. Sibner,* *American Mathematical Monthly* **72**, No. 10, 1101-1103 (December, 1965).

The degree of approximation to certain functions of several variables by sums of functions of one variable is obtained explicitly.

* Stanford University.

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, *AFIPS Conference Proceedings, Fall Joint Computer Conference* **27**, Part I, pp. 627-636 (November, 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.

Doppler Dispersion in Matched Filter Detection, W. R. Remley, *Proceedings of the IEEE* **54**, No. 1, 33-39 (January, 1966).

Conventional matched filters which use pseudo-random or noise-like waveforms attempt to compensate for the Doppler effect by cross-correlating the received waveforms with frequency shifted replicas of the transmitted waveform. However, frequency translation is only an approximation to the actual Doppler effect which is a time-expansion or time-compression of the waveform resulting from the continuous expansion or compression of the transit path. This paper investigates the effects of Doppler dispersion in matched filters which use frequency translation for Doppler compensation. It is found that the effects of Doppler dispersion are independent of the carrier frequency and negligible if the dispersion product (i.e., the absolute magnitude of the product of the signal bandwidth, duration, and delay rate) is less than unity. If the dispersion product is greater than

unity the dispersion effects are serious. In the latter case the time and frequency resolution of the system are degraded and the output pulse is reduced in amplitude. The maximum improvement that can be obtained in the signal-to-noise power ratio is equal to the reciprocal of the delay rate magnitude. This maximum signal-to-noise gain is achieved when the time-bandwidth product of the receiver is chosen such that the dispersion product is approximately unity.

An Electrically Latched EL-PC Memory Panel, B. Sunners and B. Narken, *Journal of the Electrochemical Society* **112**, No. 12, 1237-1239 (December, 1965).

An electroluminescent-photoconductive (EL-PC) panel that shows considerable advantage over existing units has been developed. It is continuous in structure; that is, it does not require an XY matrix, and thus, much of the cost and complexity of present panels is eliminated. Resolution is high, limited only by grain size.

Electric Resonance of Rotating Dipoles in Ionic Crystals, W. E. Bron and R. W. Dreyfus, *Physical Review Letters* **16**, No. 5, 165-168 (January 31, 1966).

In KCl crystals, OH^- ions may replace Cl^- . If the center of mass of the hydroxyl ion is displaced from the center of the Cl^- lattice site, then the $(\text{OH})^-$ can execute, within the site, a combined rotational-translational motion. In the octahedral symmetry of KCl, potential minima for this motion appear along $\langle 100 \rangle$ directions. Consequently, the ground configuration consists of three nearly degenerate levels with representations A_1 , T_{1u} , and E_g . The application of a dc electric field, E_z , in the $[001]$ direction of the crystal, causes a splitting of the states into two (A_1) levels with energy proportional to $\pm E_z$ and four nearly degenerate states (A_1 , E , B_1) at zero energy. These small energy splittings are investigated at 1.4°K by resonant absorption of 9 kMc/sec microwave power with its electric field in the $[001]$ direction while scanning E_z . Under these conditions, two electric dipole transitions are observed between the three states of the A_1 representation. Additional information is obtained by simultaneously applying dc electric and uniaxial stress fields, both in the $[001]$ direction. The zero field splitting of the states is found to be $< 0.3\text{cm}^{-1}$, but it depends sensitively upon electric fields from other hydroxyl ions. Measurements have been extended to include OH^- in LiF, and SH^- in KCl and KBr.

Ensembles de multiplicité aléatoires, J.-P. Kahane* and B. Mandelbrot, *Comptes Rendus, Académie des Sciences de Paris* **261**, No. 20, 3931-3933 (November 15, 1965).

Let a trigonometric series converge to zero except perhaps on a set E . Does it follow that the series is identically zero? This problem, posed by Cantor, is still unsolved in the case of general sets of zero Lebesgue measure. When the answer to the above question is no, E is called "set of multiplicity." Previous examples of sets of multiplicity were extremely complicated. The present note presents a very simple example, namely the closure of the set of values of an increasing stable process of Paul Lévy. It plays a central role in Mandelbrot's theory of turbulence.

* Faculté des Sciences de Paris-Orsay.

Epoxy Dielectric Films Produced by Electron Bombardment, A. E. Brennemann and L. V. Gregor, *Journal of the Electrochemical Society* **112**, No. 12, 1194-1197 (December, 1965).

Thin dielectric films have been produced by low energy electron bombardment of a surface which is simultaneously exposed to an evaporating epoxy resin. The rate of film growth is dependent only on the evaporation parameters when the electron flux at the surface is much larger than the molecular flux in the evaporant beam. The polymerized epoxy films are good insulators with d-c dielectric breakdown strengths greater than 10^6 V/cm. The films are stable in normal room atmosphere and may be cycled thermally from room temperature to 77°K many times without damage to their mechanical or electrical properties. A number of multilayer electrical structures consisting of alternating evaporated Pb films and epoxy films have been prepared successfully and tested.

An Experiment in Automatic Indexing, F. J. Damerau, *American Documentation* **16**, No. 4, 283-289 (October, 1965).

This report describes a method of indexing documents which is based on the assumptions, (1) that a subset of the words in a document can be an effective index to that document and, (2) that this subject can be approximated by selecting those words from the document whose frequencies are statistically unexpectedly high. The results of the experiment are encouraging, although not definitive because any index chosen must be tested by using it for retrieval from a large collection.

Flow in Networks with Amplification and Coupling, W. Oettli and W. Prager,* *Unternehmensforschung* **10**, No. 1, 42-49 (1966).

The network model presented in an earlier paper is generalized by introducing amplification in arcs and coupling between arcs. The appropriate modifications of the earlier results are stated and the usefulness of the new model is illustrated by examples.

* Present address: University of California, La Jolla.

Forecasts of Future Prices, Unbiased Markets and "Martingale" Models, B. Mandelbrot, *Journal of Business (University of Chicago)* special supplement on Security Prices **39**, No. 1, 242-255 (January, 1966).

Conditions are explored, under which a price series $Z(t)$ constitutes a "martingale": This means that the expectation of the future price $Z(t+T)$, conditioned by the knowledge of the present price $Z(t)$ and by the knowledge of any set of past prices, is identical to the present price $Z(t)$. Knowledge of past prices is then unnecessary, in forecasting, the expectation of $E[Z(t+T)]$; but it is useful in forecasting the dispersion of $Z(t+T)$ around its expectation. It is shown that a price series generated by a martingale can have a variety of striking "patterns"; conversely, this finding gives additional support to the thesis (advanced in an earlier paper: The variation of certain speculative prices, *J. Business* **36**, 394-419) that the existence of perceptual patterns does not prove that prices cannot be represented by stochastic processes, as being "fair games."

1401 Compatibility Feature on the IBM System/360 Model 30, M. A. McCormack, T. T. Schansman and K. K. Womack, *Communications of the ACM* 8, No. 12, 773-776 (December, 1965).

The "second generation" of stored-program computers, of which the IBM 1400 series was a part, brought EDP into the mass market for the first time on a large scale. As this era unfolded, rapid changes in technology led to rapid obsolescence of data processing equipment. Programs written for a particular system required tedious conversion as incompatible new machines came into use.

The IBM System/360 has been designed with the conversion problem specifically in mind. One of the conversion aids available on the Model 30 is the 1401 compatibility feature. This feature, in conjunction with other aids, permits a smooth and inexpensive transition to optimum use of the new system.

The Free Flexural Vibrations of Triangular, Rhombic and Parallelogram Plates, and Some Analogies, H. D. Conway* and K. A. Farnham, *International Journal of Mechanical Sciences* 7, 811-816 (December, 1965).

This article presents numerical data and solutions for the free flexural fundamental vibrations of simply supported isosceles triangular, rhombic, and parallelogram plates using special adaptations of the point-matching method. Vibration data for clamped rhombic plates are also given. The numerical data are believed to be very accurate since they agree very well with the exact solutions for several special cases.

The data for the simply supported polygonal problems can be shown to be analogous to (1) the buckling of simply supported polygonal plates subjected to hydrostatic in-plane loading, and (2) the free vibrations of polygonal membranes under constant tension.

* IBM Consultant and Professor of Mechanics, Cornell University.

The Functional Structure of OS/360—Part I: Introductory Survey, G. H. Mealy, *IBM Systems Journal* 5, No. 1, 3-11 (1966).

A brief outline of the structural elements of OS/360 is given in preparation for the subsequent sections on control-program functions. Emphasis is placed on the functional scope of the system, on the motivating objectives and basic design concepts, and on the design approach to modularity.

The Functional Structure of OS/360—Part II: Job and Task Management, B. I. Witt, *IBM Systems Journal* 5, No. 1, 12-29 (1966).

This part of the paper discusses the control-program functions most closely related to job and task management. Emphasized are design features that facilitate diversity in application environments as well as those that support multi-task operation.

The Functional Structure of OS/360—Part III: Data Management, W. A. Clark, *IBM Systems Journal* 5, No. 1, 30-51 (1966).

Concepts underlying the data-management capabilities of OS/360 are introduced; distinctive features of the access methods, catalog, and relevant system macroinstructions are discussed. To illustrate the way in which the control program adapts to actual input/output requirements, a read operation is examined in considerable detail.

Heat Detector Uses Fiber Optics in Semiconductor Bonding Operation, Benjamin Myers, *Electronic Design* 14, No. 2, 65-67 (January, 1966).

An infrared detector and a fiber-optic light pipe were used to measure the transistor header temperature during die-bonding operations. This arrangement solves the problem of an obstructed target in an rf field.

Heats of Dilution of Some Electrolyte Solutions in D₂O and Comparison of Thermodynamic Excess Functions in D₂O and H₂O, Y.-C. Wu and H. L. Friedman,* *The Journal of Physical Chemistry* 70, No. 1, 166-172 (January, 1966).

Heats of dilution of LiCl, NaCl, and NaI solutions in D₂O have been measured in the range 1 to 3M to supplement earlier results of Birnhauser and Lange. The solvent isotope effect on the excess enthalpies is much larger than that on the excess free energies found by Frank and Kerwin. The excess entropies in D₂O have been calculated from these data and compared with those in water with the result that, within the experimental error, we have S^{ex} (in H₂O) - S^{ex} (in D₂O) = k, m , where m is the aquamolality (moles of salt per 55.51 moles of solvent). We find $Tk_s = 54$ for LiCl, 35 for NaCl, and 35 for NaI, all in units of cal mole⁻¹ M⁻¹. These results, as well as the solvent-isotope effects on the entropies of solvation, seem to be consistent with the model of aqueous solutions developed by Frank and Evans, Gurney, and Nemethy and Scheraga.

* Department of Chemistry, State University of New York at Stony Brook.

Higher-Speed Data Transmission, A. J. Weber, *Record of the Eleventh National Communications Symposium*, pp. 23-26 (October, 1965).

With the advent of "real-time" Tele-processing Systems, where much of the data is initiated or immediately interpreted by machines rather than people, both the data processing equipment manufacturers and the common carriers visualize a whole new area of higher-speed data transmission for satisfying customers' needs. This paper explores some of the requirements, configurations, and advantages of higher-speed data transmission systems. A review of the economics of higher-speed communications reveals that the bits per dollar of the various services offered by the common carriers clearly point to the advantage of utilizing the highest speed consistent with the application.

Inch-Metric Dimensioning, A. Saliby, *Mechanical Engineering* **88**, No. 1, 50-53 (January, 1966).

This paper explains IBM's approach to the problem of inch-metric dimensioning on drawings used in more than one country. In the IBM-developed system called dual dimensioning, the designer designates all dimensions in both inches and millimeters.

Index Register Allocation, L. P. Horwitz, R. M. Karp, R. E. Miller and S. Winograd, *Journal of the Association for Computing Machinery* **13**, No. 1, 43-61 (January, 1966).

A procedure for index register allocation is described. The rules of this procedure are shown to yield an optimal allocation for "straight line" programs.

Infrared Study of the Photochemistry of Tetramethylcyclobutan-1, 3-Dione, I. Haller and R. Srinivasan, *Canadian Journal of Chemistry* **43**, No. 12, 3165-3172 (December, 1965).

The photolysis of tetramethylcyclobutan-1, 3-dione was investigated in a nitrogen matrix at 4°K and in solution in cyclohexane at room temperature. Infrared spectra of the reactant after irradiation showed the formation of carbon monoxide, dimethylketene, tetramethylethylene, and a compound with an intense absorption at 1840 cm⁻¹ which has been identified as tetramethylcyclopropanone. Since the dimethylketene that was formed was also capable of undergoing secondary photolysis, the effect of light (mainly 2537 Å) on dimethylketene in solution or in a nitrogen matrix, was also studied. It has been found that in solution 0.2 of the molecules of tetramethylcyclobutandione which decompose, do so to give two molecules of dimethylketene, while approximately the same number of molecules decompose to tetramethylcyclopropanone and carbon monoxide. The remainder of the molecules seem to give tetramethylethylene and carbon monoxide in a concerted process.

Influence of Hydrostatic Pressure on Magnetic Transitions in Terbium and Dysprosium,† L. B. Robinson,* S.-I. Tan and K. F. Sterrett,** *Physical Review* **141**, No. 2A, A548-A553 (January, 1966).

The effect of hydrostatic pressure on the magnetic transitions in terbium and dysprosium has been investigated. The transformer method is used, in which the toroidal core of the miniature transformer is the rare-earth metal itself. Results are obtained as curves of secondary voltage versus temperature. A cusp in the secondary voltage indicates the occurrence of a Néel temperature, at which a transformation takes place from a paramagnetic to an antiferromagnetic state, while a sharp rise in the secondary voltage indicates the passage through a Curie temperature, where a transformation from an antiferromagnetic to a ferromagnetic state occurs. The pressures, up to 25 kbar, are obtained by the piston-cylinder technique, using silver chloride as the pressure-transmitting medium. The temperature range is from 40°K to room temperature. This has been achieved with the use of a new 4-wall cryogenic Dewar and liquid helium as coolant. The pressure coefficient of the transition temperature of terbium is found to be -1.0°K/kbar. Under pressure, the atmospheric Néel temperature either disappears or, because of the narrowness of the antiferromag-

netic region, is difficult to separate from the Curie temperature. The pressure coefficient of the Néel temperature for dysprosium is -0.4°K/kbar. In the range of from zero to about 7 kbar, the Curie temperature appears to increase with increasing pressure; beyond 7 kbar, the Curie temperature appears to decrease with increasing pressure. In the low-pressure range, the pressure coefficient of the Curie temperature appears to be positive, and in the high-pressure range it is -0.8°K/kbar. The above results involving measurements on dysprosium must be taken as tentative. The shape of the secondary-voltage-versus-temperature curves is such that one cannot assign the coefficients in an unambiguous manner.

† Based on experiments performed by Swie-In Tan in partial fulfillment of the requirements for the Ph.D. degree. Supported in part by aid provided by the UCLA Space Science Center (Grant NSG 237-62 Libby).

* Department of Engineering, University of California, Los Angeles.

** Northrop Space Laboratories, Hawthorne, California.

Integrated Transmission Lines for Magnetic Thin Film Memories, T. D. English and J. J. McNichol, *IEEE Transactions on Magnetics* **Mag-1**, No. 4, 272-276 (December, 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.

Iterative Procedure for Analyzing Certain Networks by Digital Computer, B. A. M. Willcox,* and R. C. V. Macario,** *Proceedings of I.E.E.* **112**, No. 12, 2243-2253 (December, 1965).

The paper describes and illustrates a method of analyzing linear electrical networks which can be viewed as a set of interconnected 4-terminal networks. The iterative nature of the method makes it very suitable for programming on a digital computer. Further, it is often very economical in computer time because one can use the results of previously analyzed 4-terminal networks. The paper also outlines a program which has been written for the method.

* Deceased.

** Present address: University College of Swansea.

Linearly Separable Codes for Adaptive Threshold Networks, C. E. Kiessling and C. J. Tunis, *IEEE Transactions on Electronic Computers* EC-14, No. 6, 935-936 (December, 1965).

This article describes the significance of the coding assignment in linear threshold networks used for pattern recognition. In particular, codes more dense than the 1-out-of- n are presented. The performance of these codes is comparable to the 1-out-of- n code, but more optimum codes exist.

Magnetically Shaped RF Discharge for Polymer Film Formation, R. A. Connell* and L. V. Gregor, *Journal of the Electrochemical Society* 112, No. 12, 1198-1200 (December, 1965).

A magnetically contained glow discharge has been developed for production of thin polymer insulating films. The glow discharge is maintained by an electrodeless radio-frequency source external to the system. Film growth rates of 1200 Å/min of polystyrene have been achieved with very little substrate heating or shadowing of the polymer films. The controlled glow discharge has been used to make thin film capacitors whose plates are evaporated metal films. Insulating films as thin as 100 Å have been produced from several organic monomers.

* Present address: Midwest Research Institute, Kansas City, Missouri.

Magnetic Dichroism in EuSe, B. E. Argyle, J. C. Suits and M. J. Freiser, *Physical Review Letters* 15, No. 21, 822-825 (November 22, 1965).

Optical absorption spectra at 292, 77, and 4.2°K and the magnetic field induced changes in absorption coefficients at 4.2°K were measured in single crystal EuSe. The magnetic field dependence of the absorption coefficient appears to correlate with the transitions between complex antiferro- and ferromagnetic spin order observed in powder neutron diffraction experiments. An observed shift in the absorption spectrum at 4.2°K for right circularly polarized light produced by an applied field of 15 kOe is close to 1000 cm⁻¹. This magnitude is discussed in terms of a charge transfer mechanism of optical excitation involving a strong ferromagnetic intra-atomic exchange.

Maintenance Strategy Diagramming, D. C. Burnstein and W. H. Eppard, *Proceedings of the 1966 Annual Symposium on Reliability*, p. 497 (January, 1966).

This paper discusses a disciplined approach to the problem of maintainability trade-offs and downtime prediction. The method involves analysis of the equipment reliability, support items, maintenance facility effectiveness and priority of use, symptoms of malfunction, and the strategy required to go from symptom to repair. It accounts for the time per maintenance task and probability of task occurrence. The resulting maintenance strategy is simulated using an IBM 7094 computer. The result of the simulation is examined and the maintenance strategy model is modified to see the effect of changes in any of the items originally analyzed. In this fashion, a prediction of unscheduled downtime is performed and the impact of changes in maintainability parameters on that predicted downtime is seen. The paper will include examples of the strategy, diagramming approach, simulation results, and will discuss the types of trade-offs that can be performed and correlation results.

A New Approach to Shaker Control for Multiple Input Specimens, S. L. Casey, *Test Engineering* 15, No. 1, 16-17 (January, 1966).

A technique has been needed to reduce out-of-specification testing when using sweep-sine vibration on large or unwieldy specimens. The system described was developed to provide the desired vibration shaker control when testing any specimen requiring multiple input points.

A Nonlinear Eigenvalue Problem for Rotating Rods, F. Odeh and I. Tadjbakhsh, *Archive for Rational Mechanics and Analysis* 20, No. 2, 81-94 (1965).

This paper is concerned with a nonlinear eigenvalue problem which arises in connection with the possible equilibrium states of a rotating rod. We prove the existence of non-trivial solutions for velocities of rotation which are greater than certain characteristic values. Some of the methods used are applicable to bifurcation problems in elliptic partial differential equations and difference equations.

On the Busy Period of a Facility which Serves Customers of Several Types, P. D. Welch, *Journal of the Royal Statistical Society, Series B (Methodological)* 27, 361 (1965).

Customers of a finite number of types are attended by a single server. The input for each type is Poisson and these inputs are mutually independent. The service times are general, and a function of the customer type. The service discipline is subject only to minimal restrictions. This paper contains a discussion of the phenomenon of the busy period for the above queueing model. The main result obtained is the determination of the joint distribution of the length of the busy period and the number of each type of customer served during it.

On an Inequality for Modified Bessel Functions, R. P. Soni, *Journal of Mathematics and Physics* 44, No. 4, 406-407 (December, 1965).

A method is presented that establishes an inequality without resorting to expressions for the derivative of the function. The rather complicated expressions involving higher transcendental functions are avoided.

On the Line Graph of a Finite Affine Plane, A. J. Hoffman and D. K. Ray-Chaudhuri, *Canadian Journal of Mathematics* 17, No. 5, 687-694 (1965).

The line graph of a finite affine plane is characterized by its polynomial.

On the Line Graph of a Projective Plane, A. J. Hoffman, *Proceedings of the American Mathematical Society* 16, No. 2, 297-302 (April, 1965).

A finite projective plane of order n can be regarded as a bipartite graph on $2(n^2 + n + 1)$ vertices. It is shown that any graph on $(n + 1)(n^2 + n + 1)$ vertices whose adjacency matrix has the same spectrum as the adjacency number of the line graph of a finite projective plane of order n is itself the line graph of such plane.

On the Motions of the Perigee and Node and the Distribution of Mass in the Moon, W. J. Eckert, *Astronomical Journal* 70, No. 10, 787-792 (December, 1965).

For many years there has been a discordance between the theoretical and observed motions of the moon's perigee and node. These motions are caused by the sun, the planets, the distribution of mass in the earth and moon, and to a minute extent by relativity. The computed value of each of these contributions is based on a theoretical development and on one or more parameters determined from observation. Recent developments bearing on the question include the new solution of the main problem of the lunar theory by Eckert and Smith, the determination of the mechanical oblateness of the earth by means of artificial satellites, improved masses of the major planets and discussions of the relativity effect. In this paper the author has re-examined and clarified a number of the quantities that enter the comparison of theory and observation and the assumptions on which they are based. With current theoretical and observational evidence there is a pronounced discrepancy between the moment of inertia of the moon indicated by the motion of the node and that obtained from theoretical considerations of the moon's probable interior. The moment determined from the motion of the node implies a large concentration of mass near the surface.

On the Nonsingularity of Real Matrices, A. J. Hoffman, *Mathematics of Computation* 19, No. 89, 56-61 (January, 1965).

By exploiting the theory of linear inequalities, new bounds for the real eigenvalues of a real matrix are derived, along with sufficient conditions for matrix games to be completely mixed, for determinants to be positive, etc. The simple observation on which the derivation of new results and the unification of old results are based is that the typical conditions of diagonal dominance which insure the nonsingularity of matrices are essentially systems of linear inequalities on the rows of matrices.

On the Nonsingularity of Real Partitioned Matrices, A. J. Hoffman, *ICC Bulletin* 4, No. 1, 7-17 (January-March, 1965).

New criteria for nonsingularity of real matrices are given, in which the concept of partitioned matrix plays a forward role. The principal tool is a characterization of all systems of strong homogenous linear inequalities on the entries of a matrix which imply that the matrix is nonsingular. Corollaries of these results include new bounds for real eigenvalues of real matrices.

On a Relation Between Two-Dimensional Fourier Integrals and Series of Hankel Transforms, J. V. Cornacchio and R. P. Soni, *Journal of Research of the National Bureau of Standards* 69B, No. 3, 173-174 (July-September, 1965).

Procedures are developed for expressing two-dimensional Fourier transforms in terms of tabulated one-dimensional transforms.

Optical Properties of Copper Oxide Films,† H. Wieder and A. W. Czanderna,* *Journal of Applied Physics* 37, No. 1, 184-187 (January, 1966).

The transmittance and reflectance of $\text{CuO}_{0.97}$ and Cu_2O films ranging in thickness from 392 to 2335 Å have been measured in the wavelength region of 400 to 800 mμ. These data were used to obtain the wavelength dependence of the optical constants of these materials. Differences between the optical properties of $\text{CuO}_{0.97}$ and Cu_2O are attributed to differences in stoichiometry rather than to size effects. A method for measuring absolute reflectance is described.

† Work performed at Parma Research Center, Union Carbide Corp., Parma, Ohio.

* Present Address: Department of Physics, Clarkson College of Technology, Potsdam, N. Y.

Optimum Allocation in Stratified Sampling with Replacement,† S. P. Ghosh, *Metrika* 9, No. 3, 212-221 (1965).

In a stratified sample, when sampling is done with replacement in each stratum a better estimate of the population mean can be achieved by considering the distinct units only. An explicit expression for a variance for the mean, of a stratified sample based on the distinct units only, is obtained. Then the optimum allocation for the different stratum are obtained by minimizing this variance subject to (i) total sample size being fixed, or (ii) the expected number of distinct units being fixed. Neyman's solutions are obtained as special cases. The solutions finally arrived at are algebraically complex, hence, numerical methods are applied. In all examples, the variance of the estimates obtained by this method are smaller than the variances obtained by Neyman's allocation.

† A part of this work was supported by the Office of the Ordnance Research; U.S.A. Grant (DA-AROL(D)-31-124-G83) when the author was at University of California, Berkeley.

Partial Visual Feedback of Component Motions as a Function of Difficulty of Motor Control, J. D. Gould and A. Schaffer, *Journal of Experimental Psychology* 70, No. 6, 564-569 (December, 1965).

This research studied the interrelations of visual perception and movement. Closed-circuit television techniques allowed the joint action of S's hand, control instrument, and operational effects to be visually fed back singly or in various combinations. 2 levels of difficulty of each of the 3 task components responsible for the 3 types of visual feedback were varied independently of feedback in a task where S steered a ball through a maze. Results showed vision of the tool to be most important followed by vision of operational effects and hand-arm movements. No significant difference was found on the task-difficulty variable which may have influenced the absence of a significant interaction between type of visual feedback and movement difficulty.

The Polynomial of a Directed Graph, A. J. Hoffman and M. H. McAndrew, *Proceedings of the American Mathematical Society* 16, No. 2, 303-309 (April, 1965).

Necessary and sufficient conditions are given for a directed graph to admit a polynomial. In addition, it is shown that a certain class of directed graphs arising from a mesh on a torus is characterized by its polynomial.

Precipitates of Phosphorus and of Arsenic in Silicon, M. L. Joshi, *Journal of the Electrochemical Society* **113**, No. 1, 45-48 (January, 1966).

Precipitate particles were observed through transmission electron microscopy at different depths in silicon wafers diffused with a very high concentration of phosphorus. The precipitates, believed to be phosphorus complexes, were of various shapes, square, rod-like, and hexagonal, with no definite orientation in the silicon matrix. Silicon wafers diffused with high concentration of arsenic also showed elongated precipitate structures with no definite orientation.

Reproducibility of Carbon Resistors used as Thermometers below 1°K,† A. S. Edelstein and K. W. Mess, *Physica* **31**, No. 11, 1707-1712 (November, 1965).

The temperature dependence of certain resistors made by the Speer Carbon Company has been found to be reproducible to within 0.3% down to 0.75°K after warming to room temperature. The sensitivity to magnetic fields increases with decreasing temperature. At 0.115°K the resistance decreased by about 5% in a field of 6 kOe.

† Research performed at the Kamerlingh Onnes Laboratory, Leiden, Netherlands.

Separation and Collection of Leukocytes, E. J. Freireich,* G. Judson and R. H. Levin,** *Cancer Research* **25**, No. 9, 1516-1520 (October, 1965).

Existing methods for separation and collection of leukocytes permit collection of only limited quantities of leukocytes. An instrument has been designed to process large volumes of blood on a continuous flow basis. The instrument collects venous blood, separates leukocytes in a centrifuge, and re-injects the red cells, plasma, and platelets. The separation process is 30-60% efficient *in vitro* at flow rates up to 50 ml/min. *In vivo* tests demonstrated safety, sterility, lack of hemolysis, and adequate anti-coagulation. However, leukocyte recovery *in vivo* is low (under 20%). If this poor *in vivo* recovery can be overcome, the instrument should prove useful for collection of large quantities of leukocytes.

* National Cancer Institute, Bethesda.

** Deceased.

Similarity Relations and Characterization of Pure Fluid Elements, H. H. Glaettli, *Proceedings of the Fluid Amplification Symposium* (sponsored by the Harry Diamond Laboratories) pp. 215-222 (October, 1965).

By observing similarity relations it is possible to use a certain geometry of a fluid amplifier or a whole circuit under various conditions by changing the size and/or the fluid properties. Instead of giving minimum, maximum or average ratings for operating pressure, power consumption, response time, etc. it is sufficient and advantageous to characterize the element or circuit by a few dimensionless constants, among which the Reynolds number is one of the more important. Examples of data sheets based on dimensionless figures are given. The range over which similarity relations are valid may be limited by minimum or maximum values of Reynolds number, Mach number or cavitation number. Last but not least, the proposed dimensionless figures allow direct comparisons of various designs or even amplifier types with respect to power consumption, response time, etc.

Some Properties of Graphs with Multiple Edges, A. J. Hoffman, D. R. Fulkerson and M. H. McAndrew, *Canadian Journal of Mathematics* **17**, No. 1, 166-177 (1965).

In the first part of this paper, a special case of Tutte's theorem on the factors of graphs is proved using concepts of the theory of linear inequalities. In the second part, an interchange theorem for a class of graphs is established generalizing Ryser's interchange theorem for bipartite graphs.

Corollaries of these results are: (1) A new derivation of the necessary and sufficient conditions that a set of numbers $d_1, \dots, d_n$ by the valences of the vertices of an ordinary graph; (2) a proof that, for many numerical functions associated with graphs, such as the coloring number, the set of integers attained by the function as the graph varies with prescribed valences is an interval.

The Stationary Waiting Time Distribution for a Single-Server Queue, A. G. Konheim, *Journal Of The Society For Industrial And Applied Mathematics* **13**, No. 4, 966-976 (December, 1965).

The objective of this paper is to give a simple procedure for obtaining the stationary waiting time distribution in a single server queue (with queue discipline "first-come-first-served"). Our procedure consists of studying the Wiener-Hopf equation for discrete queues. Employing a result of Calderon-Spitzer-Widom the solution for the discrete system is obtained and the general result by approximation.

Strong Copper-Brazed Joints Bond Steel Components, W. D. Kehr, *Metal Progress* **89**, No. 1, 90-93 (January, 1966).

Design criteria and manufacturing processes required to obtain maximum strength copper-brazed joints are discussed. It is shown that using the proper types of steels, fit tolerances, surface finish, furnace brazing atmosphere, and post-brazing heat treatment, shear strengths exceeding 40,000 psi and torsional fatigue strengths greater than 30,000 psi (at 10^7 cycles) can be consistently obtained.

Surface Inversion and Accumulation of Anodized InSb, L. L. Chang and W. E. Howard, *Applied Physics Letters* **7**, No. 8, 210-212 (October, 1965).

MOS capacitance measurements were performed at 77°K on anodized InSb crystals of both *p*- and *n*-type with 10^{15} cm⁻³ concentration and (111) orientation. The effective surface state charge was found to be positive and of the order of 10^{11} cm⁻², which made the surface of *p-n*-type InSb normally inverted and *n*-type accumulated. By applying bias, the inversion and accumulation can be controlled reversibly. This result made possible the use of anodic oxide in surface experiments as well as surface channel devices.

The Use of an Adaptive Threshold Element to Design a Linear Optimal Pattern Classifier, J. S. Koford and G. F. Groner,* *IEEE Transactions on Information Theory* **IT-12**, No. 1, 42-51 (January, 1966).

This paper develops a relationship between two traditional statistical methods of pattern classifier design, and an adaption technique involving minimization of the mean-square error in the output of a linear threshold device. It is shown that the two-category classifier derived by least-mean-square-error adaption using an equal number of sample patterns from each category is equivalent to the optimal statistical classifier if the patterns are equivalent to the optimal statistical classifier if the patterns are multivariate Gaussian random variables having the same covariance matrix for both pattern categories. It is also shown that the classifier is always equivalent to the classifier derived by R. A. Fisher.

A simple modification of the least-mean-square-error adaption procedure enables the adaptive structure to converge to a nearly-optimal classifier, even though the numbers of sample patterns are not equal for the two categories. The use of minimization of mean-square error as a technique for designing classifiers has the added advantage that it leads to the optimal classifier for patterns even when the covariance matrix is singular.

*The Rand Corporation, Santa Monica, California.

The Vapor Pressure of Iodine in the Temperature Interval 43-80°C, M. Berkenblit and A. Reisman, *Journal of the Electrochemical Society* **113**, No. 1, 93-95 (January, 1966).

An improved technique for the determination of the vapor pressure of iodine is presented. The method involves the conversion of iodine to HI and the latter is then quantitatively determined via an acid-base volumetric procedure. The I_2 vapor pressures are then calculated from the titration results. A plot of $\log p_{I_2}$ vs $1/T$ K $^\circ$ yields a straight line expressed by

$$\log p_{HI} (\text{Torr}) = \frac{-3.25 \times 10^3}{T^\circ \text{K}} + 10.35.$$

The slope of this line is in good agreement with the heat of sublimation calculated from third law considerations.

X-Ray Analysis of Diffusion-Induced Defects in Gallium Arsenide, G. H. Schwuttke and H. Rupprecht, *Journal of Applied Physics* **37**, No. 1, 167-173 (January, 1966).

X-ray diffraction microscopy measurements were made on zinc-diffused surface layers. The diffraction contrast produced through diffusion-induced defects was investigated. Fault structures were deduced from changes in diffraction contrast that occur in large-area topographs recorded through different Bragg reflections. Dislocations having $\langle 110 \rangle$ axis have been identified and associated with the Lomer-Cottrell reaction. X-ray junction profiles have been obtained and correlated with zinc-concentration profiles. It is concluded that diffusion-induced defects in gallium-arsenide are generated by a stress relief mechanism.

X-Ray Diffraction Study of Vacuum-Evaporated Silver Films, T. B. Light and C. N. J. Wagner,* *The Journal of Vacuum Science and Technology* **3**, No. 1, 1 (January/February 1966).

Silver films were prepared by evaporation onto glass substrates held near 130°C at different residual gas pressures (10^{-4} to 10^{-7} Torr). Powder-pattern peaks of these films (thicknesses 2000 Å and 6000 Å) were measured with Cu $K\alpha$ radiation at room temperature, and the profiles subjected to a Fourier analysis to determine particle size, strains and faulting. Films prepared in poorer vacuum (10^{-4} - 10^{-6} Torr) show small particle sizes (~ 500 Å), very small root-mean-squared strains (~ 0.0005) and evidence for deformation stacking faults and microtwinning. Lattice parameter measurements indicate the presence of internal strains in films heated to 250°C for 2 h and measured at room temperature.

*Hammond Laboratory, Yale University.

Letters to the Editor

Radiotracer Measurements of Copper Contamination in GaAs from Quartz, P. Gansauge and W. Hoffmeister, *Solid-State Electronics* **9**, No. 1, 89 (January, 1966).

Space Radiation Effects on Transistor Gain, D. C. Sullivan, *Proceedings of the IEEE* **53**, No. 2, 209 (February, 1965).

Steady-State Mass Transfer of a Reversible Redox System in a Thin Layer of Electrolyte Between Two Plane Parallel Electrodes, H. Dahms, *Journal of Electroanalytical Chemistry* **11**, No. 1, 62-64 (January, 1966).

Substitutionsfehlordnung im Mischkristallsystem der Yttrium-Gallium-Eisen-Granate (Substitutional Disorder of the Yttrium-Gallium-Iron Garnets), P. Fischer,* W. Hälg,* E. Stoll,* B. Lüthi and A. Segmüller, *Helvetica Physica Acta* **38**, No. 7, 646-647 (1965).

*Institut für Nukleartechnik der ETH Zürich.

Threshold Dependence on Reabsorption Loss in Injection Lasers: A Comment, F. Stern, *IEEE Journal of Quantum Electronics* **QE-1**, No. 8, 358 (November, 1965).