IBM Technical Papers Published Recently in Other Journals

ABC's of Receiving Sampling Inspection, Sidney Price,* *Industrial Quality Control,* **18,** No. 5, 26-28 (November, 1961).

In a receiving inspection operation, there are many inspection paths available to the inspection manager. He can decide to do a 100 percent inspection on every item received, he can sample the lot, or he can decide to do a combination of sampling and 100 percent inspection. In making the decision between 100 percent inspection and sampling inspection, many factors have to be considered. This discussion concerns sampling, but why not do 100 percent inspection?

* Now with Burroughs Corporation, San Diego, California.

Apparatus for Studying Cyclic Stress-Strain and Fatigue at Elevated Temperatures, R. A. Willem and J. D. Morrow,* *Experimental Mechanics,* 48-54 (February, 1962).

An apparatus is described which permits tubular specimens to be heated to a uniform temperature, while being cyclically strained with a constant amplitude of alternating strain about a fixed mean strain. Under these conditions, tests were performed in which the mean stress was measured as a function of the number of cycles of repeated strain for the alloys Udimet 700 and Rene 41 at 1300° F. These data are reported along with fatigue data.

* University of Illinois.

The Automatic Collection and Reduction of Data for Nuclear Spark Chambers, H. Gelernter, *Il Nuovo Cimento,* **22,** 631-642 (November 1, 1961).

A system is described which dispenses with the traditional use of photographic film for recording the data contained in the discharge of a nuclear spark chamber. Instead, the chamber itself is directly viewed by a television vidicon camera, whose output is digitized for direct input to a computer or for recording on magnetic tape. Preliminary experiments indicate that a measurement precision of 0.1% (i.e., to locate the center of a spark to 1 mm in a meter wide chamber) will be easy to achieve with ordinary industrial vidicon tubes. The existence of currently available high-resolution vidicons makes it likely that this figure can be substantially improved. By coupling the video system directly to an IBM 7090 computer, it is shown that the automatic collection and on-line analysis of 100,000 spark chamber events per day is probably feasible.

Analysis of Variance and Analysis of Regression with More Than One Response, H. O. Posten, *Proceedings of Symposium on Application of Statistics and Computers to Fuel and Lubricant Research Problems* (San Antonio, Texas) pp. 91-109 (March 12, 1962).

A common approach when analyzing an experiment with more than one response is to perform the analysis on each response separately using the appropriate single response analysis. In many cases, it may be desirable to supplement or replace the individual analyses with the corresponding multivariate procedure which takes into account the dependence between responses. The present paper is an exposition of the procedure required for performing any multivariate analysis of variance, regression or covariance. It includes a discussion of the single response analysis and generalizes this to the multivariate case.

Attitude Stability of an Elastic Body of Revolution in Space, Leonard Meirovitch, *The Journal of the Astronautical Sciences,* **8,** No. 4, 110-113 (Winter, 1961).

The motion of a body in space is described by three angular velocities called spin, precession, and nutation. A rigid body of revolution with no external moments has an angular momentum vector, h, constant in space and its spin or symmetry axis precesses about the vector h at a constant attitude angle θ. An elastic body, however, dissipates energy and as a result the angle θ changes. If the decrease of angle θ denotes stability, it is shown on basis of energy considerations that stability is implied by $C/A>1$ and instability by $C/A<1$, where C and A are mass moments of inertia about the spin and pitch axes, respectively. A body consisting of two elastic discs connected by a rigid shaft so that $C/A<1$ is considered. Using the elastic solution of a disc subjected to gyroscopic forces, the time t required to reach an attitude angle θ is obtained. The results are compared with other investigations of the same subject and the agreement is found to be very satisfactory.

Bit Loss and Gain Correction Code, F. F. Sellers, Jr. *IRE Transactions on Information Theory,* **IT-8,** No. 1, 35-38 (January, 1962).

A block code is presented that will correct an error consisting of the gain or loss of a bit (binary digit) within the block. The code can be generalized to correct the loss or gain of a burst of bits. A further feature is the possibility of correcting additive errors appearing in the vicinity of the bit loss or gain. An additive error is a bit changed from ZERO to ONE or from ONE to ZERO. The code is constructed by inserting a known character into a burst-error-correcting code at periodic intervals. The known character locates the approximate position of the bit loss or gain. At the location a bit is inserted or removed from the block, depending on whether a loss or a gain has occurred. The error-correcting code then corrects the erroneous bits between where the error occurred and where the correction took place.

A Comparison Between the Evaporation Characteristics of a Crucible and a Ring Source, K. H. Behrndt* and R. A. Jones, *Vacuum,* **2,** No. 3, 129-138 (Last Quarter, 1961).

The properties of evaporated films largely depend on the uniformity of the evaporation parameters achieved during deposition. Several types of evaporation sources have been investigated. Data on the crucible and the ring source as sources for evaporated films are presented and their advantages and disadvantages are discussed. For both techniques, the experimental setup, the distribution of film thickness, and the variations of chemical composition over the area of a substrate are described in detail. The experimental results are compared with theoretical considerations.

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Computer Synthesis of Character-Recognition Systems, D. N. Freeman, *IRE Transactions on Electronic Computers,* **EC-10,** No. 4, 735-747 (December, 1961).

A SAP (Symbolic Assembly Program) package has been developed for the IBM 704 computer to simulate the logical tree of circuitry associated with a character-recognition device. The program has two major inputs: a particular set of logic statements (of AND and OR type) on cards, for flexibility, and tape reels of binary images of ideal or real characters. The output is the "score" of the logic: how many misjudgments it made on the images, what areas of the logic caused the misjudgments, and possible improvements of these areas.

Constriction of Hard Direction Hysteresis Loops in Thin Permalloy Films, S. Middelhoek, *Journal of Applied Physics,* **33,** 1111 (March, 1962).

According to single domain theory, thin permalloy films with uniaxial anisotropy should have straight hard direction M-H loops without hysteresis. Practically, however, the M-H loops of almost all films are open, when the ac field is applied exactly in the hard direction and the earth's magnetic field is carefully compensated. Moreover, films thicker than about 800 A often show hard direction hysteresis loops which are constricted at the origin.

As is well known, magnetization reversal in the hard direction is associated with the splitting up of the film into a great number of long domains parallel to the easy axis. Whether the walls separating these domains are of the Bloch or Néel type depends upon the strength of the applied field. It will be shown that the constricted loops can theoretically be constructed when, in addition to the anisotropy energy and the energy of the magnetization in the applied field, the energy of these walls is considered. Bitter observations of the reversal process confirm the theory, showing that the constriction is actually a result of Néel-Bloch-Néel transitions.

Control System Synthesis by Analogue Computer Based on the "Generalized Linear Feedback" Concept, J. Rissanen, *Proceedings of the International Seminar on Analogue Computation Applied to the Study of Chemical Processes,* pp. 22-30 (November 21-23, 1960), Brussels, (Presses Académiques Européenes, Brussels, 1961) (Distributors for the Western Hemisphere: Gordon and Breach, Science Publishers, Inc., New York, N. Y.).

A new method for synthesis of control systems with an analogue computer has been proposed.

The synthesis method is based on a theorem of the generalized linear feedback principle, which the author has formulated (with the proof) from the studies of R. E. Kalman. Corresponding to this theorem the feedback signal will be taken, not only from the system output, but from all of the state variables of the controlled plant. The closed loop system will include generally n unknown parameters, to be determined by the synthesis procedure.

The synthesis procedure, which will be performed with the analog computer, is an optimal one in the following sense. The output of the system will be forced to coincide optimally with a desired output by minimizing a convenient function obtained through the difference of the two outputs. The desired output that can be generated in the analog computer will be chosen so that all the specifications are satisfied. The last task is to convert the pattern of the feedback lines emanating from the state variables to some easily realizable controller.

Two applications of the method have been described. The first one is a second-order and the second, a third-order system. In both of these cases the results were most satisfactory.

Creative Aspects of Engineering Writing, H. B. Michaelson, *IRE Transactions on Engineering Writing and Speech,* **EWS-4,** No. 3, 77-79 (December, 1961).

Writing an engineering paper is shown to be an intrinsic part of the engineering work, rather than a mere recording of results. The process of writing a paper for publication in an engineering journal has some rather interesting aspects of creativity.

This paper shows how any careful attempt to record and analyze the results of an engineering project will actually contribute to the engineer's understanding of his own work. Writing a paper not only affords a fresh insight to the author, but may even inspire a more thorough study and a new approach to laboratory work before the manuscript is finished.

In addition, this paper exposes three popular fallacies about the creative aspects of writing.

Depletion Layer Properties in Double Diffused Transistors, D. P. Kennedy and R. O'Brien, *Journal of Electronics and Control,* **11,** No. 4, 303-315 (October, 1961).

For the double-diffused transistor, Poisson's equation is solved in one dimension; this solution is used to determine depletion layer properties of its collector and emitter junctions. Assuming an impurity atom distribution characterized by the summation of complementary error functions, depletion layer widths are established for the equilibrium emitter junction and for the reverse biased collector junction. Applications of this analysis are presented throughout a wide range of physical and geometrical parameters; graphical illustrations are given for the electrical base width, the collector "punch-through" voltage, and others.

Design Factors in the Development of an Optical Character Recognition Machine, J. J. Leimer, *IRE Transactions on Information Theory,* **IT-8,** No. 2, 167-171 (February, 1962).

Interest in optical character recognition has grown tremendously during the past several years. In the development of an optical character recognition machine, the engineer must be able to utilize a practical implementation that will perform the required functions at an advantage to a customer. Many concepts of optical character recognition machines that would appear to be very powerful recognition schemes are impractical or too costly to implement with available

technology. Other concepts that appear relatively inexpensive to manufacture require an input print quality that is impractical to generate. Of course, there are many concepts that fall somewhere between these two extremes. The primary factors which determine the character recognition concept to be utilized are: (1) the shapes of the symbols to be sensed, (2) the number of different symbols to be sensed, (3) the print quality range that must be accommodated, and the required performance of the system.

Unfortunately, in the present state of the art, the relationship of these factors to each other and to a given character recognition concept can only be qualitatively defined. The choice of an optimum recognition machine depends on the inductive reasoning and ingenuity of experienced engineers. This paper describes and discusses the many considerations in developing any practical recognition system. The character recognition portion of the recently announced IBM 1418 Optical Character Reader is used as an example.

Deuteron Quadrupole Coupling in Diatomic "Hydrides," H. J. Kolker* and M. Karplus, *J. Chem. Phys.* **36,** No. 4, 960-965 (February 15, 1962).

For LiD and DF, the deuteron quadrupole coupling constant (eqQ/h) has been calculated with single-determinant SCF-LCAO-MO functions. The results obtained are 38 kc/sec for LiD and 373 kc/sec for DF, in rather satisfactory agreement with the recently measured values (30±3 kc/sec for LiD and 340±40 kc/sec for DF). To evaluate the molecular integrals required for the determination of q, a formulation in terms of confocal elliptic coordinates was used. This made possible the introduction of certain auxiliary functions that are very convenient for the calculation of field gradient and related integrals. A comparison of the quadrupole coupling constants obtained with a number of different molecular orbital functions is presented. The results demonstrate the importance of using atomic basis functions with exponents optimized for the molecular system and suggest that exact Hartree-Fock functions may yield reliable values for field gradients and other one-electron weak-interaction parameters.

A calculation of the field gradient at the Li nucleus ($q=-0.0401$ a.u.) yields a value of -3.7×10^{-26} cm^2 for the Li^7 quadrupole moment when combined with the coupling constant measurement of $+346\pm1$ kc/sec.

* Woodrow Wilson and National Science Foundation Predoctoral Fellow at Columbia University.

Disseminating Current Information, Sandra Hocken, *Special Libraries,* **53,** No. 2, 93-95 (February, 1962).

An effective method of sifting useful information from the mass of incoming material has been devised by the IBM Advanced Systems Development and Research Library in San Jose. A daily library newspaper lists new books and current articles of interest to the laboratory, chosen by volunteer scanners. Copies of microfilmed articles may be requested by calling an automatic recording telephone in the library.

A Dynamic Programming Approach to Sequencing Problems, M. Held and R. M. Karp, *J. Soc. Indust. Appl. Math.,* **10,** No. 1, 196-210 (March, 1962).

Many interesting and important optimization problems require the determination of a best order of performing a given set of operations. This paper is concerned with the solution of three such *sequencing problems:* a scheduling problem involving arbitrary cost functions, the traveling-salesman problem, and an assembly-line balancing problem. Each of these problems has a structure permitting solution by means of recursion schemes of the type associated with dynamic programming. In essence, these recursion schemes permit the problems to be treated in terms of *combinations,* rather than *permutations,* of the operations to be performed. The dynamic programming formulations are given in §1, together with a discussion of various extensions such as the inclusion of precedence constraints. In each case the proposed method of solution is computationally effective for problems in a certain limited range. Approximate solutions to larger problems may be obtained by solving sequences of small derived problems, each having the same structure as the original one. This procedure of successive approximations is developed in detail in §2 with specific reference to the traveling-salesman problem, and §3 summarizes computational experience with an IBM 7090 program using the procedure.

Effect of Atmospheric Refraction on Electromagnetic Propagation, H. L. Crowson, *American Rocket Society Journal,* **32,** No. 3, 440-442 (March, 1962).

Standard equations for atmospheric density and index of refraction are used to deduce an expression for the time required for electromagnetic propagation to traverse the distance between two points in the earth's atmosphere. By Fermat's principle, the path is such that the time of traverse is a minimum. From the calculus of variations, the Euler-Lagrange equation is utilized to derive a second-order nonlinear ordinary differential equation. The solution of this differential equation gives the path along which electromagnetic propagation must travel to satisfy the constraint of Fermat's principle. Simple trigonometric considerations are then employed to deduce position error caused by atmospheric refraction.

Effect of Dislocations on Self-Diffusion in Germanium, H. Widmer, *The Physical Review,* **125,** No. 1, 30-32 (January 1, 1962).

The effect of dislocations on the rate of diffusion of radioactive Ge^{71} in intrinsic germanium single crystals has been studied at temperatures near 740°C. The dislocations were introduced by either of two methods: (a) distorting the surface by lapping under pressure, thus producing a network of dislocations; (b) bending the specimens so as to introduce up to 2×10^6 parallel edge dislocations per cm^2. Both deformation treatments produce an enhancement of self-diffusion relative to that in undeformed crystals. In both cases the diffusion can be described in terms of an enhanced volume diffusion with apparent diffusion coefficients up to 38% larger than the value for undeformed intrinsic specimens.

Effect of Elastic Strain on the Superconducting Critical Temperature of Evaporated Tin Films, R. H. Blumberg and D. P. Seraphim, *Journal of Applied Physics,* **33,** No. 1, 163-168 (January, 1962).

The superconducting critical temperature of a large number of tin films on soda-lime glass substrates are reported. The critical temperatures depend upon the stress arising in the films when they are constrained to follow the contraction of the glass on cooling to liquid helium temperature. It is shown that the crystalline orientation of the films is significant in determining the magnitude of the stress and the variation in critical temperature relative to bulk tin. For films with the tetrad axis in the plane, the stresses along that axis at helium temperature can reach 4.5×10^3 atm and the critical temperature may increase by 0.23°K. For both diad axes in the plane, the stress and the change in critical temperature is much less. The piezoresistivity $\pi_{11}=-7.0\pm$

$0.6\rho_1 \times 10^{-6}$/atm. The temperature-dependent part of the resistivity of films at 77°K is increased above the values of bulk metal in accordance with a piezoresistive effect. For films much thinner than 300 A, the critical temperature is observed to increase with decreasing thickness. For these thin films the constraint of thermal contraction imposed by the substrate appears to be insufficient to provide the entire increase in critical temperature.

Electrical Properties of Evaporated Aluminum Oxide Films, E. M. DaSilva and P. White, *Journal of the Electrochemical Society,* **109,** No. 1, 12-15 (January, 1962).

Insulating films of aluminum oxide have been prepared by evaporation of aluminum in a partial pressure of 10^{-3} mm Hg of oxygen. On exposure to air both dielectric constant and dissipation factor increase to values similar to those observed for anodized films on bulk aluminum. The results can be understood if the initial insulating film is a suboxide similar to the postulated AlO which is normally unstable at room temperature in air or oxygen, decomposing to Al_2O_3.

Energy and Entropy of Formation and Motion of Vacancies in NaCl and KCl Crystals, R. W. Dreyfus and A. S. Nowick, *Journal of Applied Physics* (Supplement) **33,** No. 1, 473-477 (January, 1962).

Recent experiments on the dc ionic conductivity of NaCl crystals doped with divalent cation impurities led to a re-evaluation of some of the basic constants for defect formation and motion in these crystals. The key parameter is the energy of motion ϵ_m of a cation vacancy. This parameter has been determined from the temperature dependence of the conductivity under conditions where the concentration of cation vacancies remains fixed. Such conditions apply (1) in the range just below the intrinsic region, and (2) in samples rapidly cooled to below 0°C such as to prevent the attainment of an equilibrium degree of association. From the present work combined with previous data, the jump rate of the isolated positive-ion vacancy in NaCl is $\nu = 12\nu_0 \exp(-\epsilon_m/kT)$ with $\nu_0 = 10^{14.1 \pm 0.3}$ sec^{-1} and $\epsilon_m = 0.80 \pm 0.02$ ev. With the aid of earlier measurements in the intrinsic range it is concluded that the energy of formation of a Schottky defect in an NaCl crystal is 2.12 ± 0.06 ev, while the entropy of formation is 6.2 ± 1.8 (in units of k). Very similar results, although of somewhat lower precision, apply to KCl. Finally, a comparison is made between these values and the predictions of existing theories.

Ergodic and Mixing Properties of Infinite Memory Channels, R. L. Adler, *Proceedings of the American Mathematical Society,* **12,** No. 6, 924-930 (December, 1961).

This paper discusses conditions imposed on channels which insure that the output will be ergodic or mixing given that the input is ergodic or mixing.

Existence Uniqueness and Stability of Solutions of Systems of Nonlinear Difference-Differential Equations, W. L. Miranker, *Journal of Mathematics and Mechanics,* **11,** No. 1, 101-107 (January, 1962).

In this paper we present a proof of the existence in the large, uniqueness, and stability of solutions of the nonlinear difference-differential equation

$$\sum_{j=1}^{n_1} B_j x'(t-t_{1,j}) = \sum_{j=1}^{n_2} A_j x(t-t_{2,j}) + f(x(t-t_{3,1}), \ldots, x(t-t_{3,n_3}), t),$$

where the A_j and B_j are constant matrices and x and f are vectors. When $B_1 = I$, $B_j = 0$, $j > 1$, $A_1 = A$ and $A_j = 0$, $j > 1$, and $t_{3,j} = 0$, $j > 1$, the equation reduces to the nonlinear differential equation $x' = Ax + f(x,t)$ and our theorem to the strong form of the Perron stability theorem for differential systems.

Thus the stability theory for difference-differential equations insofar as the Perron type theorem is concerned is advanced to the degree of development of the stability theory for differential equations. Additionally, stability statements dealing with solutions of nonlinear difference-differential equations such as periodic solutions which do not tend to zero can now be made by considering variational equations. This is the case, since such variational equation will be of the form of the equation noted above and the conditions of our theorem do not require that f converge to zero as $t \to \infty$.

Experimental Evaluation of Binary Codes for Console Display, Frank J. Minor and Stanley L. Revesman, *Journal of Applied Psychology,* **45,** No. 6, 381-387 (December, 1961).

A human factors experimental evaluation was conducted for three types of code display systems (Bi-quinary, Binary Coded Decimal, and a Combined Code) which were proposed for a data processing system console. A sampling of human subjects was employed to test encoding and decoding accuracy and speed of the console operator, under the varied code conditions. The methodology of the study is described, and the test results indicated.

Fermion Ensembles of Maximum Entropy, M. C. Gutzwiller, *The Physical Review,* **125,** 1455 (March, 1962).

Ensembles of particles obeying Fermi-Dirac statistics are considered from a point of view which is analogous to some recent work of Joseph Mayer on classical particle statistics. The density functions ρ_n are defined for n much smaller than the average number of particles in the ensemble. Since the knowledge of only a few ρ_n is sufficient for the computation of most averages of physical interest, it is important to compare different ensembles with the same density-functions, say ρ_1 and ρ_2. The ensemble with the largest entropy is constructed as being the most significant. A number of simple examples are briefly considered.

Ferromagnetic Resonance in Single-Crystal Nickel Films, M. Pomerantz, J. F. Freedman, and J. C. Suits, *Journal of Applied Physics,* **33,** 1164-1165 (March, 1962).

Ferromagnetic resonance measurements have been carried out on single-crystal nickel films obtained by epitaxial evaporation on NaCl under widely varying conditions of vacuum (10^{-5} to 10^{-10} mm Hg) and substrate temperature (300° to 500°C). Resonance measurements on thin films by previous investigators have yielded anomalous values of $4\pi M$, which have tentatively been attributed to stress in the films. In this paper it is shown that there is a second factor which must be taken into consideration to explain shifts in the resonance peak.

Experiments indicate that at high substrate temperatures, the shift in resonance peak was caused not by stresses but by a lowering of the demagnetizing field resulting from discrete particle growth.

Fiber Texture and Magnetic Anisotropy in Evaporated Iron Films,* A. Yelon, J. R. Asik,** and R. W. Hoffman,*** *Journal of Applied Physics,* **33,** 949-954 (March, 1962).

The fiber texture and magnetic anisotropy of evaporated iron films have been studied as a function of film thickness. It is found that there are three textures present: [110], [111], and [221]. In thin films, the [111] texture is dominant. It is also found that the magnetic anisotropy is of the order of 2×10^4 ergs/cm^3 for 350 A films and decreases with increasing thickness. On the basis of this experiment and information from earlier experiments, several theories of the origin of magnetic anisotropy in films are examined and shown to be inadequate for iron films. A theory for the origin of the anisotropy is proposed, based primarily on the magnetic energy associated with an array of vacancy needles. These vacancy needles can also qualitatively explain the resistivity anisotropy and dichroism observed by other workers.

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Fluorescence Properties of Aggregated Chlorophyll *in Vivo* and *in Vitro*, Seymour Steven Brody and Marcia Brody, *Transactions of The Faraday Society*, **58, Part 2,** No. 470, 416-428 (February, 1962).

Intensity of fluorescence was determined as a function of chlorophyll concentration (in ethanol at 77°K) at the maxima of aggregate and monomer emission bands, 720 and 685 mμ, respectively. An expression, derived by relating chlorophyll concentration to the ratio of fluorescence at these two wavelengths, was found to be most consistent with experimental data when the aggregate was assumed to be a dimer. The fluorescence yield of the dimer in ethanol at 77°K was calculated and found to be 0.8. The lifetime of emission from this aggregated species corresponds to $\backsim10^{-4}$ sec.

Fluorescence from the chlorophyll monomer and aggregate, *in vivo*, and *in vitro*, was measured as a function of temperature (from 293° to 77°K). In solution and in algae the activation energy from dimer emission is approximately 1 kcal, the Arrhenius constant is of the order of 10^4. The latter value reflects a low transition probability for dimer emission, suggesting origin in a triplet or nonbinding singlet state.

Further Considerations of the Thick-Plate Problem with Axially Symmetric Loading, C. W. Nelson, *Journal of Applied Mechanics*, (Transactions of the ASME), **29, Series E,** No. 1, 91-98 (March, 1962).

The Fourier-Bessel integral approach was first applied to thick-plate problems of elasticity by Lamb and later by Dougall. Still later, the method, now known as the Hankel transform-method, was applied to several cases of the thick-plate problem by Sneddon, who apparently was the first to obtain numerical results for the stresses in thick plates by this method. Sneddon devised an approximate method for evaluating the integrals, i.e., inverting the transforms, which he encountered. The main contribution of the present paper consists in the more precise numerical evaluation of the integrals involved for a special case previously considered by Sneddon, but for the values of parameters outside the range studied by Sneddon. In particular, it is hoped that the formulation of integration procedures presented will be found useful in other thick-plate problems.

A General Model for the Reliability Analysis of Systems Under Various Preventive Maintenance Policies, B. J. Flehinger, *Annals of Mathematical Statistics*, **33,** No. 1, 137-156 (March, 1962).

The problem treated is that of predicting the reliability characteristics of a complex system from data on individual components. A general model for systems maintained over a period of time is proposed, based on the idea that every system failure is induced by a component failure and corrected by the replacement of a single component. Moreover, it is assumed that components are sometimes replaced even when the system is operating correctly, in order to prevent unscheduled interruptions in operation. The assumptions which define the general model cover a number of different preventive maintenance policies, among them block changes, individual component replacement on the basis of age, system check-outs, and marginal testing.

The integral equations which determine the following measures of system performance are developed: (1) the expected number of failures in a given time interval, (2) the expected number of preventive removals in a given time interval, (3) the reliability function; i.e., the probability of no failure in a given interval following a given system age.

Results from renewal theory and the theory of regenerative stochastic processes, developed by W. L. Smith, are applied to the problem of exploring the asymptotic behavior of these quantities.

Growth Sequence of Gadolinium-Iron Garnet Crystals in Molten PbO-B_2O_3 Solutions, E. A. Giess, *Journal of the American Ceramic Society*, **45,** No. 2, 53-55 (February, 1962).

Gadolinium-iron garnet crystals grown from low-volatility molten PbO-B_2O_3 solutions exhibit macroscopic dendritic growth patterns indicative of their growth sequence and mechanism. There exists a growth anisotropy preferring the [001] direction from which (100) and (010) axial-plane dendrites radiate. The equilibrium {211} and {110} faces grow from intermediate branch dendrites which are attached to the (100) and (010) dendrites.

The Human Element in the Maintenance Package, H. J. Page, *Proceedings of the Eighth National Symposium on Reliability and Quality Control*, pp. 322-334 (January, 1962).

An important link in the maintenance package of a data processing system is the performance of maintenance personnel. In the future, a rapidly growing population of increasingly complex electronic systems may well be serviced and maintained by persons with less technical background than presently exists among maintenance personnel. Diagnostic analysis as a significant aspect of maintainability currently represents one of the most complex of man-machine relationships. This study is based upon the proposition that system down time can be decreased by investigating a number of diagnostic analysis situations encountered by field service personnel in both vacuum tube and solid state data processing systems.

Induced Changes in the Photosynthetic Efficiency of *Porphyridium cruentum*. II, Marcia Brody and Seymour Steven Brody, *Archives of Biochemistry and Biophysics*, **92,** No. 2, 354-359 (February, 1962).

In the red alga *Porphyridium cruentum*, pigment proportion does not seem to be the factor of primary importance in determining the quantum yield of photosynthesis in the spectral region in which phycoerythrin absorbs most of the total absorbed light (546 mμ)—although it seems to be the controlling factor under some circumstances. It was found that the yield at 546 mμ could be altered by prior exposure for short periods of time (2 to 3 hours) to light of certain

wavelengths. Such exposure did not alter the proportions of pigments. Exposure to red or blue light, both absorbed primarily by chlorophyll, reduced the yield at 546 mμ, while exposure to green light, absorbed primarily by phycoerythrin, promoted development of full photosynthetic efficiency in the green region. The results of the present study suggest that the yield in the region of chlorophyll absorption is relatively constant, while that in the region of the absorption maximum of phycoerythrin is subject to great modification in short periods of time.

Influence of Image Motion on the Resolution of a Photographic System,* D. P. Paris, *Photographic Science and Engineering,* **6,** No. 1, 55-59 (January-February, 1962).

Considering the influence of image motion on the performance of a photographic system, one is concerned usually with three basic types: linear motion, vibration, and random motion. Experimental curves are presented which show the decrease of resolution with increasing motion parameter d for linear motion and vibration. An attempt is made to predict these curves for all three cases using the concept of sine-wave response.

* Based on work performed by the author when he was employed by the U.S. Army Signal Research and Development Laboratory, Fort Monmouth, N. J.

Infrared Measurement of the Optical Constants of the Low Melting Temperature Glass System of 30% Arsenic —34% Sulfur—36% Thallium, P. S. McDermott, R. L. Powell, and E. R. Stack,* *Infrared Physics,* **1,** No. 3, 167-174 (December, 1961).

The low melting temperature, heavy-metal sulfide glass system of arsenic, sulfur, and thallium has proven to be optically clear from wavelengths of 1 to 23 microns. The optical constants, consisting of absorption coefficient, reflection coefficient, extinction coefficient, and refractive index, have been determined from 2 to 23 microns. The reflection coefficient was calculated from a plot of transmission measurements as a function of sample thickness, extrapolated to zero thickness. In turn, this data, through the application of the Kramers-Kronig relationship, has yielded both the real and imaginary portions of the refractive index. As a result of the low working temperature of this composition glass, the possibility exists of manufacturing lenses and domes by molding between Teflon dies and other materials.

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***Inhomogene Leitungen mit ortsabhangigem Verlustwinkel des Queradmittanzbelags* (Inhomogeneous Transmission Lines with a Power Factor of the Transversal Admittance Layer in Dependence of Location),** W. Jutzi,* *Zeitschrift fuer Angewandte Physik,* **14,** No. 3, 138-152 (March, 1962).

A termination line of a lossless homogeneous transmission line is expected to be as short as possible for a fixed admitted voltage reflection coefficient $/\rho_{zul}/$. For this purpose shorted inhomogeneous transmission lines with heavy losses are investigated. Two methods are exposed to calculate the input reflection coefficient: 1) The inhomogeneous line is understood as a series of a sufficiently large number of different homogeneous lines and the input reflection coefficient is computed by matrix multiplication. 2) The input reflection coefficient is conceived as the vector sum of three reflection coefficients: $\rho_{10}=\rho_w+\rho_i+\rho_k.\rho_w$ is generated by the difference between the characteristic impedances at the input, ρ_i is due to the inhomogeneity along the line and ρ_k depends on the influence of the reflections at the output transformed to the input. The latter method allows the evaluation of the parameters of very short high-pass terminations. This high pass is characterized by the cut-off electrical length $(l/\lambda_{10})g$ defined as the ratio of the geometrical length l of the termination to the longest wavelength λ_{10} in free space. Assuming the longitudinal impedance layer to be lossless and equal to the adjacent lossless homogeneous transmission line and the transversal admittance layer to be lossy and variable, the following admitted voltage reflection coefficients $/\rho_{zul}/=15\%/10\%/1\%/0.2\%$ lead to cut-off electrical lengths: $(l/\lambda_{10})g=0.21/0.270/1.19/1.79$.

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Integral Transforms for Algebraic Analysis and Design of a Class of Linear-Variable and Adaptive Control Systems, G. W. Johnson and F. G. Kilmer, *IRE Transactions on Automatic Control,* **AC-7,** No. 2, 97-106 (March, 1962).

A class of integral transforms has been defined which allows a compatible algebraic evaluation of a corresponding class of linear time-varying systems. It is shown that the class of variable systems which may be handled correspond to conventional invariant systems except for variable time call. The advantage of a variable time scaling on system response is demonstrated with respect to a specific example.

Investigation of the Coercive Forces of Ni, Fe, and Ni-Fe Films During Evaporation, K. H. Behrndt,* *Journal of Applied Physics,* **33,** No. 1, 193-196 (January, 1962).

The dependence of the coercive force of Ni, Fe, and Ni-Fe films upon film thickness and amount of trapped gas was evaluated *in vacuo.* The magneto-optic Kerr effect was utilized for this investigation. The different behavior of Fe films is ascribed to higher gas absorption on this material rather than a principal change in the mechanism of the coercive force. A hypothesis is proposed to explain the observed effects.

* Present address: General Dynamical Astronautics, San Diego, California.

A Large-Capacity Document Storage and Retrieval System, R. W. Porter,* *Proceedings of the Symposium on Large-Capacity Memory Techniques for Computing Systems,* The Macmillan Company, New York, 1962.

A large-capacity, random access document retrieval system providing greatly compressed image storage of many millions of documents and rapid selective output is described. This system, now in advanced development, consists basically of a random access document index, a document input converter, and a random access image file.

The system provides for the storage of 990,000 pages per image-file module, and these modules can extend the system capacity indefinitely. The high-speed, high-capacity random access magnetic index provides great flexibility in recording or searching records of documents in 1 to 2 seconds; the large-capacity, random access document image files provide reproduction of any desired document in 5 to 10 seconds.

* Now with Kalvar Corporation.

Lernversuche an der IBM 704, H. Remus, *Lernende Automaten,* R. Oldenbourg-Verlag, München, pp. 144-154 (1961).

An automatic machine simulated on the IBM 704 to play the game "Go" is investigated. The program consists of the following blocks: a main program which, while playing, calls up the other elements—lexicon, heuristic computer, and random generator one after the other, to get a decision for the move in question. The discussion is centered around the possibility of automatically improving the machine's ability to play a game.

Long-Term Component Analysis Utilizing Short-Term Materials and Design Studies, W. E. Dunkel, *Proceedings of the Eighth National Symposium on Reliability and Quality Control,* pp. 520-523 (January, 1962).

The use of materials, design, and manufacturing knowledge is recommended to predict and control reliability. A detailed approach is discussed on plastic-coated wire-wound resistors. Short-term tests for other passive components arrived at in the same manner are given. To justify the approach, field data were collected and long-term life tests were performed on components which met the short-term tests.

Magneto-optically Measured High-speed Switching of Sandwich Thin Film Elements, J. C. Suits and E. W. Pugh, *Journal of Applied Physics,* **33,** 1057-1058 (March, 1962).

A technique employing the Kerr magneto-optic effect has been used for measuring switching times as short as 10 nanoseconds in thin ferromagnetic films, both individually and when coupled together in a sandwich structure. The switching speed of individual one-millimeter-diameter permalloy bits has been found to be dependent on film thickness, the thicker bits switching more slowly. It was further observed that the time to switch 90% of a film is much more sensitive to film thickness than the time to switch 50% of the same film. When two similar films, magnetized in a head-to-tail fashion, are placed on either side of a drive line strip, the time to switch 50% of the films is essentially the same as for individual bits. However, the time required to switch 90% of the material is considerably shorter for sandwich elements than for the corresponding single bits. These results suggest that the slower switching of thick bits may be attributed to an incoherent rotational mechanism associated with the inhomogeneous demagnetizing field.

A Microprobe for Measuring Magnetic Fields, D. D. Roshon, Jr., *Review of Scientific Instruments,* **33,** No. 4, 201-206 (February, 1962).

The Hall effect has been widely utilized to measure magnetic fields. The relatively simple geometry of a Hall element suggested the use of such a device on a microscale as a probe to examine magnetic fields of small structures. Hall probes are described which were constructed with a sensitive area about 10×10 microns. Fields of less than 0.01 gauss were found to be measurable using evaporated bismuth films. Probe fabrication techniques are described, and the factors affecting probe performance are discussed. A number of instrumentation systems, which have proven suitable for measuring small dc magnetic fields and high frequency ac fields, are presented. High accuracy (1%) of field measurement is readily attained.

New Equipment for Experiments on Data Transmission and Error Analysis, A. Desblache, *IRE Transactions on Communications Systems,* **CS-9,** 244 (September, 1961).

This paper describes the test equipment which was used jointly in 1959 by Post Office authorities and IBM for evaluation of the data transmission feasibility over European telephone networks. A summary of the results gained is displayed and demonstrates the feasibility of data transmission even if many problems are still to be solved.

In the second part of the paper a method for recording and analyzing the errors is explained briefly. This method uses a conventional way of programming a computer and will be used in the future for statistical studies on error distributions.

A New Limit to the Electric Dipole Moment of the Muon, R. L. Garwin, G. Charpak,* F. J. M. Farley,** T. Muller,*** J. C. Sens,** and A. Zichichi, *Il Nuovo Cimento,* **22, Series X,** 1043-1050 (December, 1961).

By storing polarized positive muons in a magnetic field for as many as 1200 revolutions, a new upper limit to the electric dipole moment has been determined. The value is

$$EDM \leq (3 \pm 6) \cdot 10^{-5} \cdot \frac{e\hbar}{mc} \text{ or}$$

$$EDM \leq e \cdot (0.6 \pm 1.1) \cdot 10^{-17} \text{ cm},$$

consistent with time-reversal invariance.

* On leave from Centre National de Recherche Scientifique, Paris, working at CERN, Geneva, Switzerland.

** CERN, Geneva, Switzerland.

*** On leave from Centre National de la Recherche Scientifique, and Institute de Recherches Nucléaires, Strasbourg, working at CERN, Geneva, Switzerland.

A New Technique for the Measurement of Spinwave Linewidths from the Saturation of the Ferrimagnetic Resonance Line, P. E. Seiden, *IRE Transactions on Microwave Theory and Techniques,* **MTT-10,** 51-54 (January, 1962).

A new measurement technique is described that records the ferrimagnetic saturation curve in a way that permits the Suhl critical field to be evaluated directly from the recording. This technique eliminates the tedious task of constructing point-by-point saturation curves for evaluating the critical field and shortens immensely the time required to determine spinwave linewidths from the saturation of the ferrimagnetic resonance line.

Nuclear Spin Absorption Spectra in Solids, A. G. Anderson, *The Physical Review,* **125,** No. 5, 1517-1527 (March 1, 1962).

Nuclear magnetic spin absorption spectra in both parallel and perpendicular ac and dc magnetic fields are reported for lithium nuclei in lithium metal. This is a case where the predominant interactions are the Zeeman interaction of the nuclear magnetic moment with the dc field and the magnetic dipole-dipole interaction between nuclei in fixed lattice positions. For an applied dc field, H_0, the spectrum consists of absorption around zero frequency, around $\omega = \gamma H_0$, and around $\omega = 2\lambda H_0$. Line widths and relative amplitudes observed experimentally are in good agreement with the theory which predicts line widths of approximately the same magnitude for all lines and line amplitudes which vary as H_0^{-4}, H_0^{0}, or H_0^{-2}. At applied dc fields which are large compared with the internal magnetic dipole-dipole fields an additional absorption is observed for the parallel field case at very low frequencies; this is attributed to the relatively long time required for establishment of internal equilibrium at these fields.

Absorption spectra are reported for lithium-magnesium

alloys. In these alloys addition of magnesium produces electric quadrupole broadening of the lithium absorption spectra. The zero-field absorption spectrum of copper is also reported.

Nuclear Spin-Lattice Relaxation in Superconducting Aluminum, Yoshika Masuda and A. G. Redfield, *The Physical Review,* **125,** No. 1, 159-163 (January 1, 1962).

The nuclear spin-lattice relaxation time of superconducting aluminum has been measured from 0.35°K to the critical temperature. The method used was that of Hebel and Slichter; low temperatures were attained through the use of a helium-three cryostat. The estimated energy gap is $3.2kT_c$, in agreement with microwave measurements. The data are in good agreement with the predictions of Hebel and Slichter based on the Bardeen, Cooper, and Schrieffer theory of superconductivity. The data indicate a smearing or width of the BCS energy levels which decreases with increasing temperature and is approximately 1/10 of the energy gap at all temperatures.

Optical Absorption and Electron Spin Resonance After Optical and Thermal Bleaching of *F* Centers, W. E. Bron, *The Physical Review,* **125,** No. 2, 509-513 (January 15, 1962).

A correlation is observed between changes in the half-width and peak position of the *F* band and the presence of *M* and *R* centers in x-irradiated KCl crystals. The changes in the shape of the *F* band caused by optical bleaching are attributed to absorption bands of *M* and *R* centers located in the spectral region of the *F* band. The narrowing of the ESR line which occurs during optical bleaching of x-irradiated KCl crystals is removed by thermal treatment at 140°C. The narrowing is tentatively attributed to the presence of a second, narrow resonance line, due to either R_3 or *N* centers, which is superimposed on the line attributed to *F* centers. The results also suggest that *M*, *R* and V_3 centers are not paramagnetic. Both the optical absorption and the ESR measurements indicate that *F* centers are present even after prolonged optical bleaching and that the character of the *F* center is not changed during bleaching.

Optimal Error Detection Codes for Completely Asymmetric Binary Channels, C. V. Freiman, *Information and Control,* **5,** 64-71 (March, 1962).

The $(n/2)$-out-of-n code is proved to be the least redundant binary block code which permits the detection of all errors in completely asymmetric channels. It is then proved that the sum code of Berger, Smith, and Freiman is the least redundant of all separable codes of this type. The redundancies of the sum and $(n/2)$-out-of-n codes are then compared and it is shown that the former is asymptotically twice as redundant as the latter. An efficient method of constructing separable codes which detect up to a given number, but not all, asymmetric errors is included as an appendix.

Oscillographic Recording of Nanosecond Signals, K. E. Drangeid, H. P. Louis, H. P. Schlaeppi, *Proceedings of the MESUCORA Congress,* Paris, pp. 335-346 (February, 1962).

The use of the sampling principle for oscillographic displays has the fundamental advantage of virtual independence of sensitivity and time resolution. Sampling of the waveform to be displayed also permits conversion into digital quantities and processing of the samples in a special-purpose digital computer; thereby a further increase in sensitivity by two orders of magnitude at no loss in time resolution and the elimination of systematic disturbance accompanying the signal are achieved. The operating principles of a sampling oscilloscope having a sensitivity of 1 millivolt at a time resolution of ⅓ nanosecond and the digital and conversion equipment needed for sample processing are described. An analysis of the noise reduction afforded by the equipment is outlined and examples of its measured performance are shown.

Oxidation of Metals by Short Circuit and Lattice Diffusion of Oxygen,* W. W. Smeltzer,† R. R. Haering, and J. S. Kirkaldy,† *Acta Metallurgica,* **9,** 880-885 (September, 1961).

An expression has been derived for the initial oxidation rates of metals based upon the model of inward movement of oxygen through the lattice and along low-resistance paths within the superficial oxide film. The equation involves three parameters: the parabolic rate constant, the ratio of the diffusion constants for short-circuit and lattice diffusion, and the fraction of available oxygen sites lying within low resistance paths. The latter is assumed to decay in time as a first-order rate process. It is demonstrated that this equation adequately represents the oxidation kinetics of titanium, zirconium and hafnium in the temperature range 300° to 600°C. The empirically determined activation energies for decay of low resistance sites lie between 7 and 12 kcal/mole. The ratios of the activation energies for short circuit and lattice diffusion in the dioxides of these metals are found to be in the range of 0.80 while the initial fraction of oxygen sites lying within defective material is estimated to be of the order of 0.1. This corresponds to a dislocation density of $10^{12}/cm^2$.

* This work forms part of a research project sponsored by the Air Force Office of Scientific Research, Air Research and Development Command, USAF, and the Defense Research Board, Ottawa, Canada.
† Department of Metallurgy and Metallurgical Engineering, McMaster University, Hamilton, Ontario, Canada.

Paretian Distributions and Income Maximization, B. Mandelbrot, *Quarter Journal of Economics of Harvard University,* **LXXVI,** 57-85 (February, 1962).

We present some new theoretical considerations concerning the determination of personal income. Thereby, we provide more detailed predictions about the probability distribution of income, than given by the empirical law of Pareto and by our previous theoretical publications.

Phase Instability in Dilute Interstitial Solid Solutions of Nitrogen in Tantalum, D. P. Seraphim, N. R. Stemple, and D. T. Novick,* *Journal of Applied Physics,* **33,** No. 1, 136-141 (January, 1962).

An ordered structure is found in interstitial solid solutions as dilute as 0.1 at.% nitrogen in tantalum. On the basis of the symmetry of the ordered structure, tetrahedral rather than the usual octahedral sites are considered appropriate for the nitrogen atoms. The effect of the ordered structure on the properties of the solid solution are discussed.

* Presently at Columbia University.

Photo-Hall Effect in CdSe Sintered Photoconductors, A. B. Fowler, *Journal of Physics and Chemistry of Solids,* **22,** 181-188 (December, 1961). (Proceedings of the 1961 International Conference on Photoconductivity.)

Measurements of the photo-Hall effect in sintered layers of CdSe were made. The mobility was found to vary as the 0.15 to the 0.49 power of the density of carriers per unit area depending on the sample and the temperature. Measurements of the mobility as a function of wavelength indicate that the carriers do not appreciably diffuse away from the surface and there is evidence that some of the decrease of the photoresponse on the short wavelength side of the absorption edge is due to a change in mobility, possibly resulting from surface scattering.

La Physique des Leptons, R. L. Garwin, *Proceedings of the Aix-en-Provence International Conference on Elementary Particles,* **II,** Plenary Sessions, 3-13 (September, 1960).

A discussion of progress in muon and electron physics during the preceding year with an extensive presentation of the CERN g-2 experiment, the electric dipole moment of the muon, the magnetic dipole moment, its helicity and capture.

Plastic Microstrain in Silicon-Iron,* J. C. Suits and B. Chalmers,** *Acta Metallurgica,* **9,** 854 to 860 (September, 1961).

Specimens of fine and coarse grain 3¼% silicon-iron were stressed in tension to various stresses below the upper yield point and then examined by an etching technique sensitive to dislocation sites. Slip was first observed at approximately 30 kg/mm^2 independent of grain size. This is the approximate value of friction stress and single-crystal yield stress for silicon-iron observed by Stein and Low. As the applied stress was increased above 30 kg/mm^2, more and more individual grains yielded, and somewhat below the macroscopic yield stress clusters of yielded grains were observed. The behavior of this "pre-yield" plastic microstrain was markedly dependent upon grain size.

The percentage of grains yielded versus applied stress was measured for the 20μ and 170μ grain sizes. These curves are consistent with the theory that plastic microstrain nucleates at stress concentrations, e.g., precipitates, randomly distributed throughout the volume. From these curves the density of active nucleation sites was derived as a function of applied stress.

* This work was performed in the Division of Engineering and Applied Physics, Harvard University.

** Division of Engineering and Applied Physics, Harvard University.

Production Techniques, Tools, Testing in Assembling Wire Wrapped Connections, S. Plasker, A. H. Wenner and C. A. Selzo, *Electronic/Electromechanical Magazine,* **2,** No. 2, 6-9 (February, 1962).

Analyzing the results of 100 million wire-wrapped connections made by IBM in 1960 reveals major factors that lead to reliable wire wraps. The paper presents some of the major variables which were demonstrated by IBM's practical experience in tightly wrapping solid bare wire around stationary terminals. This wire wrapping produces a durable reliable pressure connection.

Properties of Evaporated Film Capacitors, F. S. Maddocks and R. E. Thun, *Journal of the Electrochemical Society,* **109,** No. 2, 99-103 (February, 1962).

The preparation of film capacitors by evaporation is described utilizing the following dielectric materials: silicon monoxide, silicon dioxide, magnesium fluoride, lanthanum fluoride, cerium fluoride, cerium dioxide, and zinc sulfide. The dielectric constants and loss tangents of these materials are presented as functions of the deposition parameters, and the contribution of the lead and condenser plate losses to the apparent loss tangents is shown. The necessary evaporation conditions are discussed for optimizing the dielectric properties of the chosen insulator material. For cerium fluoride, a deposition method utilizing a controlled partial decomposition is described yielding dielectric constants up to $\epsilon/\epsilon_0=300$ without an undue increase of the capacitor losses.

Pulse Program Generator, J. H. Hohl and R. F. Münger, *Proceedings of the 5th International Congress on High-Speed Photography,* pp. 482-483 (February, 1962).

For triggering a high-power, short-duration flash equipment, a pulse program generator has been developed. The instrument generates groups of 110 pulses with equal intervals. To form the pulse program, up to 30 pulses of the group may be arbitrarily chosen. The interval between two successive pulses can be varied continuously from 10 μsec to 1 sec. The generator can be started manually or by an external trigger, upon which the program runs off either once or repetitively. The instrument is fully transistorized.

Regulated Power Pulse Generator, R. H. Dougherty, *Electronic Equipment Engineering,* **10,** No. 3, 54-56 (March, 1962).

Pulse voltages from 18 to 54 volts at up to six amperes are obtained from generator using eight output tubes in parallel. Repetition rates can be varied from 10 to 100 cycles per second.

Semiconductor Circuits for Ternary Logic, R. P. Hallworth and F. G. Heath,* *The Proceedings of The Institution of Electrical Engineers,* **109, Part C,** 219-225 (March, 1962).

The advantages that can be obtained from using a ternary or higher-order system are enumerated. The various techniques using semiconductor devices are described with particular reference to the ternary system, and the circuits that have been developed from these techniques are reviewed. The prototype circuits described in the paper have been developed primarily to show the feasibility of a ternary computer or data-processing equipment, and it is expected that further engineering design will be needed to construct a large higher-speed machine. The main types of logic are surveyed, and the principal operators required to mechanize a system are discussed.

* Faculty of Technology, University of Manchester.

Simultaneous Determination of Tin and Indium Using Anodic Stripping Voltammetry, R. D. DeMars, *Analytical Chemistry,* **34,** No. 2, 259-262 (February, 1962).

A method is described for the simultaneous determination of tin and indium in binary alloys, using the techniques and advantages of anodic stripping voltammetry with linearly varying potential. The method is particularly suitable for the analysis of thin films and samples containing low indium concentrations. Its use for the determination of tin is extremely convenient, since the oxidation state of tin is not critical. Current-voltage curves were obtained from an electrolyte containing pyrogallol and ammonium thiocyanate. The accuracy and precision of the method are comparable to those obtained with cathodic voltammetry with linearly varying potential. The sensitivity of the method makes it possible to determine concentrations of indium as low as 10 ppm in tin.

Simultaneous Diffractions: Indexing *Umweganregung* Peaks in Simple Cases, H. Cole, F. W. Chambers and H. M. Dunn, *Acta Crystallographica,* **15,** 138-144 (February, 1962).

By simultaneous diffraction is meant those diffraction effects which occur when a single crystal is so oriented that more than one Bragg reflection is operative for a given monochromatic ray. These effects often are apparent on films and may seriously modify intensity measurements in Geiger counter diffractometry. The indexing of the planes involved in one class of these effects, namely, *umweganregung,* is worked out in some detail. Umweganregung peaks may be used as a precise measure of lattice parameter, as pointed out by Renninger.

Single-Turn Recording Heads, H. J. Kump, *Electronics,* **35,** No. 1, 89 (January 5, 1962).

A thin sheet of magnetic material with a gap through which a single turn of wire is passed comprises a simplified magnetic recording head. The general configuration of a bit recorded by this head is the same as that recorded by any ring head—two poles similar in shape and amplitude, but opposite in polarity. Although the head may represent the ultimate in simplicity of construction, it requires large drive currents (5 to 50 amperes). Accompanying the description of the head are curves showing its various recording characteristics.

Some Physical Properties of Long-Chained Esters of Dibasic Acids, H. L. McGee, J. S. Crimi, and P. M. Schwartz, *Journal of Chemical and Engineering Data,* **7,** No. 1, 102-106 (January, 1962).

The reactions of three normal long-chain alcohols with a series of dibasic acids and cyclic anhydrides to form esters. Also discussed in this paper are some physical properties of the compounds as well as the infrared spectra of the octadecyl members of the series.

Spinwave and Uniform Precession Linewidths in Rare-Earth Substituted Yttrium Iron Garnet, P. E. Seiden, *Journal of Applied Physics,* **33,** No. 3, 1234-1235 (March, 1962).

The temperature dependence of the spinwave and uniform precession linewidths of yttrium iron garnet substituted with the order of one atomic percent of holmium, erbium, and europium was measured from 4.2° to 300°K. The data are compared to the theory of de Gennes, Kittel, and Portis which attributes the linewidth to the rapidly relaxing rare-earth ions. Although the theory qualitatively predicts the temperature dependence of the linewidth, the detailed behavior varies considerably in these materials and remains to be accounted for. A new technique is briefly described that is used for obtaining $\triangle H_k$ from the main resonance nonlinear behavior of the susceptibility which avoids the detailed point measurements previously necessary.

Spoken Digit Recognition Using Vowel-Consonant Segmentation, P. N. Sholtz and R. Bakis, *The Journal of the Acoustical Society of America,* **34,** 1-5 (January, 1962).

A procedure has been developed for recognition of spoken digits by means of digital computer simulation. Using power spectra computed at 10-msec intervals, the words are segmented into vowels and consonants. Vowels are then classified into one of eleven categories by a multivariate statistical decision method operating on approximations of the measurements. Consonants are classified into one of three categories by means of an empirically derived decision tree. Recognition is then performed by means of a dictionary search. When tested on a sample of 493 words spoken by 50 speakers, and with the internal dictionary adjusted for optimum results, 97% of the words were identified correctly. It appears that this procedure is more tolerant of interspeaker variations than those previously reported.

Strongest Columns and Isoperimetric Inequalities for Eigenvalues,* I. Tadjbakhsh and J. B. Keller,** *Journal of Applied Mechanics,* **29, Series E,** No. 1, 159-164 (March, 1962).

We consider the problem of determining what shape column has the largest critical buckling load of all columns of given length and volume. This problem was previously solved for a column hinged (pinned) at both ends. We solve it for columns clamped at one end and clamped, hinged, or free at the other end, assuming that all cross-sections of the column are similar and similarly oriented. We also prove that the column previously obtained in the hinged-hinged case is actually strongest and not merely stationary. Graphs of the areas of the strongest columns as functions of distance along the columns are given for the various cases. The results are also expressed as isoperimetric inequalities for eigenvalues of second-order ordinary differential equations with various boundary conditions. Certain additional inequalities of this type are also obtained.

* The research in this paper has been sponsored by the Office of Naval Research under Contract No. (285)45.
** New York University.

Surface Vibrational Modes in Crystal Lattices with Complex Interatomic Interaction, D. C. Gazis,* and R. F. Wallis,** *Journal of Mathematics and Physics,* **3,** No. 1, 190-199 (January-February, 1962).

A general method is given for the investigation of normal modes of one-, two-, and three-dimensional lattices which are finite or semi-infinite in one dimension and have free boundary surfaces, assuming interatomic interactions of various ranges.

* Work was done while author was at General Motors Research Laboratories, Warren, Michigan.
** U. S. Naval Research Laboratory, Washington, D. C.

A Survey of Languages and Systems for Information Retrieval, M. Grems, *Communications of the Association for Computing Machinery,* **5,** No. 1, 43-46 (January, 1962).

This survey is directed toward machine-oriented information retrieval languages and systems. It is the first published list for this area of interest to include the specific data items: application, equipment, source language, status, advantages, limitations, and contact person.

Techniques for the Diagnosis of Switching Circuit Failures, J. M. Galey, R. E. Norby, and J. P. Roth, *Proceedings of the Second Annual Symposium and First Annual Symposium of Switching Circuit Theory and Logical Design (AIEE),* **S-134,** 152-160 (September, 1961).

In 2.12 minutes an IBM 7090 program found four input tests (for an 8-input parity check circuit) whose outcome determines whether any one of 102 possible failures occurred. For any single-output combinational circuit, with

no more than 35 input variables, the program computes the set of *all* inputs detecting a given failure—the essential novelty of the method. These tests, one for each failure, are then processed to find a (small) subset of tests which detect *any* failure. The underlying method extends to the diagnosis of circuits with feedback.

A Theoretical Model for Partial Rotation, H. Thomas, *Journal of Applied Physics,* **33,** 1117 (March, 1962).

A simple model which consists of a set of parallel strips with different anisotropy constants, interacting by the magnetic stray field, is investigated. It displays an incoherent reversal process similar to the partial rotation process observed in thin permalloy films, and shows under certain conditions a unidirectional rotational hysteresis.

Theory of Ferromagnetism and the Ordering of Electronic Energy Levels, E. Lieb and D. Mattis, *The Physical Review,* **125,** No. 1, 164-172 (January 1, 1962).

This paper deals with the magnitude of the total spin-angular-momentum for a set of interacting electrons, and therefore with the intrinsic magnetic moment. One first considers a system of N electrons in one dimension subject to arbitrary interactions $V(x_1, \ldots, x_N)$, and defines $E(S)$ to be the lowest energy eigenvalue (of the Schrödinger equation) belonging to total spin S. It is then proved that $E(S+1)>E(S)$. Hence the ground state is unmagnetized, and the spectrum of low-lying excited states is ordered according to increasing spin. The intrinsic magnetization being proportional to S, it follows that electrons in one dimension cannot be ferromagnetic. A similar theorem is proved for electrons in the conduction band of a one-dimensional chain of three-dimensional atoms. Results from the theory of permutation groups and the theory of angular momentum are invoked in order to prove a somewhat weaker form of the theorem for fully three-dimensional structures. One concludes that it is unlikely for conduction electrons to be ferromagnetic, and that ferromagnetism most likely has its roots in the localized atomic magnetic moments (known from Hund's rule) which become aligned in the metal. This line of inquiry is not pursued, however, in this rather mathematical paper.

Theory of Superconductivity, S. H. Liu, *The Physical Review,* **125,** 1244-1248 (February 15, 1962).

Recently Eliashberg derived the theory of superconductivity by the Green's function technique. The energy-gap equation was deduced by a self-consistent calculation. The result is similar to the integral equation of Bardeen, Cooper, and Schrieffer except that the effective electron interaction potential is different from the Bardeen-Pines potential as well as the Bogoliubov potential. The purpose of this paper is to discuss these differences. It shows that the "dangerous terms" in the Bogoliubov theory may be calculated in a different manner. The compensation of these dangerous terms leads to the result of Eliashberg. Therefore, the self-consistent calculation of Eliashberg is but a different interpretation of the Bogoliubov's idea. However, it is argued that the most reliable way of treating the problem should be the variational method because it gives the lowest ground-state energy. This method gives all the results of Bogoliubov in the lowest order of approximation, but is free from arbitrary interpretations.

Transmitting Technical Information by Strip Microfilm, C. W. Carlson, *Graphic Science,* **4,** No. 3, 13-14 (March, 1962).

A system for reproducing and distributing engineering change documents is described, which utilizes a 35 mm planetary camera, a roll film xerographic printer, and film strips. The basis of the system is a procedure whereby engineering change documents are logged in, exposed on microfilm, and the microfilm processed on an automatic processor. The engineering change is then incorporated on the master drawing, which is microfilmed and filed on an aperture card for later use. The system of logging in and processing the engineering changes is reviewed, and the role of the factory Blueprint and Reproduction Services groups is discussed. This entire procedure is described in detail, and the distribution of the documents throughout IBM is indicated. Flow charts of the process are included, along with a description of quality control measures utilizing gray scale charts, as well as lettering and spacing criteria for the original drawings.

Trapping and Recombination Measurement by a Light Modulation Technique, G. Cheroff, J. Heer, and S. Triebwasser, *Journal of Physics and Chemistry of Solids,* **22,** 51-55 (December, 1961).

A technique is described by which recombination lifetime may be resolved from trapping effects. Analysis is shown by which trap capture and release times may be measured as well as density and energy level of trapping levels. It is shown that superlinearity in CdSe sintered layers arises not from "activation," as described in currently held models of variation of recombination time with light level, but rather is associated with increase of mobility with light level.

Unit Cell Volume Effects in Some Isomorphous Ferroelectric Systems, T. G. Dunne and G. Burns, *Journal of the Electrochemical Society,* **109,** No. 1, 54-56 (January, 1962).

From a study of published data, a linear relationship between unit cell volume and ferroelectric Curie point is found for a number of isomorphous systems. The meaning of this is discussed, and for the KH_2PO_4 system it is shown how one can extend Slater's theory qualitatively so that this relationship and the deuteration effect can be understood simultaneously. Several other systems of isomorphous compounds are discussed.

Use of Paramagnetic Resonance to Detect Optical Processes in Photoconductors, R. S. Title, *Journal of Physics and Chemistry of Solids,* **22,** 235-240 (December, 1961). (Proceedings of the 1961 International Conference on Photoconductivity.)

In photoconductivity the light-induced transfer of charge from one impurity or defect site in the lattice to another is a common process. It is in fact while the charge is free that it contributes to the photocurrent. As a result the valence of the sites involved in the process will change by one. In principle this valence change should be observable using paramagnetic resonance absorption techniques because at each site we are going from a state with an even number of electrons to an odd number or vice versa. The use of paramagnetic resonance to detect light-induced charge transfer will be illustrated by several experiments carried out on II-VI compounds doped with various impurities. In addition to the observed valence change, interaction between defects in the lattice has been detected. The resonance technique is useful in that it isolates a single microscopic process occurring during photoconductivity and hence is a definite aid in setting up a model for the photoconductive process. It will also be shown how the apparatus used to detect paramagnetic resonance can be used to measure microwave photoconductivity. The measurement does not require any electrodes on the sample.