

IBM Technical Papers Published Recently in Other Journals

Adaptive Mechanisms in Digital Concept-Processing, M. Kochen, *Proceedings of the 1962 Symposium on Discrete Adaptive Processes*, AIEE, New York, 1962, pp. 50-59.

A proposed adaptive man-machine nonarithmetic information processing system (AMNIP) is sketched. Factual data to be stored and processed is represented by sentences of an elementary applied predicate calculus involving names and predicates. The growth in information content is analyzed by means of dynamic probabilistic graph models in which nodes and edges correspond to names and predicates, respectively. The current status of a 7090 simulation (in IPL-V) of such a system, to study this growth experimentally, is described.

Algorithms for Parallel-Search Memories, A. D. Falkoff, *Journal of the Association for Computing Machinery*, **9**, No. 4, 488-511 (October, 1962).

The underlying logical structure of parallel-search memories is described; the characteristic operation of three major types is displayed in the execution of searches based on equality; and algorithms are presented for searches based on other specifications including maximum, minimum, greater than, less than, nearest to, between limits, and ordering (sorting). It is shown that there is a hierarchy of dependency among these algorithms, that they appear in pairs with each member of a pair belonging to one or the other of two distinct classes, and that every type of search can be executed within each class.

Applications of Cryotrons to the High Speed Computer, E. N. Adams, *Elektronische Rechenanlagen*, **5**, 212-216 (October, 1962).

A general description is given of the operating characteristics and characteristics of merit of several cryotron types and the dependence of these characteristics on the physical and geometric parameters of design. The gain-bandwidth-power relation for circuits using each type of cryotron will be given and significant features discussed. In particular, the scaling laws for cryogenic circuits are discussed and related to the distribution of impedance in the circuit. Problems of design, packaging, refrigeration and interconnection, and the nature of probable applications will be discussed in relation to the economics of application of cryotron circuitry. The present state of the art will be reviewed and a projection will be given of the major developments which remain to be made.

Applied Mathematics: What is Needed in Research and Education,† G. F. Carrier,* R. Courant,** P. Rosen-

bloom§ and C. N. Yang,§§ H. J. Greenberg (Chairman), *SIAM Review*, **4**, No. 4, 297-320 (October, 1962).

This paper contains the proceedings of a symposium and panel discussion on the state of applied mathematics in the United States in education and in research.

† Presented to the Society for Industrial and Applied Mathematics at its meeting in Washington, D. C. on November 4, 1961.

* Department of Mechanical Engineering, Harvard University, Cambridge, Mass.

** New York University and the AEC Computing Facility, New York, N. Y.

§ Institute of Technology, University of Minnesota, Minneapolis, Minnesota.

§§ Institute for Advanced Study, Princeton, New Jersey.

Automated Information Preparation, Norman J. Smith, *The Journal of Communication*, **XII**, No. 2, 84-89 (June, 1962).

The amount of scientific information that has been printed and stored is vast. This information has value only if it can be recovered and put to use. Therefore, the problem is to devise a system which will enable one to sort through this mass of information and retrieve what is pertinent in time to be useful. The obvious solution is automation. Today the storage and retrieval phases of documentation are automated, and sophisticated techniques involving punched card equipment and computers have been developed. However, the preparation phase remains static. The question may be properly asked whether a method of preparing information for storage other than the traditional writing can be developed. No categorical reply can be given. However, developments have occurred in the past few years which significantly imply the possibility.

Avalanche Breakdown Characteristics of a Diffused p - n Junction, D. P. Kennedy and R. R. O'Brien, *IRE Transactions on Electron Devices*, **ED-9**, No. 6, 478-483 (November, 1962).

A one-dimensional analysis is presented on the avalanche breakdown characteristics of a diffused p - n junction diode. By numerically integrating the carrier ionization rate in a junction space-charge layer, avalanche breakdown voltage is calculated for diffused diodes of silicon and germanium; this voltage is graphically illustrated throughout a range of parameters applicable to most practical situations. In addition, for calculating the maximum cutoff frequency of varactor diodes, junction capability is similarly illustrated assuming the device is biased to avalanche breakdown. From these illustrations and from an accompanying nomograph which relates the physical constants of a junction to its impurity atom gradient, the above parameters can be readily

established without additional calculations. Further, examples are also presented to demonstrate the reduction of breakdown voltage resulting from a rapid increase of conductivity within the space-charge layer of a diffused p - n junction; this situation approximates many epitaxial and double diffused structures.

A Characterization of the Cauchy Distribution, M. V. Menon, *Annals of Mathematical Statistics*, **33**, No. 4, 1267-1271 (1962).

This paper settles one of the questions raised in the author's technical report (TR 02. 163, IBM General Products Division, San Jose, California, 1961) entitled, "Problems Arising in Considering the Distribution of Equivalent Resistance." It is shown that the only random variables which are stable and which satisfy the (following) Condition A are the Cauchy variables. A random variable X is said to satisfy Condition A if $1/X$ has the same distribution as $g(X)$, where $g(x)$ is a function such that $g'(x) > 0$, $g(x) = Ax + O(x)$ and $g'(x) = A + O(1/x^\epsilon)$, as $|x| \rightarrow \infty$. Here A and ϵ are positive constants.

Choosing a Power Supply, D. R. Hoch, *Electro-Technology*, **70**, No. 5, 83-87 (November, 1962).

Today's control and computational systems required dc power supplies which meet rigorous specifications. The days of supplies with wide tolerances are gone and power supplies are steadily becoming more and more complex. No single type of supply can be used in all systems; instead, various types are best suited to various equipments and circuits. This paper reviews a number of factors relating to power supply requirements, including dynamic transients, ripple, temperature, system design schedule, etc. Battery, unregulated, ferroresonant, series-regulated, and high-frequency supplies are reviewed.

Coding for Multiple Asymmetric Errors in One Channel of a Multichannel System, C. H. Wolff, *IRE Transactions on Electronic Computers*, **EC-11**, No. 5, 655-658 (October, 1962).

An efficient error correction code for correcting errors of one kind in an arbitrary N -character message is discussed. The coded check character is obtained by summing the weighted coded characters (columns of binary digits where each binary digit assumes a unique weight) within an entire record modulo a prime integer. This check character is then added to the record before transmission over a channel (e.g., magnetic tape). A single parity check is appended to each character of the record to make possible single error detection per character. The received message, perturbed by noise in a constant position or single track, is decoded by again adding up the received information plus check characters in a modulo p counter.

Error location is achieved by solving for x in the expression $ax \bmod p$, when a , the number of parity checks that failed, and $ax \bmod p$, the contents of a mod p counter, are known. This type of residue check may be employed to indicate which track is in error. Thus, error correction can be performed on the characters containing parity check failures.

Coherent Superconducting Behavior of Two Metals (Al-Pb) in a Synthetic Filamentary Structure, D. P.

Seraphim, F. M. d'Heurle, W. R. Heller, *Applied Physics Letters*, **1**, No. 4, 93-95 (December, 1962).

Lead filaments smaller than a coherence length have been drawn in a matrix of aluminum. The bulk diamagnetic effect has been measured. Two anomalies are discussed: (a) superconductivity appearing in the aluminum above its critical temperature and (b) a depression of the superconductivity in the lead.

Comparison of Various Coolants in the Basic Oxygen Steelmaking Process,* T. S. Plaskett and W. A. Morgan,† *Canadian Metallurgical Quarterly* **1**, 99 (1962).

A thermochemical analysis on the basic oxygen steelmaking process was performed for various coolant materials. A comparison of the costs of the blown metal for each of the coolants was made.

* Work performed at Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

† Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

Computer Programming Applied to Data Reduction, J. W. Joachim, *Space Aeronautics*, **38**, No. 7, 167 (December, 1962).

Describes data reduction compiler program suitable for interpreting and processing a magnetic tape which contains fixed point binary data. The tape can be read using an IBM 709/7090 DPS.

Cyclotron Resonance in Metals with H Perpendicular to the Surface, P. B. Miller and R. R. Haering, *The Physical Review*, **128**, 126-130 (October 1, 1962).

Explicit formulas are derived for the surface impedance of a single isotropic carrier in a magnetic field from the zero-field impedance by a scaling procedure originally proposed by Chambers. It is shown that the approximation of a local current-field relation ignores the Doppler effect on the carriers. When the proper nonlocal current-field relation is used, the theoretically predicted surface impedance is altered substantially in the vicinity of the resonance. The nonlocal effects can, in fact, be qualitatively reproduced by using a local theory and replacing ω by $\omega_{\text{eff}} = \omega \pm v_F/\delta_1$, where δ_1 is the inductive skin depth. The nonlocal theory leads to: (a) a resonance in the resistance at the Doppler shifted frequency $\omega = |\omega_c| - v_F/v_1$; (b) a shift in the threshold field required for the onset of an undamped electromagnetic wave (helicon wave). Recent experiments on bismuth by Kirsch and Redfield show structure believed to correspond to the Doppler shifted resonance discussed.

Die Winkelabhängigkeit des Eingangsreflexionsfaktors von Absorbern aus vielen verlustbehafteten homogenen Schichten vor einer Kurzschlussplatte (Reflection coefficient at oblique incidence of an absorber consisting of many lossy homogeneous layers in front of a short-circuit plate),* W. Jutz, *Zeitschrift für angewandte Physik*, **14**, No. 11, 692-695 (1962).

The voltage reflection coefficient at the input of an arrangement consisting of many different homogeneous dielectric

layers with heavy losses over the plane surface of a metallic half-space, is calculated in dependence of frequency and in dependence of the angle of incidence for vertically and horizontally polarized electromagnetic waves. In order to get a reflection coefficient smaller than 13% in a maximum frequency and angle of incidence range at a given total thickness of all layers, the number of lossy layers is increased from three to eight. The reflection data are only slightly improved by increasing the number of layers.

* Work performed at the Institut für Hochfrequenztechnik der Technischen Hochschule, Darmstadt, Germany.

The Diffusivity of Arsenic in Silicon, W. J. Armstrong, *Journal of Electrochemical Society*, **109**, No. 11, 1065-1067 (November, 1962).

The diffusion coefficient of arsenic in silicon has been investigated over the temperature range of 1100° to 1300°C using the formation of *p-n* junction to determine diffusion depths and concentrations. Diffusion coefficients are in good agreement with previously published data, but diffusion equation $D = 68.6 \exp(-97600/RT)$ has a higher D_0 and activation energy. Surface concentrations of arsenic were in the 10^{17} to 10^{19} range.

Disjunctively Linear Logic Nets,* H. Yamada, *IRE Transactions on Electronic Computers*, **EC11**, No. 5, 623-639 (October, 1962).

Three notions are introduced: 1) a class of logic nets with "disjunctively linear structure," 2) "disjunctively linear behavior" of logic nets, and 3) "position diagrams" to represent logic nets.

Through the study of their properties, it is shown that there is a close relationship between disjunctively linear structures and the behavior of logic nets. It is then shown that the state diagrams of Moore and Mealy and the regular expression of Kleene can be considered as particular manifestations of the notion of disjunctive linearity. By means of the notion of disjunctive linearity, a unified treatment is given to state diagrams by Mealy and the logic nets constructed by Copi, Elgot, and Wright from regular expressions. Finally, a discussion is given to the normal form and the position diagram providing a technique for describing disjunctively linear logic nets. Some problems, such as the practical application of disjunctively linear logic nets for hazard-free operation and the minimization of regular expressions through the use of position diagrams, are suggested.

* Work performed at University of Pennsylvania.

Does PERT Work for Small Projects? M. R. Childs, *Data Processing*, **IV**, No. 12, 32-35 (December, 1962).

PERT can help small projects. In this application, its benefits are somewhat different from those which it contributes to large projects. Whether for large or small projects, there are some consequences of using PERT which can be depended upon if the technique is properly applied. On the positive side, using PERT helps to organize information about the future which is otherwise unavailable. On the negative side, using PERT is hard work. Small projects which are contemplating the use of PERT should consider the benefits and disadvantages. If they want more and better information, PERT may be the answer.

Doppler-Shifted Cyclotron Resonance and Alfvén Wave Damping in Bismuth, J. Kirsch and P. B. Miller, *Physical Review Letters*, **9**, 421-423 (November, 1962).

A large kink in the 9-kMc/sec microwave absorption of bismuth has been observed as a perpendicularly applied magnetic field H was varied through 1500 gauss. The kink has been identified as a Doppler-shifted cyclotron resonance whose position is approximately given by $\omega_c = \omega + v_{oz} k_A$ where v_{oz} is the maximum velocity component along H of a carrier at the Fermi surface, k_A is the Alfvén wave vector of the microwave field and ω_c is the cyclotron frequency. The kink also marks the onset of strong damping of the Alfvén waves in bismuth corresponding to real transitions between Landau levels induced by the electromagnetic field of wave vector k_A .

Effects of Delay on the Perception of Pattern-Sequences, Werner J. Koppitz, *Perceptual and Motor Skills*, **15**, 763-774 (1962).

Sequences of concentric rings were presented with delays ranging from 1 to 250 msec between patterns and exposure times of 1 and 10 msec. The phenomena observed in this range of delays were simultaneity, apparent (gamma-) movement, and succession. A three-field mirror-tachistoscope with electronic control served for the presentation of the pattern sequences. The results obtained from 29 untrained observers showed the following trends. Up to 50 msec delay observers reported simultaneity of the patterns. Delays were not significantly different whether the exposure time was 1 or 10 msec. The same was valid also for the other phenomena. Though the luminance of the fields had been equated the second stimulus, with few exceptions, was perceived as darker. This indicates a more complex interaction than simple summation of field-intensities. Possible interaction theories are outlined. Further increase of delay evoked frequently but not always apparent movement. The temporal sequence was perceived as movement in a plane. Apparent movement rarely survived delays longer than 200 msec. Succession started generally with delays around 150 msec, though individual differences were considerable. An analysis of those cases where observers had only reported a single pattern, revealed that these responses were distributed randomly over the whole range of delay intervals. This evidence is used in assessing the importance of intensity of stimulus and delay in masking experiments.

Efficiency of a Corrugated Shell as a Radial Spring, J. H. Meier, *Experimental Mechanics*, **2**, No. 10, 312-316 (October, 1962).

This paper deals with the problem of radial support of prismatic rods. The radial expansion of the rods and the limits of radial pressure acting on them are prescribed, so that an upper limit of the spring rate is imposed. The weight of the radial support must be kept as low as possible; hence, its efficiency of material utilization should be high. Specifically, the efficiency of a corrugated cylindrical shell employed as a radial-spring system is investigated. As a preliminary convenience, general formulas are set up to describe the efficiency of material utilization in springs. Then, the elastic properties and the stresses of corrugated shells with various shapes of convolutes are established. Finally, from the formulas for the spring efficiency, the elastic properties, and the stress of the corrugated shells, their efficiency of material utilization as springs is established.

Electrical Conduction in *n*-Type Germanium at Low Temperatures, S. H. Koenig, R. D. Brown, III, and W. Schillinger, *The Physical Review*, **128**, No. 4, 1668-1696 (1962).

A thorough study has been made of the electrical conductivity (including Hall effect) of high-purity *n*-type Ge in the temperature range 4° to 25°K. Both the Ohmic region and non-Ohmic or "hot electron" region were studied, the latter by both dc and high-speed pulse techniques. From measurements in the Ohmic region, accurate values for the impurity concentrations, in particular the compensating impurities, and for the donor activation energies are obtained; these must be known in order to convert the pulse data to cross sections for certain elementary processes that were investigated. As a subsidiary result, it is confirmed that for P and As donors there is a difference between the thermal and optical activation energies which is proportional to the singlet-triplet splitting of the ground state. By comparing experimental results for the electric field dependence of the drift mobility with the (hot electron) theory for acoustic phonon scattering including anisotropy, it is shown that the electrons appear to be hotter at lower temperatures than the theory would predict. One must conjecture a "forward scattering effect" that reduces the average collision rate for hot electrons moving in the heavy-mass direction, i.e., they can scatter only through small angles at low temperatures because of a dearth of the appropriate phonons. The conjecture is confirmed by a measurement of the mobility anisotropy parameter K ($= 4.2$ for phonon scattering), obtained from data on the magnetic field dependence of the breakdown field. The major aim of the work was to determine values for the (velocity- and temperature-dependent) cross sections for two recombination processes: the recombination of a single electron with an ionized donor (the inverse of thermal ionization) and the Auger recombination of an electron with an ionized donor (the inverse of ionization of a donor by collision). Cross sections have been determined for these processes, and for the inverse processes as well. (Abbreviated version of authors' original abstract.)

Error Sensitivities Applicable to Satellite Ascent and Orbital Transfer Guidance,* Richard W. Gretz, *American Rocket Society Journal*, **32**, 1860-1866 (December, 1962).

Equations are derived by relating variations in the state of a vehicle at the end of an elliptical transfer to the variations in the state at the start of the transfer. Simplified sets of equations are presented for the more important special cases of transfer orbits. Some of the results are presented in the form of curves that are easily applied for estimating quickly the transfer errors for ascent and orbital transfers. These results are applicable in particular for rendezvous conditions, where time in orbit is important.

* Work performed at Sperry Gyroscope Company, Great Neck, N. Y.

Evaluation of Input Devices for a Data Setting Task, Frank J. Minor and Stanley L. Revesman, *Journal of Applied Psychology*, **46**, No. 5, 332-336, (September-October, 1962).

This study evaluates a set of numeric manual entry devices. The task required was to set numeric data into the devices. The devices evaluated in this study were: a 10-key keyboard, levers, a matrix keyboard, and rotary knobs. The

criteria by which the devices were evaluated were: error rate, entry, time, and operator preferences. A repeated measurements design was utilized. Each of 24 subjects made 175 10-digit entries into each of the four devices. The conclusions based upon the data are: (a) the 10-key keyboard yields a significantly lower error rate and is significantly preferred compared to the other devices. This device required significantly less time per entry compared to the lever and rotary knobs. (b) The matrix device required significantly less time per entry and was significantly preferred compared to the lever and rotary knobs. The matrix device does not result in a significantly lower error rate than the latter two devices. (c) There were no significant differences between the lever and rotary knob devices.

An Exploratory Study of Three-Dimensional Photothermoelasticity, Herbert Trampusch and George Gerard,* *Journal of Applied Mechanics*, **28**, Series E, No. 1, 35-40 (March, 1961).

A sandwich technique which utilizes an embedded polariscope consisting of two sheets of polarizing material cemented within a plastic model was evaluated for application to three-dimensional photothermoelasticity. The evaluation included strength tests of cemented joints, photoelastic tests of simple bending models and a sphere, all under mechanical loading. The technique proved to be rather simple to apply particularly since the resulting fringe patterns are readily interpreted. The sandwich technique was then applied to thermal-stress problems associated with a thick-walled cylinder under steady-state conditions. The experimental results correlated well with theory. The results obtained indicate the general applicability of the sandwich technique to three-dimensional stress problems generated by mechanical or thermal loads. It is noted that since other experimental thermal-stress-analysis methods are not highly developed, photothermoelasticity would seem to be particularly useful.

* College of Engineering, New York University.

Failure from Corrosion of Hydraulic Actuators, R. J. Cappell, *Materials Protection*, **1**, 30-36 (December, 1962).

Hydrochloric and other acids resulting from the breakdown of residual trichloroethane cleaning agent in hydraulic fluid combined with iron corrosion products to form a gummy deposit which caused operation failure by sticking of hydraulic actuators. These actuators were part of a magnetic disk storage device being tested. Careful tests of all other possible sources of chlorides verified their origin in the trichloroethane.

Formation of Dielectric Films by Ultraviolet Photolysis of Several Organic Monomers, L. V. Gregor and H. L. McGee, *Insulation*, **8**, No. 13, 27 (December, 1962).

The ultraviolet photopolymerization of several simple unsaturated organic compounds has been studied with respect to the formation of a dielectric film on metallic film surfaces. The monomers gave films which were used as the dielectric medium in a number of test capacitors. Photopolymerization was carried out at a monomer partial pressure of a few mm Hg, the light source being a medium-pressure Hg arc. The test capacitors were made on a glass substrate by evaporating a Pb film, photopolymerizing the

monomer to produce a dielectric film on the metal surface, and then evaporating a second Pb film.

The logarithm of the rate of polymer film growth is proportional to the reciprocal of the absolute substrate temperature ($\Delta H \cong 10\text{-}25$ kcal/mole), and growth rates of 2.5 A/sec have been achieved. The rate of growth is proportional to the partial pressure of monomer and is a linear function of illumination time. The dependence of rate on initiator partial pressure is uncertain, the rate tending to increase as some function of the partial pressure and then dropping off suddenly. The dielectric constants of the films vary from 2.5 to 3.5; dissipation factor varies from 0.012 to 0.11 as thickness increases from about 400 Å to over 6000 Å. The dielectric strength of the thin films exceeds 1×10^8 v/cm. The insulation reliability of the films is considered good, a test run under optimum conditions giving 23 out of 24 initially short-free capacitors. Thermal cycling between 298° and 77°K induced no new short-circuits after as many as 61 cycles. The dielectric quality of the films may be due to their high molecular weight or chemical bonding to the surface or both. The detailed molecular structure of the polymeric films has not yet been elucidated, but the data are in agreement with a free radical polymerization mechanism.

Frequency Spectrum of a Monoclinic Crystal Plate,*
R. K. Kaul and R. D. Mindlin,** *Journal of Acoustical Society of America*, **34**, 1902-1910 (December, 1962).

A sketch is constructed of the branches of Ekstein's frequency equation for an infinite, monoclinic crystal plate. The sketch is for the *AT* cut of quartz and covers a wide range of frequencies and propagation constants. The real, imaginary, and complex segments of the branches are included.

* Work performed at Columbia University.

** Department of Civil Engineering, Columbia University, New York, N. Y.

Generation of Self-Dual Threshold Functions and Lower Bounds of the Number of Threshold Functions and Maximum Weights, S. Muroga, *Proceedings of the AIEE Annual Symposium of Switching Circuit Theory and Logical Design*, **S-141**, 170-184, (September, 1962).

This paper discusses the following: recursive methods of generating self-dual threshold functions, a class of self-dual threshold functions which have interesting properties, a lower bound of the number of threshold functions, and a lower bound of the maximum of minimum weights. Any threshold function can be obtained from a self-dual threshold function by assigning 1 or 0 to some variables. In this paper, discussion is limited to self-dual threshold functions without loss of generality. Strong asymmetry of a threshold function is defined.

High Field Gauss Meter for Use at Liquid Helium Temperatures, M. W. Dowley, *Review of Scientific Instruments*, **33**, 1290-1291 (November, 1962).

The magnetoresistance of a short length of bismuth wire was determined as a function of magnetic field in the temperature range 4.2° to 1.3°K. Various orientations of the current and field were examined. Based on these measurements, a small magnetic field probe, about 10^{-3} cu. in. in volume, was constructed. The probe displayed a linear variation of resistance with magnetic field from about 2.5

to 93 kgauss, the variation being 24.6 Ω /kgauss. The resistance was temperature independent in the range 4.2° to 1.3°K.

Hyperfine Field and Ground-State Spin Alignment in Antiferromagnetic KMnF₃, H. Montgomery,* D. T. Teaney and W. M. Walsh, Jr.,** *The Physical Review*, **128**, 80-81 (October, 1962).

The specific heat of antiferromagnetic KMnF₃ at low temperatures has been measured and the contribution of the Mn⁵⁵ polarization extracted. The hyperfine field, when expressed as a frequency, is found to be $A^{55} \langle S \rangle / h = 686 \pm 10$ Mc/sec. A^{55} has been separately measured for KMgF₃: Mn²⁺, and the result is corrected to give A^{55} for KMnF₃ at low temperature. By comparison of the two experiments, the ground-state spin alignment of the antiferromagnet is found to be $\langle S \rangle / S = (99.8 \pm 1.5)\%$, in disagreement with spin-wave predictions.

* Atomic Energy Research Establishment, Harwell, England.

** Bell Telephone Laboratories, Murray Hill, New Jersey.

The Impact of a Rigid Circular Cylinder on an Elastic Solid,* Martin C. Gutzwiller, *Philosophical Transactions of the Royal Society of London (Series A, Mathematical and Physical Sciences)* **255**, No. 1053, 153-191 (November 29, 1962).

A method is described for approximating to any degree of accuracy the solution of the following problem: An elastic body which is bounded by a plane on one side, but extends to infinity otherwise, is hit by a circular disk of given mass, radius, and initial speed perpendicular to the plane boundary. The whole surface of the disk enters into contact with the elastic body at the same time and stays in contact at all its points from then on. The disk is assumed to be rigid, i.e. it does not allow the particles of the elastic body in the contact area to move relative to each other in a direction perpendicular to the plane boundary. For the relative motion of these particles parallel to the face of the disk several conditions are considered, representing perfect lubrication, various degrees of viscous friction and perfect adherence. With the help of various Mellin transformations a method is indicated which leads to an expansion of the motion in powers of the Laplace transform variable.

The case of perfect adherence needs some special consideration, and a simple approximation for the static problem is found. The case of perfect lubrication is then treated in more detail by a different method which replaces the condition of constant normal displacement in the contact area by an equivalent number of requirements for certain averages over the normal displacement in the contact area. The condition of rigidity for the disk is not exactly satisfied, but it is possible to judge the accuracy of the approximation (with the help of asymptotic expansions in the Laplace transform variable) at the initial time, when discrepancies are largest. The concept of 'mode of vibration' is introduced. Any transient in the coupled system of elastic body and rigid disk can be described as superposition of modes, each of which is an exponentially damped harmonic oscillation of the coupled system with a frequency and damping constant independent of the particular transient. The motion of the impinging disk is then seen to be dominated mostly by the lowest mode, provided the mass of the disk is not too small. The displacement perpendicular to the boundary outside of the contact area has

been calculated. This calculation is not more difficult than the corresponding one in the case of a point-like source at the plane boundary of an elastic solid. Numerical computations were carried out for the case of perfect lubrication with the help of the Elecom digital computer in order to determine the first two modes and their contributions to the motion of the disk. As long as Poisson's ratio for the elastic solid exceeds $\frac{1}{4}$, the results do not depend strongly on the value of Poisson's ratio. The ratio of the areal mass densities of the disk to the elastic solid is the main parameter of the theory. The shear wave velocity of the elastic solid determines the time scale of the motion.

The Influence of the Anisotropy Variations on the Domain Behaviour of Ni-Fe Films, S. Middelhoek, *Proceedings of the Symposium on the Electric and Magnetic Properties of Thin Metallic Layers* (Koninklijke Vlaamse Academie voor Wetenschappen, Letteren en Schone Kunsten Van België), 182-192 (December, 1962).

The description of the reversal process in thin Ni-Fe films with uniaxial anisotropy is usually based on the single-domain theory. Experiments show, however, that the reversal processes in almost all directions deviate from the theoretically expected ones. These deviations result from the fact, that besides the induced uniaxial anisotropy, residual crystal and stress anisotropies also occur in the films. Because of these stray anisotropies, the film splits up into a large number of elongated domains, which block further rotation. This happens at a field slightly larger than the critical field for rotation, as obtained from the single domain theory. Subsequent magnetization reversal takes place by wall motion. The different domain structures, which occur as a function of the angle between the magnetic field and the easy direction are studied by means of the Bitter technique.

An Investigation of Surface States at a Silicon/Silicon Oxide Interface Employing Metal-Oxide-Silicon Diodes,* L. M. Terman, *Solid-State Electronics*, **5**, 285-299 (February, 1962).

A new solid-state device is introduced, the M-O-S diode, of which an oxidized silicon surface is an integral part, and a theory for its operation in the absence of surface states is obtained. The capacitance of this device may be considerably more voltage sensitive than that of a *p-n* junction. The existence of surface states with nonzero relaxation times is introduced into the theoretical model. It is shown that the states may increase the capacitance of the device, as well as affect the proportion of applied voltage which appears across the silicon. A small-signal equivalent circuit is derived which includes the effect of the surface states. It is also shown that a comparison of the theoretical capacitance-vs-voltage curve without states and a measured high-frequency capacitance-vs-voltage curve may be used to obtain the distribution of all states, regardless of their time constants.

Results are given of measurements and calculations on two M-O-S diodes having different surface treatments before oxidation. Both surfaces have a total density of about 3×10^{12} states/cm². In both cases, the distribution of states is continuous and has its highest peak about 100 mv above $E_F(0)$, the position of the Fermi level at the silicon surface if there is no voltage drop across the silicon. The time constants of the states extend from 10^{-8} sec to longer than 10^{-2} sec. There is a tendency for states located at deeper

energy levels to have longer time constants, but some of the states in the high density of states above $E_F(0)$ have long time constants. The distribution of time constants with energy level is somewhat different for the two surfaces.

A comparison is made between the distribution of states obtained here with the distribution reported by others working in the field. The results are similar in density and location of the peaks of the distribution reported here, but differ in that some other sources report a discrete distribution.

* The work contained in this report was done at Stanford University, Stanford, California.

Ionic Contribution to Field Gradients in the Rare Earths, G. Burns and E. G. Wikner,* *Physics Letters*, **2**, 225 (October 1, 1962).

Values of the antishielding factor, σ_z , are calculated for the rare earths. Using these values the ionic contribution to the field gradient for several typical lattices is calculated and shown to be of importance.

* General Atomics, San Diego, California.

Kinetics of the Photochemical Dimerization of Olefins to Cyclobutane Derivatives I. Intramolecular Addition, R. Srinivasan, *Journal of the American Chemical Society*, **84**, No. 21, 4141-4145 (November 5, 1962).

Photolyses of 2,3-dimethyl-1, 3-butadiene and isoprene in solution gave rise to 1,2-dimethyl- and 1-methyl cyclobutene, respectively. Quantum yields were obtained for the intramolecular rearrangement of seven 1,3-dienes to the corresponding cyclobutenes. The effect of substitution on the efficiency of ring closure was mainly due to a favorable conformation in the ground states of the reactant molecules.

Learning Process and Inverse H-Theorem, Satoshi Watanabe, *IRE Transactions on Information Theory*, **IT-8**, No. 5, 246-251 (September, 1962).

It is shown that the time rate of decrease of the "response entropy" is a suitable measure of the speed of learning. What the author introduces under the name of "Inverse H-Theorem" governs the behavior of the response entropy.

L'Influence de la Température sur l'Effet Kerr dans les Lames Minces de Gadolinium (The temperature dependence of the Kerr effect on thin gadolinium films), C. Schüller, *Le Journal de Physique et le Radium*, **23**, 533-535 (August-September, 1962).

Measurements are reported of the longitudinal Kerr effect on thin Gd films, prepared and measured in ultra-high vacuum. The temperature dependence of the angle of Kerr rotation agrees fairly well with the magnetization curve between 80°K and the Curie point, though a deviation was found which might be due to the different magnetization of films and bulk material.

Logical Circuitries Utilization for Digital Data Transmission, A. Desblache, *Bulletin Technique de la Suisse Romande*, **20**, 302-311 (October, 1962).

After a survey of the problems encountered in the transmission over telephone lines, the basic principles of circuitries used are displayed over all shapes of received

waveforms, start-stop and isochronous systems, character synchronization. A study is made about statistical results of error distribution and some explanation is given on test equipment used to gain the distribution.

The next section of the paper is a survey of the various codes, fixed codes, systematic codes, linear codes and cyclic codes. Examples of the implementation of these codes into logical circuitries are given. As a conclusion of the use of error detecting codes, the expected reliability of transmission over actual lines is derived.

The last part of the paper concerns the principles used to set up complex systems using data transmission between locations, half duplex, full duplex and common channel systems.

Machine Recognition of Constrained Handwritten Arabic Numbers, J. L. Masterson and R. S. Hirsch, *IRE Transactions on Human Factors in Electronics*, **HFE-3**, No. 2, 62-65 (September, 1962).

A scanner and optical system were constructed to recognize handwritten arabic numerals. The paper describes the scanning technique, its associated optical system, the logic design and the results of a study evaluating the ability of a group of subjects to write arabic numbers within the specified constraints of the system.

Magnetic Field Dependence of Thermodynamic Properties of Antiferromagnets; Adiabatic Magnetization,* R. J. Joenk, *The Physical Review*, **128**, 1634-1645 (November 15, 1962).

The magnetic field dependence of the thermodynamic properties of cubic or uniaxial antiferromagnets is examined using spin wave theory. The specific heat, magnetization, and parallel susceptibility are shown to be exponentially increasing functions of applied field for values of H_0 less than the critical spin-flopping field. Since this field dependence suggests that an antiferromagnet can be cooled by the adiabatic application of a magnetic field, the theory of adiabatic magnetization is investigated. Field dependent nuclear spin effects are evaluated on an effective field model by perturbation theory and are included in the analysis. It is found that when spin wave effects are dominant, cooling should be observed; at lower temperatures, when nuclear effects are non-negligible, either cooling or heating may be observed, depending on the initial temperature and final value of the magnetic field. The dependence of the cooling on the physical parameters of the antiferromagnet is discussed and detailed calculations are made for MnF₂.

* Work done at the University of Pittsburgh supported by AFOSR Contract #AF49(638)-323.

Magneto-resistance in Thin Evaporated Gadolinium Films, C. Schüler, *Proceedings of the Symposium of the Electric and Magnetic Properties of Thin Metallic Layers* (Koninklijke Vlaamse Academie voor Wetenschappen, Letteren en Schone Kunsten van België), pages 30-36 (December, 1962).

In ferromagnetic metals, scattering of conduction electrons by disordered spins gives rise to an additional term in their electrical resistance. This effect is particularly pronounced in bulk gadolinium [B. R. Coles, *Advanc. Phys.* **7**, 40 (1958)]. Thin films of gadolinium have been prepared in ultra-high vacuum and the temperature dependence of the

resistivity has been measured between 80°K and 450°K. A magnetic resistivity term can be derived from the resistance vs temperature curve. The behavior of the thin gadolinium films as compared to bulk material is discussed.

Majority Decision Functions of Up to Six Variables, S. Muroga, I. Toda,* and M. Kondo,* *Journal of Mathematics of Computation*, **XVI**, No. 80, 459-472 (October, 1962).

Lists of majority decision functions of up to six variables and their numbers from various viewpoints are made by the parametron computer MUSASINO-1. A computer program is outlined and observations on majority decision functions through the preparation of these lists are described.

* Electrical Communication Laboratory of Nippon Telegraph and Telephone Public Corporation, Tokyo.

Majority Logic and Problems of Probabilistic Behaviors, S. Muroga, *Self-Organizing Systems 1962*, pp. 243-282, Spartan Books, Inc.

The first half of this paper discusses some of the basic notions and theorems of majority logic (or threshold logic), including some of the highlights in recent development. The presentation is partially expository but includes new results. The second half discusses various problems of probabilistic behaviors of majority elements which may be coherently related to the deterministic theory of majority logic. It deals with how to determine a structure for getting the greatest reliability of a single element and how to organize elements for giving a network the greatest reliability.

Measuring Tunnel Diode Equivalent Circuit Parameters, George E. Fox, *Solid State Design*, **3**, No. 10, 27-33 (October, 1962).

This paper presents a brief review of the basic physics of tunnel diodes and derives the criteria for stability in terms of the equivalent circuit parameters. Techniques for measuring these parameters are discussed and utilized by measuring several devices. Due to the stability criteria which must be met, a special curve tracer was constructed to make possible the tracing of the tunnel diode curves through the negative conductance region. Results of all measurements are presented in graphical form showing the variation of the equivalent circuit parameters with bias voltage.

Mechanical Stresses in Silicon Oxide Films, J. Priest,* H. L. Caswell, and Y. Budo, *Vacuum* **12**, 301-306 (November-December, 1962).

The residual stress in thin films formed by vacuum sublimation of bulk silicon monoxide has been studied as a function of source temperature, residual gases present during deposition, and exposure to atmospheric air after preparation. Highly stable films of silicon monoxide having a tensile stress from 2 to 5×10^9 dynes/cm² can be prepared at system pressures less than 5×10^{-6} torr and at source temperatures between 1300° and 1400°C. If higher source temperatures are used, the resultant films anneal with time and are susceptible to cracking. Those produced at lower source temperatures are under a high tensile stress unless a high partial pressure of water vapor or oxygen is present. In this case oxidation occurs, resulting in a decrease in the film stress. For completely oxidized films, a com-

pressive stress of 3×10^8 dynes/cm² was observed. Partial oxidation results in a film which is highly unstable in air. High partial pressures of carbon monoxide, carbon dioxide, nitrogen and hydrogen were found to have very little effect on the residual stress.

* Present address: Miami University, Oxford, Ohio.

A Model of Mind-Body Relation in Terms of Modular Logic, S. Watanabe, *Synthese*, **XIII**, No. 4, 261-302 (December, 1961). (Appeared in the summer of 1962).

This paper shows that if we assume a certain set of plausible postulates about the mind-body relation, we are forced to face a paradox of logical nature, and that this paradox can be resolved by the use of modular logic.

Nomograms for Helical Springs, M. E. Arthur, *Design News*, **17**, No. 19, 88-91 (September 19, 1962).

Two nomograms solve the equations for maximum load and maximum deflection per coil with the inclusion of the Wahl factor correction for spring index and fiber stress for the wire size for carbon steel springs. Therefore, the solutions require no further corrections for that material. An example is given showing the part the nomograms can provide in the design of a spring.

Non-Stoichiometry in Cadmium Selenide and Equilibria in the System Cadmium-Selenium,* A. Reisman, M. Berkenblit, and M. Witzten, *The Journal of Physical Chemistry*, **66**, No. 11, 2210-2214 (November, 1962).

Studies of the condensed system Cd-Se have indicated a solubility limit of Cd in CdSe corresponding to a Cd/Se molar ratio of from 1.010-1.015. The system shows the formation of a two-liquid region in the selenium-rich portions, and a tendency toward such formation in the cadmium-rich portions. The melting point of the selenide was determined as $1239 \pm 3^\circ$. Using precision x-ray fluorescence techniques to study products of vacuum heat treatments of initially stoichiometric CdSe, it has been concluded that this compound vaporizes incongruently and achieves a steady-state vaporization along the three-phase line Cd₁ + δ Se solid solution-liquid-vapor.

* This paper was presented in part at the Symposium on Non-stoichiometric Compounds, 141st National Meeting of the American Chemical Society, Washington, D. C. March 20-29, 1962.

Note on Certain Combinatorial Designs, N. C. Hsu, *Proceedings of the American Mathematical Society*, **13**, 682-685 (October, 1962).

In this Note we prove some propositions which show that apparently more general conditions can be realized only by tactical configurations which are our old acquaintances, such as finite projective planes, Steiner systems.

Note on Green's Function in Anisotropic Elasticity,* Martin C. Gutzwiller, *Quarterly of Applied Mathematics*, **XX**, No. 3, 249-256 (October, 1962).

Green's function for an elastic, anisotropic medium is constructed with the help of the method used by Courant and Hilbert in the study of light propagation through an anisotropic dielectric. The amplitudes of the arrivals corresponding to each wave surface are expressed as functions of

the curvature of the normal surfaces. Multivalued solutions are expressed as integrals over the dislocation lines, whose motion is assumed to be known, but otherwise arbitrary. The formulae are worked out in detail for the isotropic medium.

* Work performed at Shell Development Company, Exploration and Production Research Division, Houston, Texas.

Nuclear Magnetic Resonance in the Demagnetized State,* A. G. Anderson and S. R. Hartmann,† *The Physical Review* **128**, 2023-2041 (December 1, 1962).

A discussion is given of experimental results and theoretical considerations which apply in the case of complete adiabatic demagnetization in the rotating frame (ADRF) for nuclear spin systems in solids. Although the net magnetization in this state is zero, both cw and pulse signals are predicted and are readily observed at the normal resonance frequency. These signals appear to be much like the derivative of the signals observed in the normal nmr cases with amplitudes comparable to normal nmr signal amplitudes and they persist for times comparable with T_1 at high fields even when the line is purely homogeneously broadened. A simple heuristic theory is used to calculate, after ADRF, the shape of the free induction decay and the form of the absorption at $\omega \approx 0$, Ω , and 2Ω where Ω is the resonance frequency of the spin system. The density matrix method is then used to calculate line shapes and free-induction decay signals which are found to be in agreement with experiment and the heuristic model calculation. The concept of spin temperature is used to calculate the effect of applying an rf field to produce a line asymmetry in a homogeneously broadened system. It is also shown that in general the free-induction decay signal is not the Fourier transform of the line shape and homogeneously broadened lines do not saturate uniformly. In addition, it is found experimentally that ADRF is reversible, spin systems are coupled, spectra at low frequency and double the resonance frequency are observed, and spin system relaxation times vary rapidly with field at low dc fields but are of order of T_1 of high fields.

* Work supported in part by Office of Naval Research and National Science Foundation.

† University of California, Berkeley; now at Columbia University.

The Numbers that Count,* Wade Poole† and Michael Montalbano, *Business Automation*, **9**, No. 1, 35-37 (January, 1963).

An Inversion Method of creating self-checking numbers is described and illustrated. The principle of this system is simply to count the number of inversions (occurrences of a digit greater than the digit to its right) within an identify number, using the oddness or evenness of the count as a means of determining the number's validity.

* Work performed at Kaiser Steel Corporation, Oakland, California.

† Kaiser Steel Corporation, Oakland, California.

On a Property of a Test for the Equality of Two Normal Dispersion Matrices Against One-Sided Alternatives, Wadie F. Mikhail, *The Annals of Mathematical Statistics*, **33**, No. 4, 1463-1465 (December, 1962).

The purpose of this paper is to establish the monotonicity property of some tests suggested by Roy and Gnanadesikan for the problem of testing the null hypothesis of equality of two dispersion matrices against some specific alternatives. If Σ_1 and Σ_2 denote the dispersion matrices of two non-

singular p-variate normals and $\gamma_1, \gamma_2, \dots, \gamma_p$ denote the characteristic roots (all positive) of $\Sigma_1 \Sigma_2^{-1}$, then the null hypothesis is H_0 : all γ_i 's are equal to unity. The alternative hypotheses to be considered are: (i) H_1 : $\gamma_m > 1$; (ii) H_2 : $\gamma_m < 1$; (iii) H_3 : $\gamma_m > 1$; (iv) H_4 : $\gamma_m < 1$, where γ_m and γ_M denote, respectively, the smallest and the largest of the γ_i .

On Some Transformation Theorems in Many-Valued Logical Systems,* C. K. Tung, *Switching Circuit Theory and Logical Design* (Proceedings of the Third Annual AIEE Symposium), pages 185-199 (September, 1962).

Since the well-known DeMorgan theorem in two-valued logical systems may be considered as a special transformation theorem, we are interested in finding its counterpart in many-valued logical systems. Some basic concept and theorems regarding the existence of duality and N -ality relationships due to transformations in many-valued logical systems are introduced in terms of isomorphism. On the basis of these concepts and theorems, a number of special transformation theorems involving some practical logical operations are developed. Several aspects of the generalization of the DeMorgan theorem to transformation theorems are presented. It is shown that biuniqueness, monotonicity and simplicity are three significant properties of transformations in many-valued logical systems. In terms of the concept of isomorphism, transformations even with composite ones including those of two or more variables such as from two variables to two variables may be studied rather conveniently. Functional relationships involving transformations may exist not only in duality, but also in N -ality, in many-valued logical systems. It can be seen that transformations are important in the study of equivalence, interrelations and conversions between logical functions or operations and are useful in both analysis and synthesis of logical systems.

* Work performed at Case Institute of Technology.

On the Limitations and Special Effects in Fluid Jet Amplifiers, R. A. Comparin,* H. H. Glaetli, A. E. Mitchell, H. R. Müller, *Proceedings of the Symposium on Fluid Jet Control Devices*, (Winter Annual Meeting of the ASME, New York, N. Y.), pages 65-73, (November, 1962).

The effect of Reynolds number on the operation of fluid amplifiers which utilize the interaction of jets and solid boundary walls are discussed. Estimates are given for the minimum size, the power requirements and response time.

* Now at the University of Maine, Orono.

On the Sign Reversal of a Magnetic Field Penetrating a Superconducting Layer, K. E. Drangeid, M. C. Gutzwiller, R. Sommerhalder, H. Thomas, *Proceedings of the Symposium on the Electric and Magnetic Properties of Thin Metallic Layers* (Koninklijke Vlaamse Academie voor Wetenschappen, Letteren en Schone Kunsten Van België), pages 326-337 (December, 1962).

According to the nonlocal theory of superconductivity, a magnetic field penetrating a superconducting material should change sign at a distance d from the surface which depends on the value of the coherence length. The order of magnitude of d has been calculated numerically for the

case of a thin, hollow cylinder in a longitudinal magnetic field. An equipment to check theoretical expectation by experiment has been built. Preliminary results are discussed.

Open Loop Digital Hydraulics Positions Computer Memory Arm, M. E. Freeman and J. C. Gilmore, *Hydraulics and Pneumatics*, **15**, 92-95 (November, 1962).

Hydraulics quickly and accurately positions magnetic pickup heads over any one of 250 information tracks on this computer disk memory file [the IBM 1301 Disk Storage Unit]. Positioning time for the 13-lb load, consisting of the carriage and heads, ranges from 50 to 180 msec.

Optical Properties of Heavily Doped Compensated Germanium, A. B. Fowler, W. E. Howard and G. E. Brock, *The Physical Review*, **128**, No. 4, 1664-1667, (November 15, 1962).

Measurements of the optical properties of a compensated, heavily doped sample of germanium are reported. Although the sample contained about 10^{20} gallium atoms/cc and 10^{20} arsenic atoms/cc, the compensation was such that the absorption coefficient could be measured from a minimum value of 7 cm^{-1} to a maximum at about 10^4 cm^{-1} . The major observation was that of an exponential tail beginning at about 0.78 eV which was not strongly dependent on the carrier concentration for densities between $2 \times 10^{17}/\text{cm}^3$ and $10^{19}/\text{cm}^3$.

Optical Spectra and Paramagnetic Resonance of U^{4+} Ions in Alkaline Earth Fluoride Lattices,* R. S. Title, P. P. Sorokin, M. J. Stevenson, G. D. Pettit, J. E. Scardefield and J. R. Lankard, *The Physical Review*, **128**, No. 1, 62-66 (October 1, 1962).

Paramagnetic resonance absorption measurements of uranium in various symmetries in CaF_2 and SrF_2 crystals are given. It is concluded that the centers seen in trigonal symmetry are U^{4+} ions. This conclusion is based on the observed direct correlation between the trigonal center resonance and one of two components which, generally speaking, together constitute the optical absorption spectra of these crystals. This spectral component is isolated and shown to agree with the published optical absorption spectra of U^{4+} compounds. Also, it is shown that the observed asymmetry of the trigonal center resonance and its zero g_{\perp} value characterize the ground state ($f^3, {}^3H_4$), in trigonal symmetry and cannot be properties of the state ($f^3, {}^4I_{9/2}$). A model is proposed for the U^{4+} center.

* This work was supported partly under a contract administered by the U. S. Army Research Office (Durham).

PERT for Small Projects, N. C. Loeber, *Machine Design*, **34**, 134-139 (October 25, 1962).

One of the most valuable by-products of U. S. missile and space research is the engineering-management technique called PERT (Program Evaluation and Review Technique). Although PERT grew up with the Polaris missile and is generally associated with large computer-oriented programs, it is now being adapted—with much success—to small engineering projects. This article describes a practical pencil-and-paper version of PERT that enables engineering schedules, prone to elusiveness, to be forecast with clarity and confidence.

Phase-Shift Characteristics of Dielectric Loaded Waveguide, G. F. Bland and A. G. Franco.* *IRE Transactions on Microwave Theory and Techniques*, **MTT-10**, No. 6, 492-496 (November, 1962).

An investigation of waveguide phase-shifting techniques was conducted for the purpose of establishing the design criteria for a device capable of meeting the following specifications: a phase-shift variable over a minimum range of 360° and a maximum phase error of $\pm 5^\circ$ at any phase setting over at least a 10 per cent frequency bandwidth. The dielectric loaded waveguide is the basis of a device which meets the design requirements. In this paper the analytical expressions applicable to the dielectric loaded waveguide cross section are derived using the transverse resonance procedure. A rigorous description of the propagation characteristics of this structure for various parameter values is obtained through the use of a high-speed computing machine. The excellent correlation between computed values and the data obtained from an experimental model is presented.

* Now at Hughes Aircraft Co.

Potentiometer Resolver, R. E. Tomek, *Electromechanical Design*, **6**, No. 10, 51 (October, 1962).

Brief description of past and improved means for generating the sine and cosine components of a shaft position. Improvement is accomplished by means of simplified mechanical construction, low cost, and high accuracy.

Predicting Transistor Storage Time for Non-Step, Quasi-Voltage Inputs, R. J. Wilfinger and R. P. Nanavati, *IRE Transactions on Electron Devices*, **ED-9**, No. 6, 492-499 (November, 1962).

The differential equation which has been derived by earlier workers for minority carrier storage in the base of a one-dimensional transistor model has been solved for storage time assuming a general, time dependent, "off" base current. Specific base currents treated include those encountered when driving the base with a step, ramp, or exponential voltage in series with a speed-up network. The theoretical results are compared with the storage time observed for germanium mesa, MADT, PADT, and epitaxial transistors in the common emitter configuration. Although the solution obtained assumes minority carriers are stored predominately in the base, the agreement between theory and observed results for mesa units, which have carrier storage in the collector also, is good.

Propagation of Microwave Phonons in Germanium, M. Pomerantz, Robert W. Keyes, and P. E. Seiden, *Physical Review Letters*, **7**, 312 (1962).

Recent work has shown that there is an appreciable electronic contribution to the shear elastic constant C_{44} in heavily doped *n*-type germanium. The electronic contribution is of the relaxation type; it depends on the redistribution of electron population in the several valleys of the germanium conduction band when the crystal is strained. Therefore, one can anticipate that relaxation dispersion and absorption will be present if the elastic constant is measured in an appropriate frequency range. This communication reports the observation of large anelastic absorption associated with the electronic redistribution at a frequency near 10^{10} cycles/sec.

Real-Time Computation and Recursive Functions Not Real-Time Computable,* H. Yamada, *IRE Transactions on Electronic Computers*, **EC-11**, No. 6, 753-760 (December, 1962).

As an attempt to investigate a general theory of real-time computability in digital computers, a subclass of Turing machines is formally introduced together with some classes of functions that are computable by them in real time. The existence is then established of a class of recursive functions that are not computable in real time by use of a class of machines, no matter how general we make the machines subject to a given constraint.

* Work performed at University of Pennsylvania.

Recombination Radiation in GaAs by Optical and Electrical Injection, M. I. Nathan, G. Burns, *Applied Physics Letters*, **1**, 89-90 (December, 1962).

Fluorescence experiments on homogeneously doped *n*- and *p*-type GaAs as well as sectional diodes have been carried out. It is shown that the diode emission at 1.47 eV (the laser line) comes from *p*-side of the diodes.

Reducing Wiring Lengths, O. B. Shafer, *Electro-Technology*, **70**, No. 4, 92-95 (October, 1962).

The cabling or harness method of systems wiring is always useful in that it supplies a flexible medium for distributing components in a pseudological manner throughout the machine system. The design effort is to place the circuit elements so that a minimum or near minimum total length of connecting wire results. An algorithm has been evolved for organizing the units in a single dimensional array so that a near optimum arrangement for minimum bulk and weight of connecting wire is achieved. The method suggested can be applied readily and is programmable on a digital computer such as the IBM 704. The algorithm is developed and applied to an example followed by the development of a mathematical definition. Although the solution arrived at is not a global solution, the result will be close enough to a minimum for practical purposes. The method can be used for other problems of a similar nature.

Shielding and Crystal Fields at Rare-Earth Ions, G. Burns, *The Physical Review*, **128**, 2121-2130 (1962).

Several aspects of the crystal field problems of rare earth ions in ionic solids are discussed. In particular, three problems are considered: (1) A calculation is performed to determine to what extent the $5s^2p^6$ electrons shield the $4f$ electrons from the crystal field. The shielding is small ($< 10\%$) and unimportant compared to the many other uncertainties in crystal field calculations. The calculation was carried out by considering the crystal field, $\sum B_n^m r^n Y_n^m$, as a perturbation on the $5s^2$ and $5p^6$ state. The excited state wave functions are calculated and the extra potential, $\sum B_n^m Y_n^m F_{n,m}(r)$, due to the distorted charge distribution is compared to crystal potential. (2) The reason as to why the rare earth ions effectively see smaller crystal fields than the iron series ions is considered by performing the lattice sums in several typical lattices so that the B_n^m coefficients could be compared. One observes that the crystal field to spin orbit coupling ratio is considerably larger in the iron series ions than for the rare earth ions for straightforward reasons (the iron series ions have $B_n^m \approx 3$ to 10 times larger, $\langle r^n \rangle \approx 2$ times larger and spin orbit coupling constants $\approx 1/2$ as large as the rare earth ions). Thus, the dif-

ference in behavior between these two groups of ions comes about for straight-forward reasons without resorting to shielding. (3) The calculated crystal field parameters, (r^n) $B_n^m = V_n^m$, for the rare earth ions are compared with those obtained by fitting optical levels. A discussion of the problems involved in calculating the lattice sums (B_n^m) is given and one can see why detailed agreement is not expected. The calculated V_n^m for $n = 4$ and 6 are reasonable but smaller than those obtained from the optical data. Little can be said for the $n = 2$ terms because of the uncertainties involved in the lattice sums.

Singular Perturbation Analyses of the Differential Equations of a Tunnel Diode Circuit, W. L. Miranker, *Quarterly of Applied Mathematics*, **XX**, 3, 279-299 (October, 1962).

This paper contains an analysis of the differential equations of the tunnel diode using the techniques of the phase plane and of asymptotic theory. It gives a mathematical description of the operation of this diode as a bistable device and obtains asymptotic expansions for the solutions of the differential equations. These asymptotic formulas are applied to give expressions for the transition time in the circuit.

Some Factors Controlling Gross Leakage Current in Sputtered Tantalum-Film Capacitors, L. I. Maissel and N. W. Silcox, *Journal of Electrochemical Society*, **109**, No. 12, 1151-1154 (December, 1962).

Methods for producing sputtered tantalum-film capacitors are described. The breakdown voltage of such capacitors is shown to depend on the type of metal used for the counter electrode and on the counter electrode area. This dependency is explained as being due to microfissures (in the oxide), which some metals are more likely to enter than others. Electronmicrographs of these fissures are shown. The origin of the microfissures is thought to be lattice mismatch between oxide and metal in those regions where the original tantalum was not sufficiently smooth. It is suggested that anodizing these films in hot solution will establish a thermal mismatch between metal and oxide, which will partly compensate for the lattice mismatch.

The Static Dielectric Constant of CdAs₂ and the Donor Ground State Energy, R. D. Brown and S. H. Koenig, *Physics Letters*, **2**, No. 7, 309 (November 1, 1962).

A measurement is reported for the low frequency dielectric constant of CdAs₂: $K = 18.5 \pm 5\%$. This is the value of a diagonal component of the dielectric constant tensor measured perpendicular to the tetragonal axis. The measurements were made at 4.2°K using silver paint electrodes and a Tektronix 130 LC meter, for five thicknesses and three surface treatments. Edge corrections, $\sim 10\%$, are included in the final result.

Stimulated Emission of Radiation from GaAs p-n Junctions, M. I. Nathan, W. Dumke, G. Burns, F. H. Dill, Jr., G. J. Lasher, *Applied Physics Letters*, **1**, 62 (1962).

The observation of laser action in GaAs p-n junctions is reported. The laser action is demonstrated by the observation of drastic line narrowing above a threshold injection current. Lines are observed to narrow from 125 Å to 2 Å at 77°K.

Surface Effects in the Second-Order Doppler Shift of the Mössbauer Resonance, R. F. Wallis* and D. C. Gazis, *The Physical Review*, **128**, No. 1, 106-110 (October, 1962).

The second-order Doppler shift in the Mössbauer effect depends upon the mean-square velocities of the emitting and absorbing atoms. On the basis of a theorem discussed by Born in connection with the lattice dynamical theory of the Debye-Waller factor, a general expression has been obtained for the mean-square velocity of an arbitrary atom in a crystal lattice, assuming harmonic forces. The result is valid for any temperature and may be applied to lattices having free surfaces or impurities. Approximate expressions are developed for the high- and low-temperature limits. The general results are applied to specific calculations of the mean-square velocity for atoms at or near a free surface. Ordinarily, the mean-square velocity turns out to be smaller for an atom at the surface than for one in the interior of the crystal. This is a consequence of the surface atom being linked to fewer neighboring atoms than is the case for an interior atom. It is concluded, however, that whether or not a crystal lattice possesses surface modes of vibration has little direct bearing on the mean-square velocity of surface atoms.

* U. S. Naval Research Laboratory, Washington, D. C.

Transistorverstärker mit Impulsanstiegszeiten von weniger als 5 ns (Transistor amplifiers with risetimes of less than 5 ns), G. Kohn, *Nachrichtentechnische Zeitschrift*, **10**, 531-536 (1962).

The principles of transformer-coupled grounded base transistor amplifiers are outlined with respect to circuits of very short risetime. Basing on direct measurement of transient response, the parameters of an appropriate equivalent circuit are derived. The influence of ideal and real coupling transformers on the transient response of a multistage amplifier is theoretically investigated and a practical transformer construction is described. In a five-stage amplifier a voltage gain of 1000 and a risetime of 3 ns has been achieved. In a high-current driver the output current of 400 ma flowing into a 5Ω load has a risetime of 4 ns and a maximum repetition rate of 20 mc/s. The first circuit has been used as a sense amplifier, the second one as a word driver in thin magnetic film memory models.

Trends in Dielectric Research During 1961, Ann M. Parks, *1961 Digest of Literature on Dielectrics*, **25**, (Publication #1034), 1-5 (1962).

The results of some of the more significant research in the field of dielectrics and insulating materials published during 1961 are briefly described as well as the trends which indicate the areas in which future work will be directed. The more important applications of new and/or well known insulating materials for improved "in service" performance are also mentioned.

Uncountably Many Nonisomorphic Nilpotent Lie Algebras,* Chong-Yun Chao, *Proceedings of the American Mathematics Society*, **13**, No. 6, 903-906 (December, 1962).

The purpose of the paper is to prove the following: *Theorem 1*. There exist uncountably many nonisomorphic nil-

potent real Lie algebras for any given dimension $N \geq 10$. *Theorem 2*. There exist uncountably many nonisomorphic solvable not nilpotent real Lie algebras for any given dimension $M \geq 11$.

* Work performed at the University of Michigan.

Vapor Phase Equilibria for the Systems: GaAs-Ga_{1-x}As_x and Ga-Ga_{1-x}As_x, V. J. Silvestri and V. J. Lyons, *Journal of the Electrochemical Society*, **109**, No. 10, 963-968 (October, 1962).

Analysis of pressure measurements has led to the determination of the vapor species resulting from the reaction of GaAs with I. The reaction determined from the analysis is $2\text{GaAs}(s) + \text{GaI}_3(v) \rightleftharpoons 3\text{GaI}(v) + \frac{1}{2}\text{As}_2(v)$ in the range 560° to 850°C. The equilibrium constant is given by the equation $\log K_p = -23,650/T + 19.4$. The enthalpy calculated for the reaction is 54.1 kcal/mole of GaAs. A similar analysis for the system Ga-Ga_{1-x}As_x resulted in the determination of the reaction $2\text{Ga}(l) + \text{GaI}_3 \rightleftharpoons 3\text{GaI}(v)$ in the range 420° to 650°C. The equilibrium constant for this reaction is given by $\log K_p = 11,000/T + 12.4$. The enthalpy for the reaction is 25.2 kcal/mole of Ga. By combining the two equilibria in the region of overlapping temperatures, the arsenic pressures in equilibrium with GaAs along the three-phase line are obtained. In the range 560° to 640°C the predominant reaction is $\text{GaAs}(s) \rightleftharpoons \text{Ga}(l) + \frac{1}{2}\text{As}_2(v)$. The enthalpy calculated for this reaction is 44.4 kcal/mole of GaAs. The dissociation pressures are in good agreement with extrapolations from two previous measurements made at higher temperatures.

Vibrations of an Infinite, Monoclinic Crystal Plate at High Frequencies and Long Wavelengths,* R. K. Kaul and R. D. Mindlin,** *Journal of Acoustical Society of America*, **34**, 1895-1901 (December, 1962).

An asymptotic solution of the frequency equation of an infinite, monoclinic crystal plate is derived. Formulas are given which describe the variation of frequency with wavelength at high frequencies and long wavelengths.

* Work performed at Columbia University.

** Department of Civil Engineering, Columbia University, New York, N. Y.

Viscosity and Boundary Effects in the Dynamic Behavior of Hydraulic Systems, Hirsh Cohen and Yih-O Tu, *Journal of Basic Engineering*, **84**, No. 4, 593-601 (December, 1962).

The use of hydraulic mechanisms in low-energy transfer and information-transmittal devices requires a working understanding of dynamic hydraulic behavior. In this paper the effects of fluid viscosity and wall interference on wave motion in a simple hydraulic device are considered. It is shown that, for the applications considered, these phenomena may be treated by boundary-layer methods. Calculations are carried out to show their effect on piston displacement, and these effects are compared with the behavior when viscosity is not taken into account.

Wear, Friction, and Electrical Noise Phenomena in Severe Sliding Systems, Morton Antler, *ASLE Transactions*, **5**, No. 2, 297-307, (November, 1962).

The sliding mechanisms of unlubricated gold and palladium are described. Transfer, roughening, wear, friction, and con-

tact resistance phenomena involve the same discrete events. With rider-flat geometry, severely worked transfer particles form a prow-shaped wedge which adheres to the smaller member. Even when rider and flat are different, prow material comes from the larger part. Loss of prow occurs by adhesive weld-back transfer and, to form loose debris, by shearing or fatigue fracture. Friction rises in the early stages of sliding as prows grow. Soon, back transfer increases hardness of the larger member and friction falls to an equilibrium level. Friction also falls when prows are kneaded into rollers and become loose debris. During these stages, wear rate diminishes. Contact resistance noise originates in stick-slip, roller formation, surface hardening, and changing composition at the sliding interface when dissimilar contact metals are involved.

* Work performed at Shell Development Company (A Division of Shell Oil Company), Exploration and Production Research Division, Houston, Texas.

Letters to the Editor

Optical Properties of Thin Adsorbed Films on Metal Surfaces Undergoing Stress, W. T. Pimbley, *Journal of the Optical Society of America*, **52**, No. 12, 1410-1411 (December, 1962).

Measurement of Effective Susceptibility of Magnetic Inks, H. J. Kump, *Proceedings of the IRE*, **50**, No. 12, 2502 (December, 1962).

Ionic Selectivity of Hydrolyzed Polyethylene Terephthalate, G. D. Fatzer, *Journal of Applied Polymer Science*, **6**, No. 23, S37 (September-October, 1962).

Systematic Matrix Inversion by Signal-Flow Graph, J. P. Jacob, *Proceedings of the IRE*, **50**, 2511-2512 (December, 1962).

High Voltage Vacuum Leadthrough, W. E. Bron, R. Mannheimer, and G. E. Taylor, *The Review of Scientific Instruments*, **33**, 1287 (November, 1962).

Impurity Incorporation into CdSe and Equilibria in the System CdSe-CdCl₂, A. Reisman and M. Berkenblit, *Journal of the Electrochemical Society*, **109**, No. 11, 1111-1113 (November, 1962).

Internal Conversion in the Photochemistry of Di- and Triolefins, R. Srinivasan, *Journal of the American Chemical Society*, **84**, No. 20, 3982-83 (October 20, 1962).

Variation-Perturbation Approach to the Interaction of Radiation with Matter, M. Karplus, *Journal of Chemistry and Physics*, **37**, No. 11, 2723-2724 (December 1, 1962).