

IBM Technical Papers Published Recently in Other Journals

An Abstract Mathematical Basis for Network Analysis and Its Significance in Physics and Engineering, F. H. Branin, Jr., *The Matrix and Tensor Quarterly*, 12, No. 2, 31-49 (December, 1961).

This report emphasizes the theoretical importance of the network concept and its practical value in computing solutions to a wide variety of physical problems. The abstract mathematical characteristics of the network problem are delineated in order to establish exact ground rules for setting up network models. An indication of the fundamental nature of the network concept is given in the form of a correspondence between the algebraic structure of the network problem and the operational structure of the vector calculus. This correspondence is shown to justify the existence of network representations for an important class of the partial differential equations of theoretical physics.

Anisotropy of the Hyperfine Interaction in Magnetite, E. L. Boyd and J. C. Slonczewski, *Journal of Applied Physics* (Supplement), 33, No. 3, 1077-1078 (March, 1962).

This paper describes effects of anisotropy of the hyperfine interaction on nuclear magnetic resonance in a ferromagnetic or ferrimagnetic material. It is shown how the line shape in a polycrystalline sample depends on whether the excitation is through domains or domain walls. The absorption spectrum of Fe^{57} in powdered magnetite (Fe_3O_4) is observed, and the results show that, in this case, the excitation is predominantly through domains. They also establish a value for the hyperfine anisotropy on octahedral sites.

Approximate Solution of the Equations of Magnetization Reversal by Coherent Rotation,* R. F. Elfant and F. S. Friedlaender,** *Journal of Applied Physics*, (Supplement), 33, 1071-1072 (March, 1962).

A complete solution of the modified Landau-Lifshitz equation of magnetization reversal by coherent rotation is presented for $\alpha^2 \gg H_a/4\pi M_s$, where α is the phenomenological damping constant, H_a is the applied field, and M_s is the saturation magnetization. This solution extends previous work in that it is valid for $t \geq 0$, whereas, other solutions have not been valid over this entire range. In addition, from this solution the time dependence of the demagnetizing field is found.

* Work performed at Purdue University.

** Purdue University.

Automatic Diode Tester Provides Permanent Record, J. Dickerson, *Electrical Design News*, 7, No. 5, 64-71 (May, 1962).

This report describes a diode tester that can automatically perform five tests on a diode. The results of each test can be read in terms of voltage on a digital voltmeter. If the voltmeter

is used in conjunction with an IBM typewriter or modified IBM 026 card punch, the test results can then become a permanent record for future use.

Eine Bandleitung zur Untersuchung von steilen Impulsen* (A strip line for nanosecond pulse investigations), D. Seitzer, *Frequenz*, Band 16, Nr. 4, 125-130 (April, 1962).

A triplate strip line results as a line type with which the influence of inhomogeneities on the pulse shape can be investigated. Its characteristic impedance is defined independently of the environment and it can be varied by simple means within wide limits. The attenuation can be neglected.

An approximate analysis establishes the relationship between the dimensions of the line and its characteristic impedance. An orienting measurement verifies this relationship and gives, simultaneously, guiding points for the influence of the transitions to the coaxial terminals with which the strip line is fitted at beginning and end. An accurate measurement reveals for the transitions a reflection coefficient $< 1\%$ up to the highest measuring frequency of 2.700 Mc/s and allows a reduction of the error of the characteristic impedance of the homogeneous strip line to less than 0.5%.

The homogeneous strip line including the transitions thus transfers without distortion the measuring pulses with rise times of nanoseconds. A comparison with the pulses sent over the line fitted with well-defined inhomogeneities gives the relationships shown in earlier papers.

* Work performed at Institute of Communication Technology, Stuttgart, Germany.

Bibliography of Thin Magnetic Films, H. Chang and G. C. Feth, *AIEE Summer General Meeting*, Conference Paper No. CP 62-1068 (June 17-22, 1962).

A collection of 450 articles on thin magnetic films, including such variants as twistors and cylindrical films, are grouped according to year of publication and are ordered alphabetically according to the author's name. Some 60 patents from the U.S.A. and some foreign countries are listed in numerical sequence by country. To facilitate search for related articles, each entry is indexed to identify its category: 1) preparation and physical properties, 2) static magnetization properties, 3) dynamic magnetization properties, 4) measurements, 5) visual observations, 6) devices and circuits and 7) miscellaneous. Also included is a perspective, sketching the historical development, the present status and the future trend.

Brightness Discriminations with Constant Duration Intermittent Flashes, Robert L. Erdmann, *Journal of Experimental Psychology*, 63, 353-360 (April, 1962).

This study was performed to determine the probability of detection of constant duration intermittent flashes as a function

of flash frequency, with flash luminance and background luminance as parameters.

The subjects were adapted to a $14^{\circ}30'$ field of constant luminance and presented with a 1° test flash train in the center of the field. The duration of the stimulus train of flashes was one second. Twenty observations were gathered on two practiced subjects for each of nine frequencies ranging from 1 to 20 flashes per second.

The results indicate: (1) increasing flash luminance increases the probability of detection for every condition, (2) for the condition of low background luminance, probability of detection increases as flash frequency increases, and (3) for the higher background luminances, the initial increase in probability of detection is followed by a systematic decrease at frequencies of 15 and 20 flashes per second.

The increase in the number of chances for flash detection with increasing flash frequency may account for the initial increase in probability of detection that occurs for all luminance values.

The decreases in detection probability for the higher flash frequencies at the higher background luminance levels can possibly be attributed to a period of diminished sensitivity that is dependent upon the time interval between flashes. The failure to observe this effect at the lowest background luminance can possibly be attributed to a difference in critical duration.

Carrier Characteristics in Copper-Doped WO_3 from Conductivity, Hall Voltage, and Thermal Emf Studies,* M. J. Sienko** and P. F. Weller,† *Inorganic Chemistry*, 1, No. 2, 324-331 (May, 1962).

Single crystals of $\text{Cu}_{0.076}\text{WO}_3$, $\text{Cu}_{0.094}\text{WO}_3$, and $\text{Cu}_{0.95}\text{WO}_{3+\delta}$ have been prepared by thermal decomposition of CuWO_4 and WO_3 . Potential-probe resistivity measurements in the range 120 to 770°K indicate complex semiconducting behavior. $\text{Cu}_{0.094}\text{WO}_3$, which is orthorhombic, shows three linear segments in the $\log \rho$ vs $1/T$ dependence, the apparent activation energies being 0.05 eV below 170°K, 0.4 eV between 170 and 220°K, and 0.45 eV above 500°K. Between 220 and 500°K, behavior is "metallic". $\text{Cu}_{0.95}\text{WO}_{3+\delta}$, which is triclinic, shows no metallic region but has two linear segments with activation energy 0.10 eV below 700°K and 0.15 eV above. Measurements of the Hall voltage and of the thermoelectric power indicate that carriers are electrons. At 300°K, representative carrier densities are 5×10^{18} , 15×10^{18} , and 1×10^{18} electrons/cc with mobilities 6, 10, and 0.4 $\text{cm}^2/\text{V}\cdot\text{sec}$. for $\text{Cu}_{0.076}\text{WO}_3$, $\text{Cu}_{0.094}\text{WO}_3$, and $\text{Cu}_{0.95}\text{WO}_{3+\delta}$, respectively. Thermal emf values fall in the range -220 to -300 $\mu\text{V}/\text{deg}$. Results are interpreted in terms of a conduction band model with destruction of the band below room temperature due to a probable ferroelectric transition in the host lattice. Excess oxygen acceptor centers of appreciable ionization energy apparently are present in small concentration in the low-copper materials and in large concentration in the high-copper material.

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† Work was done while the second author was at Baker Laboratory of Chemistry.

Circuit Protection for a Transistorized Magnetic Core Memory, W. A. Christopherson, *Electronic Engineering*, 34, 234-237 (April, 1962).

The circuit protection system described in this article will protect a magnetic core memory against fault currents as low as 40 ma even though the normal memory current during operation is some 4 to 5 amp. The over-current protection system can be combined with a temperature-compensating voltage regulator to provide over-voltage protection to the memory circuits.

Compound Repetition in Oxide-Oxide Interactions: The System $\text{Li}_2\text{O}\cdot\text{V}_2\text{O}_5$, A. Reisman and J. Mineo, *Journal of Physical Chemistry*, 66, 1181-1185 (June, 1962).

Previous work on compound repetition in oxide-oxide interactions has been extended with studies of the system $\text{Li}_2\text{O}\cdot\text{V}_2\text{O}_5$. It has been found that crystallization from the melt occurs metastably in the high vanadium pentoxide portions of the system with the resultant exclusion of a stable phase, $2\text{Na}_2\text{O}\cdot17\text{V}_2\text{O}_5$, which melts incongruently at 621°. The phase $2\text{Na}_2\text{O}\cdot5\text{V}_2\text{O}_5$ has been found to melt congruently at 603° in the metastable equilibria and incongruently at 601° in the stable solid-liquid equilibria. A compound having the composition $\text{Na}_2\text{O}\cdot\text{V}_2\text{O}_5$ melts incongruently at 616°, while another compound having the composition $3\text{Na}_2\text{O}\cdot\text{V}_2\text{O}_5$ melts congruently at 1152°. This phase exhibits three crystallographic inversions, at 724, 773, and 1152°. The results of the present work are compared with other reported data on the system $\text{Li}_2\text{O}\cdot\text{V}_2\text{O}_5$ and are used as a basis for prediction of compound repetition in the system $\text{Na}_2\text{O}\cdot\text{V}_2\text{O}_5$.

A Computer Application to Reliable Circuit Design, L. Hellerman, *IRE Transactions on Reliability and Quality Control*, RQC-11, No. 1, 9-18 (May, 1962).

The problem of reliable electronic circuit design by statistical methods is described. After a brief historical account of this problem, we give the principle of one successful method—Monte Carlo. Two implementations of this method, as digital-computer programs, are given. The first program analyzes the reliability of a given circuit. The second program picks component values to optimize the circuit behavior with respect to several performance aspects. Examples illustrating the nature of the input and output information are included.

Computers and Engineers: Full Partners in Design, W. D. Bolton, *Steel*, 150, 88-92 (April 23, 1962).

This article, directed to a general engineering audience, shows how the modern digital computer can become a powerful tool for the engineer. Examples and applications from design and development engineering are given. Iterative problems, cam design, simulation, design automation, and planning and scheduling are discussed, with specific references being made to the San Jose General Products Division Development Laboratory.

On a Conjecture of Fomin, R. L. Adler, *Proceedings of American Mathematical Society*, 13, No. 3, 443-436 (June, 1962).

One of the central problems in ergodic theory is the complete classification of measure-preserving transformations. Several invariants have been investigated and the search for a complete set is one of the major areas of current research. It has long been known that spectral properties are insufficient to distinguish different transformations in general. Recently Kolmogoroff suggested a new invariant called entropy, derived from information theory, which has served as a powerful tool in settling some questions that went unsolved for twenty years. The conjecture arises as to whether spectral invariants along with entropy form a complete set in the classification of measure-preserving transformations. The purpose of this present paper is to present a counter example.

The Contribution of Rare-Earth Ions to the Anisotropy of Iron Garnets, B. A. Calhoun, M. J. Freiser, and R. F. Penoyer, *Journal of Applied Physics* (Supplement), 33, 1259-1260 (March, 1962).

The low-temperature properties, in iron garnets, of rare-earth ions with an odd number of electrons can be described by a

simple model. This model represents the energy levels of the rare-earth ion by an isolated doublet which is subjected to an anisotropic exchange interaction. The complex shapes of the torque curves, predicted by the model and observed at low temperature, are represented by Fourier expansions. A small torque contribution proportional to the applied magnetic field is predicted and evidence of its existence is observed in (YbY) and (YbGd) iron garnets. A comparison of the behavior of Yb and Dy in YIG and GdIG indicates a moderate influence of the host lattice on Yb and a drastic influence on Dy. The anisotropy anomaly observed for Yb in YIG [at 32° from [001] in the (110) plane] is not present when Yb is substituted into GdIG.

Control of Deposition Rate and Film Thickness with the Crystal Oscilloscope, K. H. Behrndt* and R. Love, *Vacuum*, 12, No. 1, 1-9 (January/February, 1962).

A device has been designed and built to measure the film thickness during evaporation and to control the rate of deposition. Vibrating quartz crystals are employed as sensitive elements. After discussing sensitivity and possible errors of the crystals, the principle of operation is described. The experimental results show that the total deposition rate can be maintained constant within $\pm 1\%$, while larger variations of the rates of the components may occur over short periods of time. Presently the chemical composition can be predicted to $\pm 0.5\%$.

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Critical Concentrations in Magnetism, S. H. Charap, *Physical Review*, 126, 1393-1394 (May, 1962).

In the application of the Bethe-Peierls-Weiss method to dilute magnetism, Smart has exaggerated the interaction between a cluster and its surroundings by retaining the uniform molecular field. The calculation is improved by allowing the molecular field to vary from site to site on the first shell of the cluster, thereby taking into account the fact that this interaction is sensitive to the relative location of magnetic atoms in the first shell of the cluster and in the surrounding layer. For the three-dimensional lattices treated, the critical concentration is very nearly $2/z$, where z is the coordination number of the lattice.

Critical Field Measurements of Thin Superconducting Sn Films, R. H. Blumberg, *Journal of Applied Physics*, 33, No. 5, 1822-1826 (May, 1962).

Sn films varying in thickness from 200 to 4500 Å have been prepared by vacuum deposition. The surface roughness has been held to a minimum and the grain size restricted to approximately 1000 Å by cooling the substrate to 80°K and depositing the film at an evaporation rate of 100 Å per sec. The film purities have been calculated from residual resistance data. The mean free paths are in the range of 1000 to 5000 Å. Critical fields for films in this thickness and purity range are reported. The London and Ginzburg-Landau models have been used to calculate from experiment the penetration depth, which has been found to be in general agreement with Ittner's effective penetration depth concept. The temperature dependence of the penetration depth lies between the two temperature-dependence predictions of the Bardeen, Cooper, Schrieffer (BCS) theory.

Current Voltage Characteristics of Germanium Tunnel Diodes, Mr. I. Nathan, *Journal of Applied Physics*, 33, No. 4, 1460-1469 (April, 1962).

The current-voltage characteristics of germanium tunnel diodes with phonon-assisted current predominant is found to be in agreement with that obtained from high-pressure experiments.

The value of the pre-exponential factor obtained from both experiments is much larger than predicted by theory. Calculations of the tunnelling current which take into account non-parabolic effects of the energy band structure and the electric field variation with position in the junction are presented and compared with experiment. The results of current-voltage measurements on germanium diodes with non-phonon current predominant are also presented and discussed.

Data Processing and Information Transmission for Space, E. L. Gruenberg, *Proceedings of the IRE*, 50, No. 5, 1351-1361 (May, 1962).

This paper reviews and predicts the roles that data processing and information transmission have played, and will play, in space. The trend toward digital transmission is shown to be a result of increasing requirements for precision, reliability, high information rates, and long paths. Thus, data processing and transmission techniques appear to be converging rapidly, both because of the advantages of digital communication systems and because of the predicted weight and volume reductions for computer equipment. Many improvements in transmission efficiency will result from this merging of techniques, notably in the areas of data compaction and computer-controlled adaptive communications.

The Design of a High-Speed Thin Magnetic Film Memory, W. E. Proebster, *Digest of Technical Papers*, V, 38-39 (February, 1962).

The design of a high-speed thin magnetic film memory with a capacity of 18,432 bits is outlined. The technology of evaporating magnetic films onto silver substrates, of etching the bit pattern and the wiring array is discussed as well as the properties of the associated high-speed nanosecond circuitry. Initial experimental results indicate that a cycle time of 100 ns is possible with an access time of 60 ns.

The Design of a Simple Direct-Stress Fatigue Machine for Cumulative Damage Studies, G. W. Brock and R. F. Braune, *Materials Research and Standards*, 2, No. 5, 401-402 (May, 1962).

A fatigue machine for the study of cumulative damage and complex force-time impulses is described. The machine is particularly suited for tension-tension impulses of stress using tape specimens where the maximum loads are of the order of 150 lbs.

Development in High-Speed Switching Elements, A. W. Lo, *Proceedings of the IRE*, 50, No. 5, 1067-1072 (May, 1962).

Recent developments in high-speed switching elements are outlined to indicate the trend of recent work and thoughts on physical implementation of high-speed digital data processing systems. Four outstanding switching elements (thin film cryotron, high-speed transistor, microwave parametric phase-locked oscillator, and tunnel diode) as well as some related circuit and fabrication techniques, are briefly described and discussed.

The transistor remains the predominant switching element for these systems. Other technologies are presenting an ever increasing challenge to the transistor in this area.

Dislocation Damping in Copper After Low Temperature Plastic Deformation, L. J. Bruner and B. M. Meeks, *Acta Metallurgica*, 10, 494-495 (April, 1962).

An investigation of the dislocation relaxation or Bordoni peaks in plastically deformed copper has been carried out under

experimental conditions which permit deformation of specimens at liquid helium temperature and measurement of their internal friction upon subsequent warmup.

We have observed: 1) After plastic deformation at 4.2°K two internal friction peaks of comparable height are resolved, one at 24°K and another at 53°K; 2) After annealing at room temperature, the 24°K peak is reduced in amplitude while the higher temperature peak grows and its maximum is shifted to 64°K; 3) Annealing at room temperature increases overall relaxation strength in the temperature range by about 30%.

The work of Seeger and others indicates that these relaxation peaks can be explained in terms of intrinsic dislocation properties. Efforts have been made to assign various portions of the relaxation spectrum to specific dislocation configurations. Our results, interpreted in these terms, suggest that both a significant redistribution and an overall enhancement of dislocation configurations favorable for relaxation can occur upon room temperature annealing after plastic deformation at low temperature. If, on the other hand, the interaction of point defects with dislocations plays a significant role in the relaxation process, our results might be explicable in terms of their migration to and redistributions near dislocations.

Domänenwandkriechen in dünnen Ni-Fe-Schichten (Domain wall creeping in thin Ni-Fe-Films), S. Middelhoek, *Zeitschrift für angewandte Physik*, Band 14, Heft 4, 191-193 (April, 1962).

When a dc field is applied in the easy direction, which is smaller than the critical field for wall motion in this direction, and an additional ac field is applied in the hard direction, it can be observed that the walls start to creep. The velocity of the walls sensitively depends not only on the amplitude of the ac field in the hard direction, but also on the magnitude of the dc field in the easy direction.

In combination with the Bitter technique, the effect is also of importance as it facilitates the investigation of continuous changes of the domain structures.

The Effect of Zone Purification on the Transition Temperature of Polycrystalline Tungsten,* J. L. Orehtsky and R. Steinitz,** *Transactions of the Metallurgical Society of AIME*, 224, 556-560 (June, 1962).

An analysis was made of the influence of floating molten zone traversal on the purification of tungsten rods and the effect of this purification on the brittle-to-ductile transition temperature. The major impurities detectable in the original rods, i.e., molybdenum and oxygen, were reduced by zone refining from 30 to 3 ppm. Changes in the trace amounts of other impurities could not be quantitatively determined since they were below the limit of detection. Tensile tests on 3-mil wires, drawn from these rods and recrystallized to 17,000 grains per mm², showed a transition temperature of 60°C for the zone purified and 175°C for the original material.

* Work performed at General Telephone and Electronics Laboratories, Inc., Bayside, New York.

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Effects of Pattern of Reinforcement and Verbal Information on Acquisition, Extinction, and Spontaneous Recovery of the Eyelid CR,* Thomas F. Hartman and David A. Grant,** *Journal of Experimental Psychology*, 63, 217-226, (March, 1962).

The effects of 100% reinforcement, (Group 100%) 50% random reinforcement, (Group R) double-alternation reinforcement (Group DA), and double-alternation reinforcement with a

trial counter (Group DAC) upon the acquisition, extinction, and spontaneous recovery of the conditioned eyelid response were studied. In addition, the effects of telling S at the beginning of extinction or spontaneous recovery that the air puff would no longer be presented were observed. In Group DA, neither the nonvoluntary nor voluntary Ss responded significantly more to the reinforced than to the nonreinforced trials; however, in Group DAC, the voluntary Ss responded significantly more to the reinforced trials. Knowledge of cessation of the UCS produced a significant decrement of response during the first five extinction trials with both nonvoluntary and voluntary Ss. The voluntary Ss did not show immediate extinction when told the air puff would be omitted. Voluntary Ss, therefore, showed two contradictory aspects in their responding. They were able to respond significantly more to the reinforced trials in Group DAC, but they were not able to utilize knowledge of the cessation of the UCS during extinction to respond appropriately.

* Work performed at University of Wisconsin.

** University of Wisconsin.

Electrochromism (Stark Effect) in Solids Due to Isolated Absorbing Centers, J. Kumamoto, J. C. Powers, Jr., and W. R. Heller, *Journal of Chemical Physics*, 36, 2893-2896, (June, 1962).

A study has been made of the effect of applied electric fields upon the absorption spectrum of a dye molecule (methyl red) dissolved in a relatively inert, transparent, matrix of high dielectric strength (polystyrene). Theory indicated that the existence of a large dipole moment in either ground or excited state (or in both, if the moment differs in the two states) should lead to a broadening of the absorption band. In contrast, the existence of excited states of appropriate type lying close to that involved in the transition should produce a shift to the red. In the present instance the second shift dominates, and one observes, with a field of about one million volts/cm, a shift of around ten angstroms of the principal band which is centered near 5000 angstroms. Possible uses of this technique are in evaluating the local field at an absorbing molecule and in estimating dipole moments of various states.

Die Erzeugung von Bewegungen mit mehreren Rasten mit Hilfe des fünf gelenkigen Zweikurbelgetriebes (Generation of Multi-Dwell Motion from Double Crank Five-Bar Linkage), D. C. Tao, *Das Industrieblatt*, 74 (February, 1962).

The double crank five-bar linkage is capable of generating more complex coupler curves than the four-bar linkage. While laying the foundation for the symmetrical versions of the five-bar linkage, the coupler curves generated by the middle joint of the five-bar linkage are also reviewed. These coupler curves are expressed in numerical codes which determine the proportions of the length of the various links. Examples are shown, pointing out the possibilities of applications using these coupler curves to generate three, four or more dwell motions.

Evaporation of Helium I Due to Current-Carrying Leads, Harold Sobol* and James J. McNichol, *The Review of Scientific Instruments*, 33, 473-477 (April, 1962).

The heat introduced into a cryogenic system by current-carrying leads has been investigated experimentally and theoretically. The experimental work consisted of measuring the heat conducted by various cables and wires into a helium Dewar. The experimental results show that the use of long coaxial cables to the helium bath minimizes boil-off and also that there

are optimum wire sizes for the current ranges 0-0.5 amp (#38 AWG) and 0.5-1.0 amp (#34 AWG). The theoretical analysis of the heat input takes into account the varying electrical and thermal conductivities of the leads and also allows for heat exchange with the effluent helium vapor. The results of this analysis indicate the importance of including gas cooling in predicting the boil-off rate.

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The Evolution of Computing Machines and Systems, R. Serrell,* M. M. Astrahan, G. W. Patterson,** and I. B. Pyne,† *Proceedings of the IRE*, **50**, 1039-1058 (May, 1962).

The development of digital computing machines is described and illustrated, from the mechanical devices of the seventeenth century to the electronic systems of today, in three chronological sets of sketches. Only a few typical modern systems are treated and not all early machines are discussed. A bibliography is appended.

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Experimental Verification of Field Ionization of Traps in Luminescent Materials, D. E. Brodie,* H. E. Petch,** and R. R. Haering, *Canadian Journal of Physics*, **40**, 665-669 (May, 1962).

Trapping states in phosphors may be emptied by the application of an electric field. A phosphor, which is held at very low temperatures ($T < 30^\circ\text{K}$) throughout the experiment, is excited optically. An electric field increasing linearly with time is then applied across the phosphor, and the light emission is measured. A curve of the intensity of light emission versus electric field shows peaks similar to those in glow curves and one may obtain the trap energies from these data. Experiments of this type have been performed by Mattler and Curie (1950), by Boer, Kümmel, and Rompe (1952), and by Boer and Kümmel (1954) but they were carried out at moderately high temperatures ($\sim 120^\circ\text{K}$) where the probability of thermal ejection still exceeds the probability of field ionization for a typical trap. We have studied the applicability of this method of measuring trap energies under conditions such that true field-stimulated maxima may be expected.

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Formänderung von steilen Impulsen durch Mehrfach-reflexionen entlang einer Leitung* (Distortion of nanosecond pulses by a sequence of reflections along an inhomogeneous line), D. Seitzer, *Archiv der Elektrischen Uebertragung*, Band **16**, Heft 6, 263-270 (June, 1962).

An investigation is made on how a sequence of irregularity points acts on the shape of a passing step wave, if their characteristic impedances and relative positions along a homogeneous line are known. The reflected and broken voltage components generated at the points where the characteristic impedance changes can be presented in a matrix from which further contributions that appear at a later time can be determined by multiplication with another matrix that describes the inhomogeneous line. In this form the method is suitable for programming on a digital computer. A number of typical applications are so calculated.

The buildup transient of a sequence of irregularity points consists of two contributions. One equals that of a multistage

RC-amplifier of unity gain and different cut-off frequencies of the individual stages. Its differential quotient is always positive. The other contribution comes about by interaction between the individual irregularity points and gives rise to an oscillating voltage pattern. With the inhomogeneities encountered in practice the first contribution, which causes flattening of the rise, is less disturbing than the interaction component which causes oscillations on the pulse top.

As a practical example the deformation of a step voltage is calculated which passes a mercury switching ampoule that is built in a 60-ohm coaxial line.

* Work performed at Institute of Communication Technology, Stuttgart, Germany.

Fundamental Aspects of Establishing a Skills Inventory, S. M. Bailes, *Personnel Journal*, **41**, No. 5, 226-230 (May, 1962).

Management is often forced to make decisions based on incomplete, inaccurate, non-objective or even obsolete data. Through use of modern data processing and information retrieval techniques, personnel management, at least, has reduced the problem through the establishment of Skills Inventory Systems. These systems can provide almost instantaneous information for optimum utilization of manpower resources. Regardless, however, of the varying degrees of sophistication the systems achieve, certain underlying principles should be basic to them all. It is to this end that this paper is directed.

General One-Center, Two-Electron Integrals for Laguerre Functions,* J. C. Browne** and James Miller, *Journal of Chemical Physics*, **36**, 2324-5 (May, 1962).

Calculation of the total electronic energy of atoms or molecules involves the evaluation of certain difficult integrals to obtain the repulsion energy between each pair of electrons. These integrals have the form

$$[p, q | r, s] \iint \psi_{n_p, 1, p, m_p}(r_1) \psi_{n_q, 1, q, m_q}(r_1) (1/r_{12}) \psi_{n_r, 1, r, m_r}(r_2) \psi_{n_s, 1, s, m_s}(r_2) d\tau_1 d\tau_2,$$

where r_{12} is the distance between electrons 1 and 2 and r_1 indicates the distance of electron 1 from the coordinate system center and similarly r_2 refers to electron 2.

This paper gives a general formula for this integral where the one electron functions have the form

$$\psi_{n, 1, m}(r) = \frac{(2\beta)^{3/2}}{(n+1+1)!} \frac{[(n-1-1)!]^{1/2}}{[(n+1+1)!]} (2\beta r)^{1+2} L_{n+1+1}^{2+2}(2\beta r) \exp(-\beta r) Y_1^m(\theta, \phi),$$

where

$L_{n+1+1}^{2+2}(2\beta r)$ is an unnormalized associated Laguerre polynomial

and

$Y_1^m(\theta, \phi)$ is a spherical harmonic.

* This work was done at the University of Texas.

** University of Texas.

General Ray-Tracing Procedure,* G. H. Spencer** and M. V. R. K. Murty,† *Journal of the Optical Society of America*, **52**, 672-678 (June, 1962).

Computing formulae are presented for tracing skew rays through optical systems containing cylindrical and toric

surfaces of arbitrary orientation and position. Particular attention is given to the treatment of diffraction gratings, and a vector form of the diffraction law is suggested.

* This work was partly supported by the National Aeronautics and Space Administration under a contract with the University of Rochester.

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Inversion-Vibration and Inversion-Rotation Interactions in the Ammonia Molecule,* W. T. Weeks, K. T. Hech,** and D. M. Dennison,** *Journal of Molecular Spectroscopy*, **8**, No. 1, 30-57 (January, 1962).

An attempt has been made to extend the theory of ammonia inversion to account for the dependence of the inversion splitting on the full set of vibrational and rotational quantum numbers. The potential energy of ammonia is approximated by a double minimum potential $V(\zeta)$ plus the potential of a system of harmonic oscillators in the remaining five vibrational coordinates. $V(\zeta)$ has been chosen to have the form $V(\zeta) = -2F \cos(\zeta/L) + 2G \cos(2\zeta/L)$ in which ζ is an inversion coordinate and L a constant, ($|\zeta| + \pi L$). The double minimum wave functions are computed numerically. Inversion-vibration interactions are obtained by developing the parameters F and G , which are regarded as mild functions of the five vibrational coordinates, in a Taylor expansion in the vibrational coordinates. With the exception of the state $2\nu_4^0$ this potential accounts for the dependence of the inversion splittings on the vibrational quantum numbers of the two doubly degenerate modes ν_4 (eleven experimental data are fitted with four empirical interaction constants). However, the potential fails to describe completely the interaction between the inversion coordinate and the remaining nondegenerate vibrational coordinate associated with ν_1 . Since the task of diagonalizing the complete rotation-inversion Hamiltonian is complicated by the presence of several resonances, the rotation-inversion constants $B^- - B^+$ and $C^- - C^+$ are calculated only from the lowest order vibration-rotation-inversion Hamiltonian. The calculated constants for the pure inversion states $n_2 = 0, 1, 2$, and 3 and the states $n_2 = 1$ in combination with the remaining vibrational modes agree surprisingly well with the experimentally observed values.

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Ionic Conductivity of Doped NaCl Crystals, R. W. Dreyfus and A. S. Nowick, *The Physical Review*, **126**, 1367-1377 (May, 1962).

A detailed study is made of the "conductivity plot" ($\log \sigma T$ vs. T^{-1}) for the dc conductivity, σ , of NaCl crystals doped with various divalent cation impurities. This plot, when examined over a range from the melting point down to -35°C , divides itself into a number of distinct regions. Below the intrinsic range is the region in which the cation-vacancy concentration is equal to the impurity concentration. Below this range the plot steepens because of vacancy-impurity association, after which it again steepens (for slowly cooled samples) due to impurity precipitation. At still lower temperatures, (below about 100°C), the plot returns to a slope characteristic of the association reaction. Finally, by "quenching" a sample to -60°C (at $30^\circ\text{C}/\text{min}$), the association reaction may be frozen and an abnormally high conductivity observed below 0°C . From an analysis of the data for quenched samples, a value for the activation energy for motion of a cation vacancy in NaCl, or $0.79_6 \pm 0.02$ ev, is obtained. The isothermal annealing of the quenched-in vacancies is also studied and found to obey essentially first-order kinetics, rather than the second-order kinetics characteristic of direct recombination.

Low Temperature Anisotropy of Manganese-Iron Ferrites, W. Palmer, *Journal of Applied Physics* (Supplement), **33**, No. 3, 1201-1202 (March, 1962).

The anisotropy of the composition system $\text{Mn}_x\text{Fe}_{3-x}\text{O}_4$, $0.40 \leq x \leq 1.80$, has been measured between 4.2° and 77°K by the torque method, supplementing previous measurements on this system by Penoyer and Shafer between 77° and 313°K . The anisotropy curves for $0.4 \leq x \leq 1.25$ show a minimum below 110°K and appear to be the summation of a number of components of different sign and different temperature dependence-negative components which decrease in magnitude relatively slowly with increasing temperature and positive components which decrease more rapidly. Over most of the composition range studied K_1 is negative at 4.2°K , but at $x = 0.80$ the magnitude of the positive, low-temperature contribution is sufficient to change the sign of K_1 from negative to positive at 34°K . In the region $x \leq 1.0$, this contribution can be attributed to the presence of Fe^{2+} ions, but such an explanation is not applicable to the positive contributions observed in compositions for which $x \geq 1.25$ and in which there is no Fe^{2+} . For $1.25 \leq x \leq 1.80$, negative values of K_1 at 4.2°K of unexpectedly large magnitude ($< -3.7 \times 10^5$ ergs/cm³) are observed. Unlike values at 77°K in this composition region, these values of K_1 are of too large a magnitude to be attributed to the splitting of the $3d$ levels of Fe^{3+} ions in a cubic crystalline field.

The Magnetic Configuration of Stylus Recording, H. J. Kump, *IRE Transactions on Electronic Computers*, EC-11, No. 2, 263-273 (April, 1962).

A cylindrical magnetic stylus driven by a coil can be used to transfer bits of information onto a magnetic surface. These bits are recorded as round spots and combinations of these spots can form a desired pattern, e.g., numbers and letters.

A mathematical model, corresponding to the magnetic properties of a recorded spot, is proposed and analyzed. The major considerations in the analysis are: the field pattern existing about the spot, the self-demagnetization of the spot, and interference resulting from crowding the spot. Field mapping obtained with a miniature Hall probe was used to experimentally verify the proposed model. The experimental results show that the analytical model can predict the magnetic configuration of the spot at distances away from the recording surface that are considerably greater than the surface thickness.

An alternate model is proposed for studying spot properties in regions quite close to the recording surface.

Magnetic Field Effects on InSb Tunnel Diodes, L. Esaki and R. R. Haering, *Journal of Applied Physics*, **33**, 2106-2109 (June, 1962).

For InSb tunnel diodes placed in a magnetic field H , the ratio of longitudinal to transverse tunnel currents yields a relative direct measurement of the tunnelling exponential, $\lambda(V)$. For a typical InSb diode we found λ_0 , the zero bias value of λ , to be 10.7 ± 0.2 , which implies an effective built-in junction field of $5.7 \pm 0.1 \times 10^4$ volt/cm. This value agrees well with the maximum and average junction fields calculated using the known doping concentrations and assuming a step junction. The pre-exponential tunneling factor is found to be $(1.8 \pm 0.4) \times 10^7$ amp/volt cm², which is about 30 times larger than Kane's theoretical result. The voltage dependence of λ is found to be expressible as $\lambda = \lambda_0[1 - V/V_0]^{-1/n}$ with $V_0 = 0.2$ ev and $n = 2.2$.

Magnetic Properties of Hydrogen Fluoride I. Rotational Moment,* T. P. Das,** and M. Karplus, *Journal of Chemical Physics*, **36**, 2275-2281 (May, 1962).

A variation-perturbation formulation is presented for the calculation of the electronic contribution to the rotational energy and magnetic moment of $a^1\Sigma$ molecule. An application of the method to a one-center single-configuration wave function for hydrogen fluoride is given and compared with a two-center function result. The calculated magnetic moment is found to be 0.9276 nuclear magnetons for the one-center function and 0.6354 nuclear magnetons for the two-center function in relatively good agreement with the experimental value of 0.7392 nuclear magnetons. Analysis of the results shows that the nuclear charges make the dominant contribution and that the electronic "slippage" is almost complete. Furthermore, the convergence of the variational expansion indicates that a significant improvement in the theoretical value can be obtained only by refinements in the ground-state wave function.

* The work reported in this paper was begun while the authors were associated with the Departments of Physics (T.P.D.) and Chemistry (M.K.) of the University of Illinois. Partial support was supplied by the National Science Foundation.

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Magnetic Properties of Hydrogen Fluoride II. Susceptibility,* R. P. Hurst,** Martin Karplus, and T. P. Das,† *Journal of Chemical Physics*, **36**, 2786-2792 (May, 1962).

A method is outlined for the calculation of the magnetic susceptibility χ from the ground-state wave function of 1Σ molecules. The diamagnetic contribution χ^d is obtained directly by first-order perturbation theory and the paramagnetic contribution χ^p is determined by a variational technique based on minimizing the second-order energy in an external magnetic field. When applied to an SCF-LCAO-MO function for hydrogen fluoride, the theoretical result is $\langle\chi\rangle_{av} = -8.74 \times 10^{-6}$ erg gauss $^{-2}$ mole $^{-1}$, in excellent agreement with the experimental value of -8.6×10^{-6} erg gauss $^{-2}$ mole $^{-1}$. The separate contributions, with respect to the fluorine as origin, are somewhat more in error, with $\langle\chi^d\rangle_{av} = -9.58 \times 10^{-6}$ erg gauss $^{-2}$ mole $^{-1}$ (exp.: -9.2×10^{-6} erg gauss $^{-2}$ mole $^{-1}$) and $\langle\chi^p\rangle_{av} = 0.855 \times 10^{-6}$ erg gauss $^{-2}$ mole $^{-1}$ (exp.: 0.609×10^{-6} erg gauss $^{-2}$ mole $^{-1}$, as obtained from the rotational magnetic moment). For the isoelectronic atoms F $^-$ and Ne (in which there is only a diamagnetic term), analytic Hartree-Fock functions yield $\langle\chi\rangle_{av}$ values equal to -12.7×10^{-6} erg gauss $^{-2}$ mole $^{-1}$ (exp.: $\sim -12 \times 10^{-6}$) and -7.48×10^{-6} (exp.: -6.7 to -7.7×10^{-6}), respectively.

By a comparison of the results obtained with different molecular wave functions for hydrogen fluoride (one-center and two-center approximations), the sensitivity of the magnetic susceptibility components (especially the paramagnetic terms) to the form of the wave function is clearly demonstrated. This suggests that χ and its components can serve as useful criteria for the accuracy of electron distributions and indicates, in particular, the need for additional refinements in the hydrogen fluoride functions. Finally, the availability of a method for the theoretical evaluation of the susceptibility tensor components suggests that additional measurements should be done to improve the experimental values.

* The work reported in this paper was begun while the authors were associated with the Department of Chemistry (R.P.H. and M.K.) and the Department of Physics (T.P.D.) of the University of Illinois. Some of the results were presented by M.K. at the Symposium on Molecular Structure, American Chemical Society, Seattle, Washington, June 1960.

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Mass Storage, A. S. Hoagland, *Proceedings of the IRE*, **50**, 1087-1092 (May, 1962).

One key to expanding the applications potential for information processing systems is the economic availability of on-line memory of extremely large capacity to permit the automatic servicing of record files. Further, mounting emphasis on management decision-making will accelerate the emergence of true file-centered systems. This paper reviews the evolution and future trends in the implicit "mass storage".

The term mass storage indicates a unit capacity ranging upward from one million characters. Such memory cannot currently be realized or projected with solid-state devices (e.g. fabricated matrices of discrete bit elements such as core arrays). Thus, continuous (and generally interchangeable) surfaces with associated coupling transducers are exploited.

The access time variability to memory locations, arising from the requisite mechanical motion, makes the structuring and organization of mass memory (software) of major significance to effective systems integration.

Areas covered include systems perspectives and memory organization, memory modularity and mass storage structure, reliability and economic considerations, magnetic recording technology, and nonmagnetic media (including image storage).

Minority Carrier Injection Characteristics of the Diffused Emitter Junction, D. P. Kennedy and P. C. Murley, *IRE Transactions on Electron Devices*, **ED-9**, No. 2, 136-142 (March, 1962).

For the double-diffused transistor, a one-dimensional analysis is presented on the minority carrier injection properties of a diffused emitter junction. This junction is bounded on one side by a reverse-biased collector and on the other by an ohmic contact of arbitrary recombination velocity. Furthermore, arbitrary magnitudes of minority carrier lifetime are assumed in both the emitter and base regions of this semiconductor device.

Injection efficiency characteristics are graphically illustrated throughout a wide range of physical and geometrical parameters. Assuming, for example, variations in the emitter junction depth, injection properties are demonstrated for transistors exhibiting a fixed collector location and also for transistors exhibiting a fixed base width. A comparison is also shown between the calculated minority carrier injection from this analysis and from other, more approximate, methods.

Eine neue Methode zur Bestimmung der ferromagnetischen Austauschkonstanten (A new method for the determination of the ferromagnetic exchange constant), S. Methfessel, S. Middelhoek, and H. Thomas, *Zeitschrift für angewandte Physik*, **Band 14**, Heft 4, 185-187 (April, 1962).

The exchange forces in a ferromagnet cause a stiffness of the magnetization since spatial gradients of the magnetization direction $\vec{\alpha}$ are associated with an exchange energy density, $E = A[(\nabla\alpha_x)^2 + (\nabla\alpha_y)^2 + (\nabla\alpha_z)^2]$.

The exchange constant A , which is important for instance in the calculation of the energy and thickness of a domain wall, is known only with poor accuracy.

In this paper, a new method for the determination of the exchange constant is described. It is based on the response of the magnetization to an inhomogeneous magnetic field, which is generated by passing a current through a thin ferromagnetic sample. The solution of this micromagnetic problem is given for the two cases of the infinite plane sheet and the circular cylinder. The response depends on the ratio of the linear dimensions of the sample (thickness of the sheet or diameter

of the cylinder, respectively) to a certain critical length, which is of the order of the classical domain wall thickness.

Experiments are carried out on thin permalloy films, and the results will be discussed.

New Concepts in Computing System Design, G. M. Amdahl, *Proceedings of the IRE*, **50**, No. 5, 1073-1077 (May, 1962).

New system concepts are discussed within the framework of market requirements and corresponding design goals. These goals are: 1) Programming and compiling aids for increased operating efficiency and flexibility, 2) Higher machine speeds for increased throughput and reduced job cost, 3) Multi-programming (time sharing) and multiprocessing (load sharing) for greater concurrent utilization of system hardware; 4) System exchanges for greater flexibility in system hardware complement and allocation.

A New Measurement of the Anomalous Magnetic Moment of the Muon, G. Charpak,* F. J. M. Farley,* R. L. Garwin, T. Muller,** J. C. Sens,* and A. Zichichi,* *Physics Letters*, **1**, No. 1, 16-20 (April, 1962).

An improved experimental value for the muon g -factor is presented: $g = 2(1 + a)$, $a = (1162 \pm 5) \times 10^{-6}$, in good agreement with the quantum-electrodynamic theoretical value. Some details are given of the experimental technique and of the statistical calculations. There is a discussion of implications of this new result on the existence of muon structure, physical cut-offs, and new fields.

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New Phenomenon in Magnetoresistance of Bismuth at Low Temperature, Leo Esaki, *Physical Review Letters*, **8**, No. 1, 4-7 (January, 1962).

In studying the transverse magnetoresistance at low temperatures in pure single-crystal bismuth at a magnetic field above several kilo-oersteds, we have found a strong non-linear conduction behavior, that is, a sharp change of slope in the current-voltage curve at a certain high electric field called the kink field E_k . The ratio E_k/B has turned out to be a constant over the wide range of the magnetic field B , and the numerical value cE_k/B is approximately 10^5 cm/sec, which seems quite comparable to the sound velocity in bismuth, where c is the light velocity. This fact may indicate that a strong electrophonon interaction (phonon emission) occurs when the drift velocity reaches this critical value. If this phonon emission once starts, the scattering time τ may drastically decrease and therefore we could see a sudden decrease in the transverse magnetoresistance.

Noise Temperature of Hot Electrons in Germanium, E. Erlbach and J. B. Gunn, *Physical Review Letters*, **8**, No. 7, 280-282 (April, 1962).

The random fluctuations in velocity of free electrons in a semiconductor give rise to electrical noise which, in analogy with Nyquist's formula for a passive resistor, can be characterized by a noise temperature T_n , where kT_n is the available noise power per unit bandwidth. This letter gives, for the first time, results of measurements of T_n for hot electrons in a solid.

A Note on Translation Invariants, R. L. Adler and A. G. Konheim, *Proceedings of the American Mathematical Society*, **13**, No. 3, 424-428 (June, 1962).

Let G be a locally compact abelian group, μ Haar measure, and $L_{1,r}(G)$ the space of μ -integrable real-valued functions on

G . For each seG , define the translation operator T_s by $(T_sf)(x) = f(sx)$ and denote $T[f]$ the set of $(\mu$ almost everywhere) translates of f . A functional $\rho(\cdot)$ with domain $L_{1,r}(G)$ will be called *translation invariant* if $\rho(f) = \rho(g)$ for all $g \in T[f]$. A class of translation invariants $P = \{\rho_\omega(\cdot) : \omega \in \Omega\}$ is *complete* if $\rho_\omega(f) = \rho_\omega(g)$ for all $\omega \in \Omega$ implies $g \in T[f]$. The k^{th} order *auto-correlation function* of $f \in L_{1,r}(G)$ is the real-valued function $\rho_k(f) \equiv \rho_k(f)(x_1, x_2, \dots, x_k)$ with domain $G^{(k)} = G \times G \times \dots \times G$ (k copies) defined by $\int_G f(\xi)f(\xi x_1)f(\xi x_2) \dots f(\xi x_k)\mu(d\xi)$. Theorem: $\{\rho_k(\cdot) : k = 1, 2, \dots\}$ is a complete set of translation invariants for $L_{1,r}(G)$.

Performance on a Five-Finger Chord Keyboard, R. Seibel, *Journal of Applied Psychology*, **46**, 165-169 (June, 1962).

Discrimination Reaction Times (DRTs) were examined for each of the 31 chords possible with a 5-finger chord keyboard. Each of 4 paid subjects showed marked improvement in performance over 4,000 to 11,000 DRTs on the 31-chord task despite extensive prior practice on subsets of the 31 chords. RDTs between 0.30 and 0.35 sec were obtained for the average of all 31 chords. Information transmitted from stimulus to keyboards was greater than 4.25 bits. In terms of average DRTs, the relative difficulties of the 31 chords were very similar for the four subjects. The per cent of error for each of the chords was highly correlated with the DRTs.

Predicting Transistor Turn-On Delay Time in the Common Emitter Configuration, R. J. Wilfinger, *Solid State Design*, **3**, No. 4, 34-41, (April, 1962).

A general expression which describes turn-on delay for transistors in the common emitter configuration is derived from an expression describing the stored charge. It is assumed that the driving source appears as a current source to the device and that the input terminals of the device may be represented by a parallel arrangement of linear and voltage dependent capacitors during turn-on delay time. Specific expressions are derived for a current step, a ramp, and an exponential input function, with and without a base speed-up capacitor. Certain expressions are shown to be merely unique cases, and the more general expressions are pointed out. Some theoretical results are compared with empirical data obtained from circuits using representative *pnp* germanium mesa, MADT* and PADT transistors.

* Registered Trademark, Philco Corp., Lansdale, Pennsylvania.

The Preisach Diagram and Interaction Fields for Assemblies of γ -Fe₂O₃ Particles, G. Bate, *Journal of Applied Physics* (Supplement), **33**, No. 3, 1313-1314 (March, 1962).

The Preisach diagram calculated for an assembly of γ -Fe₂O₃ particles at a packing density of 20% by volume has been used to obtain a distribution function of the particle remanence-coercivities in the absence of interaction fields. This function, which has a peak at 275 oe, is then compared with the function obtained by differentiating the remanence hysteresis loop, i.e., with the distribution function in the presence of interaction fields. It is found that the latter function is broader than the former; this can be qualitatively explained in terms of a two-particle model for the interacting particles. The magnitude of the interaction fields can be estimated from the Preisach diagram and is found to have a maximum value of roughly 300 oe.

A Programming Language, K. E. Iverson, *AFIPS, Proceedings 1962 Spring Joint Computer Conference*, 345-351.

The paper describes a succinct problem-oriented programming language. The language is broad in scope, having been developed

for, and applied effectively in, such diverse areas as micro-programming, switching theory, operations research, information retrieval, sorting theory, structure of compilers, search procedures, and language translation. The language permits a high degree of useful formalism. It relies heavily on a systematic extension of a small set of basic operations to vectors, matrices, and trees, and on a family of flexible selection operations controlled by logical vectors. Illustrations are drawn from a variety of applications.

Pyromagnetic Test of Spin Wave Theory in Metallic Nickel, E. W. Pugh and B. E. Argyle, *Journal of Applied Physics*, **33S**, 1178-1186 (March, 1962).

The temperature dependence of the spontaneous magnetization of metallic nickel has been studied between 4.2° and 120°K by a pyromagnetic technique developed by the authors. Fractional changes in magnetization as small as a few parts per million could be detected near 4.2°K. The resultant data were fitted by the method of least squares to a theoretical equation containing terms descriptive of thermal excitation of spin waves in the presence of an effective magnetic field plus a T^2 term descriptive of collective electron behavior. The best fit of the data to this equation is obtained using the spin wave terms alone, provided an intrinsic energy gap is assumed in the spin wave dispersion law of 2.7°K for magnetization parallel to the [111] axis and 1.9°K parallel to the [100] axis. Enhancement of this gap by an externally applied field follows theoretical predictions. It is noted that the measured difference between the gap temperature along the two principal axes has the value theoretically predicted from previous measurements of magnetic anisotropy energy; however, the isotropic contribution observed in this experiment has not been theoretically anticipated. A possible origin for the isotropic gap is proposed in terms of interaction of polarized s and d electrons. It is also pointed out, however, that the "isotropic effective field" may be a spurious result, originating in thermal expansion effects not included in the theoretical equation to which the data were fitted. Finally, a new type of pyromagnetic measurement is described which can be used to determine the temperature dependence of the magnetic anisotropy.

The Relation Between Kron's Method and the Classical Method of Network Analysis, F. H. Branin, Jr., *The Matrix and Tensor Quarterly*, **12**, No. 3, 69-104 (March, 1962).

This paper compares Kron's method of piecewise analysis with the classical mesh and node methods of network analysis. Although the paper is largely expository, several new results are reported. Along with these new results, a brief resumé of the standard relations of graph theory and of the mesh and node methods is included for reference. In addition, an abstract formulation of the network problem is explained which relates directly to a description of Kron's original derivation of his formulas for interconnecting solutions.

Relation of Coercive Force to Structural Properties of Electroplated Films, J. C. Lloyd and R. S. Smith, *Canadian Journal of Physics*, **40**, 454-462 (April, 1962).

Coercive forces (H_c) of Fe-Ni films were observed to depend on thickness, Fe/Ni ratio, and preferred crystal orientation in accordance with predictions based on the Behringer-Smith model. Annealing induces marked crystal growth and orientation [111] axis normal to the plane in the Ni-rich films (>80% Ni), but only moderate growth in the Fe-rich (<80% Ni) films. H_c for Ni-rich films increases markedly while H_c for iron-rich films decreases slightly due to annealing. Variations of the anisotropy field, H_k , due to applied stress, indicate that

reduction of H_c for the Fe-rich films results from moderate crystal growth, while the increase of H_c for the Ni-rich films is due to the preferred orientation.

Reverse Transient Characteristics of a p - n Junction Diode Due to Minority Carrier Storage, D. P. Kennedy, *IRE Transactions on Electron Devices*, **ED-9**, No. 2, 174-182 (March, 1962).

Analysis of the transient switching characteristics of a p - n junction diode is considered a boundary value problem; solution to this problem yields mathematical equations applicable to the design of high-speed computer components. This analytical technique is used to establish the transient current of a semiconductor diode when an external biasing potential is rapidly switched from the forward to the reverse direction. Using a one-dimensional model of finite geometry, minority-carrier storage is assumed within a region of arbitrary lifetime, bounded on one side by the junction and on the other side by an ohmic contact of arbitrary recombination velocity. Further, this region of carrier storage is assumed to contain a drift field of constant magnitude as would result from an exponential type of conductivity grading.

Mathematical equations are presented which characterize this transient situation from its initiation until the junction current has decayed to some arbitrary magnitude. Applications of this analysis are illustrated in graphical form throughout a range of parameters characterizing practical semiconductor devices.

Review of Internal Friction due to Point Defects, B. S. Berry, *Acta Metallurgica*, **10**, 271-280 (April, 1962).

Simple considerations lead to the expectation that point defects will cause internal friction (by a stress-induced ordering mechanism) in all cases where the introduction of the defects sets up local asymmetric distortions of the surrounding lattice. Three categories of specific examples are considered, in which the relaxation centers are believed to contain (a) a single isolated elementary point defect, (b) two interacting elementary point defects and (c) several interacting elementary point defects. The elementary point defects considered are (1) an interstitial solute atom, (2) a substitutional solute atom, (3) a vacancy and (4) a split interstitial. The material for this review is taken from the existing literature with the exception of a brief account of some recent experiments by the author on cold-worked nickel, which relate to the report of a peak due to the split interstitials in this metal by Seeger et al. Due to a background recovery phenomenon, it was not found possible to obtain support for the existence of the peak.

Review of Russian translation: 'Model of the Memory Loading of a Control Device by the Method of Self-Analysis', F. B. Wood, *Electrical Engineering*, **81**, 495 (June, 1962).

The translation reviewed is an analysis of the memory-loading problem encountered in computer identification of nonstationary patterns such as radar path tracks or noise tracks on an oscilloscope, or nuclear particle tracks on photographic plates.

Schaltmassnahmen am Ausgang von kurzen, stetigen inhomogenen Dämpfungsleitungen* (Influence of circuits at the output of short, uniform, inhomogeneous transmission lines with large attenuation), W. Jutzi, *Zeitschrift für angewandte Physik*, **Band 14**, Heft 6, 365-369 (June, 1962).

Uniform inhomogeneous transmission lines with a short circuit at the output are used to absorb electromagnetic waves. If

a voltage reflection coefficient of $|\rho_{zul}| = 10\%$ is admitted, the reflection remains within this limit down to the ratio of the geometrical length of the line to the wavelength in free space of $(1/\lambda_{10})g = 0.27$.

The input voltage reflection coefficient is represented by the sum of three vectors in the Gaussian plane. One of these vectors is related in a simple manner to the reflections from the output to allow the determination of an output impedance that improves the frequency dependence of the input reflection coefficient.

The output impedance consists of an ohmic resistance in parallel with a series resonance circuit. The inhomogeneous transmission line has an exponentially rising capacitive and a shunt conductance layer, while the ohmic layer is zero and the inductive layer is equal to that of the adjacent line at the input. The inhomogeneous transmission line together with the impedance at the output has a limit ratio of $(1/\lambda_{10})g = 0.232$, if $|\rho_{zul}| = 10\%$ and if only 7% of the real power at the input of the inhomogeneous line is absorbed in the circuit at the output.

* Work performed at Institut für Hochfrequenztechnik, Technische Hochschule, Darmstadt, Germany.

Search for an Anisotropic Debye-Waller Factor in Cubic Copper-Base Solid Solutions,* R. W. Cahn** and R. Feder, *Acta Crystallographica*, **15**, 322-325 (April, 1962).

A re-examination has been made of the Debye-Waller temperature factor $\exp\{-2B(\sin \theta/\lambda)^2\}$, where B , according to Weiss and co-workers, is a varying function of $\{hkl\}$ when measurements are made on α brass powder. The integrated and peak intensities of several different lines from powder samples of α brass and α aluminum bronze were obtained at 77°K and room temperature, with MoK α radiation, after heat treatments designed to induce varying amounts of short-range order. It was found that deviations of B from isotropy were marginal and not significant except possibly for the 222 lines. No deviations comparable in magnitude with those reported by Weiss and co-workers were found.

* Work performed at Frankford Arsenal, Philadelphia, Pennsylvania.
** University of Birmingham, Birmingham, England.

Silicon Monoxide Undercoating for Improvement of Magnetic Film Memory Characteristics, B. I. Bertelsen, *Journal of Applied Physics*, **33**, No. 6, 2026-2030 (June, 1962).

The results of two experiments are presented to illustrate the levelling effect of thick layers of SiO on rough substrate surfaces. This effect permits the use of metallic underlayers as substrates for films of NiFe.

A Simple Technique for Mounting Minute Samples for X-ray Diffraction Analysis, F. A. Toman, *Norelco Reporter*, **IX**, No. 2 (March-April, 1962).

The problem of mounting extremely small particles in the powder camera for x-ray diffraction analysis becomes increasingly difficult as the quantities and sizes of the sample particles are decreased.

This IBM Laboratory has, for the past several years, routinely used an epoxy adhesive (Shell Epon 828) for mounting particles, down to dimensions limited only by the resolving power on the x-ray diffraction equipment, on fine glass fibers.

The Solution of a Transition Problem in a Superconducting Strip,* Werner Liniger, *Journal of Mathematical Physics*, **3**, 578-586 (May-June, 1962).

The isothermal transition of a strip of superconducting material from the superconducting state to the normal state, under the

influence of a supercritical external magnetic field, is studied on the basis of the London theory of superconductivity. The problem can be formulated as a free boundary problem with parabolic differential equations which is solved mainly by numerical methods; an analytical solution in the form of series expansions is given for the early part of the transition.

It is found that, in the beginning, the transition in the strip behaves almost like the transition in a half-space. However, the two differ quite drastically as the transition nears completion. It is pointed out that to predict the total transition time for the strip by extrapolating from the analytical solution for the half-space is incorrect. The results show that such an estimate for the transition time would be much too small.

* The results reported in this paper were obtained in the course of research jointly sponsored by the Mathematics Branch of the Office of Naval Research [Contract Nonr-3504(00)] and IBM.

Some Geometrical Considerations for X-ray Collimation in Single-Crystal Diffraction Work, H. Cole, F. W. Chambers, and C. G. Wood, *Review of Scientific Instruments*, **33**, 435-438 (April, 1962).

In positioning an x-ray tube in an experiment in order to gain optimum power, the variables at the operator's control are the take-off angle and the collimation (or slit) system. These variables should be fixed by consideration of sample size, focal-spot size, target "absorption shadow", and the amount of divergence to be permitted. Consideration of these factors leads to an uncommon collimator for simple large-single-crystal diffraction work.

Die Stabilität von Stapelfehlertetraedern in abgeschreckten kubischflächenzentrierten Metallen und Legierungen,* G. Czjzek,** A. Seeger,† and S. Mader, *Physica Status Solidi*, **2**, 558-565 (1962).

An investigation is made of the energy and stability of tetrahedral stacking faults as compared with triangular stacking faults bounded by extended dislocations. As the size and energy of the faults varies, four different stable situations may occur; in each of which only one type of stacking fault is stable, the other being either metastable or completely unstable. For a given stacking fault energy the tetrahedra have a maximum size. Numerical values for the stacking fault energy are derived from the observed size distributions of tetrahedra in quenched Au and NiCo. These values are in general agreement with the results obtained by other methods. The experimental results indicate that nearly perfect tetrahedra are capable of growing in size by the absorption of further vacancies. The growth mechanism is at present unknown.

* Work done at Max-Planck Institut für Metallforschung, Stuttgart, Germany.
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† Max-Planck Institut für Metallforschung.

The Stenowriter—A System for the Lexical Processing of Stenotypy, E. J. Galli, *IRE Transactions on Electronic Computers*, **EC-11**, No. 2, 187-199 (April, 1962).

The system design and evaluation of an experimental system are presented. The Stenowriter utilizes a special-purpose translation computer, equipped with a large random-access memory, to provide real-time processing of spoken material into typewritten English. The input is provided by an operator using a special keyboard with which information may be stenographically encoded as rapidly as it is spoken. The stenographic code is automatically processed by the translation system into corresponding English with proper spelling and format. The output appears on an electric typewriter. Through multiplexing techniques, information for a large number of input-output

units can be processed, each on a real-time basis, by one computer.

Stress Effects on the Magnetic Properties of Evaporated Single-Crystal Nickel Films, J. F. Freedman, *Journal of Applied Physics*, 33S, No. 33, 1148-1150 (March, 1962).

It has been shown that nickel single-crystal films, grown epitaxially on NaCl, exist in a highly strained condition because of thermal contraction differences between film and substrate. The stress causing this strain is elastic in nature and is relieved by floating the film off the rock salt. It is verified experimentally and theoretically that the externally applied stress system contributes to the total magnetic energy of the system through a magnetoelastic interaction resulting in high values for the first order crystalline anisotropy constant as well as for the anisotropy resulting from rotation of the magnetization out of the plane of the film.

Superconductivity in the CuAl₂ (C16) Crystal Class, M. F. Gendron and R. E. Jones, *Journal of the Physics and Chemistry of Solids*, 23, 405-406 (April, 1962).

Several superconducting compounds have been found in the CuAl₂ (C16) crystal class, indicating that this structure is among those favorable to the occurrence of superconductivity. The compounds were: AuPb₂ ($T_c = 4.42^\circ\text{K}$), PdPb₂ ($T_c = 2.95^\circ\text{K}$), RhPb₂ ($T_c = 2.66^\circ\text{K}$), and AgIh₂ ($T_c = 2.30\text{-}2.46^\circ\text{K}$). In addition, two compounds related to the C16 class were found to be superconducting: AuSn₄ ($T_c = 2.38^\circ\text{K}$) and PtPb₄ ($T_c = 2.80^\circ\text{K}$).

Survivable Computer Communications Systems: Goal of New IBM Center, R. P. Crago, *Signal*, 16, No. 9, 14-15 (May, 1962).

This article contains a description of how the IBM Federal Systems Division's Communications Systems Center approaches the problems of complex modern communications systems.

Symmetric Strip Transmission Line Tee Junction, A. G. Franco and A. A. Oliner,* *IRE Transactions on Microwave Theory and Techniques*, MTT-10, No. 2, 118-124 (March, 1962).

Several different network forms have been employed previously to characterize the symmetrical strip line tee junction, and the parameters of these networks have been obtained by various means. In this paper the available theoretical and experimental results are systematically correlated. A choice, based on design convenience, is made of the most appropriate network form, and recommendations are given for the values of each of the parameters in this representation. In some ranges, the available data were inadequate, and additional experimental results were taken in order to clarify the recommendations.

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Theory of Diffusion and Equilibrium Position of Interstitial Impurities in the Diamond Lattice, K. Weiser, *Physical Review*, 126, 4, 1427-1436 (May, 1962).

A theory is developed for diffusion of interstitial impurities in the diamond lattice. For ionized impurities the theory is based on a model in which the interaction of the ion with the host atoms is given by an attractive potential produced by the polarization of the host atoms, and a repulsive potential due to overlap of nonbonding electrons. The interaction energy is

calculated at two interstitial positions of symmetry, and the activation energy for diffusion is taken as the difference between the two. Good agreement with experiment is found for lithium, copper, and silver. The theory predicts an optimum impurity size for diffusion, and thus explains the great diffusivity of copper. It also claims that the interstitial position of lithium and copper is not one of tetrahedral symmetry.

Theory of Polar Phonon Assisted Tunneling, W. P. Dumke, P. B. Miller, and R. R. Haering, *Journal of the Physics and Chemistry of Solids*, 23, 501-507 (May, 1962).

A comparison of theoretical and experimental pre-exponential tunneling factors is made for direct and phonon assisted tunneling in InSb. We find a theoretical ratio of 0.003 for the phonon to direct current ratio, whereas the observed ratio is about 0.10. This discrepancy cannot be accounted for by a lack of knowledge of the band structure, scattering mechanisms or junction widths in InSb, but reflects the inadequacy of the current theory of tunneling. Similar discrepancies in the pre-exponential factors of Ge are also discussed.

Thermal Conductivity of Dilute Indium-Mercury Alloys, A. M. Taxen, G. K. Chang,* and R. E. Jones, *Physical Review*, 126, 919-922 (May, 1962).

The thermal conductivities of a series of polycrystalline specimens of indium containing 0.1 to 2.5 at. % mercury have been measured in the temperature range $1.4^\circ\text{-}4.0^\circ\text{K}$. By using an extrapolation procedure the amount of phonon conduction in the superconductive state was calculated and was found to be about one-half as large as the value calculated from the theory of Bardeen, Rickayzen, and Tewordt. From the ratio of the electronic thermal conductivity in the superconductive state to that in the normal state, the temperature and composition dependences of the Bardeen-Cooper-Schrieffer (BCS) energy gap were calculated. Small systematic deviations of the measured gaps from the predictions of the BCS theory were observed.

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Treated and Untreated Papers and Boards, T. D. Callinan, *Insulation*, 8, No. 6, 67-79 (May, 1962).

The present status and anticipated progress in the field of electrical insulating papers is discussed. The increasing importance of engineering and physics in a technology which was usually considered a sub-discipline of chemistry is established.

Turn-Off Transition Mechanism, S. Steiner, *Solid State Design*, 3, No. 6, 29-34 (June, 1962).

In the literature there is a known solution for the turn-off transition mechanism if the pull-off current is constant and there is no capacitive load between the collector and ground. The relationship between the output current and the time is given by the formula:

$$i_c(t) = (I_{cS} + I_b H_{FE}) \exp \left\{ \frac{-t}{H_{FE}[(1/\omega_N + RC)]} \right\} - I_b H_{FE}.$$

However, in the output circuit there are always components (diodes, long wires, etc.) which represent capacitances, and in certain cases might alter the fall time very significantly. If this happens, the output signal will be very different from that given by the formula above.

The following study investigates this case extensively and gives both a qualitative and quantitative description of the mechanism.

Two-Plane Magnetic-Core Comparator Cuts Computer Costs, H. M. Sierra, *Electronic Design*, **10**, 74-79 (June, 1962).

For a magnetic-core, high/low/equal comparator, a large cost reduction was achieved by designing a two-plane matrix with a novel inhibit feature instead of a conventional single-plane matrix.

Typically, a unit capable of one-by-one comparison of signals representing the 48 characters of a standard typewriter keyboard would require a single-plane matrix of 2304 cores. The cost of such a unit would be prohibitive, particularly in terms of the required switches, core drivers, and specifically regulated power supplies.

By using two planes, the same high/low/equal decisions can be performed by 356 cores. If the computer already has a matrix-core adder, only 256 cores are needed.

Ultrasonic Amplification in Semimetals, W. P. Dumke and R. R. Haering, *Physical Review*, **126**, 1974-1977 (June, 1962).

When a semimetal is placed in crossed electric (E) and magnetic fields (H), both electrons and holes drift in the $E \times H$ direction with velocity Ec/H . A sound wave propagating in this direction with velocity s may be amplified if $Ec/H > s$. The effect is similar to that described by Hutson, McFee, and White, except that the present arrangement allows one to obtain conditions of amplification at much lower current densities, since the magnetic field limits the current flowing in the electric field direction. The theory of sound amplification in a semimetal has been worked out for the above conditions assuming the field produced by the sound wave can be described by a deformation potential. Because of the relatively large carrier densities in semimetals such as bismuth, it is found that large amplification factors can be obtained.

Unvollständige Schaltvorgänge in dünnen magnetischen Schichten (Partial rotational switching in thin magnetic films), W. Dietrich, *Zeitschrift für angewandte Physik*, Band **14**, Heft 4, 210-212 (April, 1962).

The switching behavior of thin magnetic films is investigated when the magnetization is only partially rotating at pulse driving fields just exceeding the theoretical threshold for rotation. The split configuration of the magnetization is demonstrated by Bitter pattern technique. The "creep effect" at pulse driving fields with amplitudes far below the wall motion threshold have been measured in dependence on pulse rise time, pulse amplitude, pulse length and number of applied pulses.

The Zener Relaxation as a Distribution of Relaxation Times, A. S. Nowick and B. S. Berry, *Acta Metallurgica*, **10**, 312-318 (April, 1962).

Most relaxation processes are not describable in terms of a single relaxation time, but require the introduction of a distribution of relaxation times. To obtain complete information about a relaxation process, it is important to know something about

the functional form of the distribution and its width (the "distribution parameter"). In the present work this type of information is sought for the Zener relaxation in an Ag-30% Zn alloy. It is first shown that the form of the distribution function is difficult to determine, because the distribution is so narrow; however, a lognormal distribution is assumed as most reasonable. Next, the distribution parameter is obtained as a function of $1/T$ by using creep data as well as internal friction at various frequencies. The results indicate that a major part of the distribution of relaxation times is due to a distribution of the activation energies. Finally, an attempt is made to interpret the distribution of activation energies in terms of local concentration fluctuations in the solid solution.

Zur Anregung von stehenden Spinwellen in dünnen Permalloy-schichten durch inhomogene Wechselfelder (On the excitation of standing spinwaves in thin permalloy films by means of an inhomogeneous high frequency field), P. Wolf, *Zeitschrift für angewandte Physik*, Band **14**, Heft 4, 212-214 (April, 1962).

In permalloy films (81% Ni, $d = 1300 \cdots 1700$ Å) a strongly inhomogeneous rf-field excites standing spinwaves which, by usual methods, are not or only weakly excitable. The 4000 Mc/s inhomogeneous field is generated by a rf-current flowing in the film. In a film magnetized by a dc field parallel to its surface not only the uniform precession is excited but also a second mode. From these two modes the exchange constant is derived, the value of which ($A = 0.80 \cdot 10^{-6}$ erg/cm) is in agreement with results reported in the literature. By comparing the two spin-wave spectra of a film magnetized once parallel and once perpendicular to its surface, an approximate value of the surface anisotropy constant is found: $K_0 = +0.7$ erg/cm².

Letters to the Editor

Comments on Kinetics of Nickel Ferrite Formation, S. H. Charap and E. A. Geiss, *Journal of the American Ceramic Society*, **45**, No. 4, 200 (April, 1962).

Comments on the Signs of Proton Coupling Constants, M. Karplus, *Journal of the American Chemical Society*, **84**, 2458-2460 (June, 1962).

A Comparison of Error Rates for Coherent and Phase-Comparison Detection of Two- and Four-Phase Digital Signals in the Presence of Rayleigh Carrier Fading, C. R. Laughlin* and R. E. Sullivan, *Proceedings of the IRE*, **50**, No. 4, 468-469 (April, 1962).

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Growth of Single-Crystal $MgGa_2O_5$ Spinel from Molten PbO - PbF_2 Solutions, E. A. Geiss, *Journal of Applied Physics*, **33**, No. 6, 2143 (June, 1962).