January through March, 1961

IBM Technical Papers Published in Other Journals

Absolute Calibration of a Light Detector, R. L. Christensen and I. Ames, *Journal of the Optical Society of America,* **51,** No. 2, 224-236 (February, 1961).

A method is described for the determination of the absolute spectral sensitivity of a photomultiplier in the wavelength range from 2200 A to cutoff. The standard of radiation is thermal radiation from a tungsten strip lamp, and the dispersing instrument is an arrangement of two conventional grating monochromators in tandem. The major portions of the calibration are the determinations of the monochromator transmissions and then of the relative and finally absolute spectral sensitivity of the photomultiplier. As an example of the use of this detector, the determination of the absolute spectral output of two lamps is described.

Absorption Measurements on a Plastic Scintillator, R. J. Potter, *The Review of Scientific Instruments,* **32,** No. 3, 286-288 (March, 1961).

The absolute absorption coefficient of a commercial plastic scintillator was measured as a function of wavelength over the region of its luminescence. The absorption coefficient was found to be quite small ($\sim 10^{-3}$ cm^{-1}) through most of the visible spectrum with strong absorption beginning at about 4000 A. The details of the experimental apparatus and the procedure are described. Some interpretations of the absorption properties are offered.

An Accurate Calorimeter for High Microwave Power,[*] Jorgen P. Vinding, *The Microwave Journal,* **4,** No. 1, 41-46 (January, 1960).

A calorimetric arrangement is described for measuring RF powers between 30 and 1000 w with accuracy of 1%, or better, and reading time of about 1 minute. The frequency range covered at present is DC-4kMc with a coaxial rf termination and 5.8-12.4 kMc with waveguide terminations. Sources of errors are analyzed in detail and the evaluation of each error is presented.

Analysis and Synthesis Techniques of Oriented Communication Nets, D. T. Tang and R. T. Chien, *IRE Transactions on Circuit Theory,* **8,** No. 1, 39-43 (March, 1961).

An oriented communication net is a communication network in which channel capacities between pairs of terminals are not symmetrical. The concept of a minimum valued cutset is extended for the oriented graph representing such a network to determine the terminal capacity matrix which gives the maximum possible communication capacity between any ordered pair of terminals. The realizability conditions of a terminal capacity matrix are analyzed. Synthesis techniques of a realizable terminal capacity matrix based on matrix partition and addition are given with some special cases treated in detail.

Anisotropy and Magnetostriction in Magnetic Oxides, J. C. Slonczewski, *Journal of Applied Physics,* **32,** No. 3, 253S-263S (March, 1961).

Recent theories of the anisotropy and magnetostriction due to the presence of Co^{2+} in spinel ferrites are reviewed and new work on the effects of Fe^{2+} is presented. The effects of these ions are great because the orbital angular momentum is not fully quenched by the crystal field. In the case of Co^{2+}, the orbital moment of the ground state is coupled strongly to the trigonal axis of the crystal field. The very large anisotropy and magnetostriction arise from spin-orbit coupling in first order. The theory is found to account for many of the effects of cobalt-iron ferrite and cobalt-manganese ferrite at higher temperatures. The contribution of Fe^{2+} to these effects is less extreme but still striking. Here the orbital moment is more nearly quenched but the spin is still coupled strongly to the trigonal axis. The coupling gives rise to cubic anisotropy in second-order approximation. This term appears to account for the large compositional dependence of anisotropy in manganese-rich manganese-iron ferrite. A crystal-field calculation of the orthorhombic distortion of the low-temperature form of magnetite is found to be consistent with observations at about 80°K, assuming a high degree of Verwey ordering. However, the anisotropy calculated on the same assumption is found to be inconsistent with experiment. It is concluded that the one-ion crystal-field theory is largely applicable to the effects of Co^{2+} and Fe^{2+} in ferrites. However, it does not work when the concentration of Fe^{2+} is high.

Antishielding and Contracted Wave Functions, G. Burns and E. G. Wikner,[*] *The Physical Review,* **121,** 155-158 (January 1, 1961).

The antishielding factors, γ_∞, of several contracted negative ions are calculated and compared to the apparent experimental values. Although the use of contracted wave functions results in considerably smaller γ_∞'s, the agreement is still not encouraging for the negative ions. Interrelations are found among the wave functions contracted by different means. Also γ_∞ of several closed-shell positive ions and two ^6S state ions (Mn^{+2} and Fe^{+3}) are calculated so that information from measured quadrupole coupling constants can be obtained. These positive-ion results with other published values should enable γ_∞ of all closed-shell ions to be estimated. The results are used to determine the nuclear quadrupole moment of Fe^{57m} from the published value of the quadrupole coupling constant in Fe_2O_3. This result is discussed.

249

Automatically Controlling Vacuum Deposition, R. E. Thun, K. H. Behrndt, M. Beckerman, and K. B. Scow, *Automatic Control,* **14,** No. 2, 26-31 (February, 1961).

This article describes the influence of the different evaporation parameters such as source geometry, evaporation rate, chamber pressure, substrate temperature and film thickness on the electrical and structural properties of vacuum deposited films, and points out that the tight specifications in the production of electronic film circuits can only be met by an automatic control of substrate temperature, deposition rate and film thickness. Sensors for these quantities are described with automated evaporation systems which feature the simultaneous control of two separate sources. The accuracy of the control approaches $\pm 1\%$ of the preselected film composition.

Carrier Lifetime in Indium Antimonide, * R. A. Laff and H. Y. Fan,** *The Physical Review,* **121,** No. 1, 53-62 (January 1, 1961).

The recombination of excess electron-hole pairs in indium antimonide has been studied in the temperature range $200\,^{\circ}\mathrm{K}$-$15\,^{\circ}\mathrm{K}$, where it is controlled by localized centers. Minority carrier trapping is found in extrinsic p-type material. The lifetimes of electrons and holes obtained from photoconductivity and photoelectromagnetic effect data on n- and p-type samples lead to a model for the recombination, consisting of a donor center having two energy levels in the forbidden gap, at 0.055 and 0.12 ev above the valence band. The capture coefficients for holes and electrons have been determined for the center in each of the two charge states. In p-type material, the chemical acceptors are in statistical equilibrium with the free holes in the valence band. When holes freeze out onto acceptor centers ($T < 60\,^{\circ}\mathrm{K}$), an increase of free holes due to photoexcitation leads to a corresponding increase in the hole concentration on the acceptors. This effect of majority carrier trapping reduces the rise of hole lifetime with decreasing hole concentration. In order to determine the nature of the recombination centers, different treatments are used to introduce additional centers. It is found that bombardment with 4.5-Mev electrons produces additional centers having the same recombination properties as the original centers. The result indicates that the recombination centers have the nature of structural defects rather than chemical impurities.

*Work done at Purdue University and supported by an Office of Naval Research contract.
**Department of Physics, Purdue University.

Computer Solutions to Some Non-Computational Psychological Problems, R. Seibel, *Educational and Psychological Measurement,* **21,** No. 1, 185-201 (Spring, 1961).

This is a transcript of a talk written for social science students with little or no experience with computers. Areas of computer applications in social science are outlined and several specific examples described. The applications emphasize computer usage for other than the computation of "standard" statistical measures. The talk was given as part of the University of Texas Lecture Series entitled "Impact of Computers on Behavioral Sciences Research," and presented in the spring of 1960.

Coupling Principle in Thin Film Switching Circuits (Die Verknepfungsaufgabe in einem aus dünnen Magnetschichten bestehenden Schaltkreissystem), H. T. Oguey,

Bulletin des Schweizerischen Elektrotechnischen Vereins, **51,** 1004-1010 (October, 1960).*

Thin permalloy films possess two useful properties with respect to their use as computer elements: 1) Uniaxial anisotropy leading to a bistable behavior, and 2) Single magnetic domain necessary to achieve very fast coherent rotation of the magnetization. Switching times of about 10^{-9} sec have been measured.

This paper is concerned with a system in which the information is represented by the positive or negative flux direction in the magnetic elements, the information is transmitted and processed by means of strip lines. This principle is useful for the construction of shift registers and logical elements. Amplification and decoupling is achieved without semiconductors. In spite of its simplicity, this system is expected to work at a bit frequency of 20 Mc/sec.

*For period October 1 through December 31, 1960 .

Cryotron Storage, Arithmetic and Logical Circuits, M. K. Haynes, *Solid-State Electronics,* **1,** No. 4, 399-408 (September, 1960).*

A major advantage of cryotron elements is that storage of digital information may be accomplished by the use of persistent supercurrents. This type of storage yields a steady-state indication of the stored condition without requiring steady-state-power dissipation to maintain that condition.

The minimal storage cell employs three cryotrons for use in a two-dimensional-storage-selection system, and is capable of simultaneous and separate access for reading and writing. By using five cryotrons per cell, simultaneous triple access is achieved — one can simultaneously read the contents of any two words in storage, and write information into any word in storage without restrictions.

Persistent-supercurrent-storage loops can also be used in circuits for data registers, interchange of data between registers, shifting data within storage, and counting within storage. These circuits require no extra cells for temporary storage, since persistent-current loops exist in the interconnections which can perform this function at no extra cost.

Logic and arithmetic circuits employing cryotrons can be readily designed to minimize cryotron count, using a collapsed-tree structure. A parallel binary adder requires only 14 cryotrons per bit position. Any three-variable function can be realized with no more than 10 cryotrons, and any four-variable function can be designed with no more than 16 cryotrons.

*For period July 1 through September 30, 1960.

Currents and Fields in a Superconducting Film Carrying a Steady Current, Paul M. Marcus, *Proceedings of International Low Temperature Conference, Toronto, Canada,* August 19-September 3, 1960, pp. 418-421 (March, 1961).

The inhomogeneous integral equation over the cross section satisfied by the steady current carried by a cylindrical superconductor is derived from London's and Maxwell's equations. A systematic solution procedure for rectangular cross section is used to obtain the current distribution in thin films of various sizes and the corresponding magnetic fields at the surface of the film. The distributions show pronounced peaking at the ends of the film.

Cyclic Codes for Error Detection, W. W. Peterson* and D. T. Brown, *Proceedings of the IRE,* **49,** No. 1, 228-235 (January, 1961).

Cyclic codes are defined and described from a new viewpoint involving polynomials. The basic properties of Hamming and Fire codes are derived. The potentialities of these codes for error detection and the equipment required for implementing error detection systems using cyclic codes are described in detail.

*University of Florida.

Decision Problems of Finite Automata Design and Related Arithmetics, C. C. Elgot, *Transactions of the American Mathematics Society*, **98,** No. 1, 21-51 (January, 1961).

Certain formal arithmetics may be employed as design languages for finite automata. In these arithmetics the (design) conditions, the notion of automaton, and the notion of an automaton satisfying a condition are all expressible. An automaton satisfies a condition if a certain formula of the arithmetic is valid.

For certain arithmetics algorithms are produced which enable one to decide (1) whether a given automaton satisfies a given condition, (2) whether there exists an automaton satisfying a given condition (and if there is one, producing one), (3) whether there exists at most one automaton satisfying a given condition, and (4) whether a given sentence is true.

These results make use of a theorem which characterizes finite automata behavior by means of formulas of an arithmetic. For certain other arithmetics, it is shown that algorithms of the type indicated above fail to exist.

Density Expansions of Correlation Functions for Equilibrium Systems, H. L. Friedman, *Journal of Chemistry and Physics*, **34,** 73-78 (January, 1961).

A method of deriving density expansions of correlation functions from density expansions of the excess free energy is based on certain thermodynamic relations between derivatives of the grand partition function and derivatives of the excess free energy. The method also depends on using the most general expansion of the interaction energy into components; it is *not* assumed that this energy is limited to pairwise components. Expansions are obtained for the correlation functions in multicomponent gases and for the correlation functions for solute species in solutions. The method is also applicable to ionic solutions. A mathematical difficulty limits the systems for which these equations are proved, to those in which there is a certain flexibility in treating the model.

Dielectric Relaxation Due to Impurity-Vacancy Complexes in NaCl Crystals, R. W. Dreyfus, *The Physical Review*, **121,** 1675-1687 (March 15, 1961).

Sodium-ion vacancies are introduced into sodium chloride crystals by the addition of the following divalent cation impurities: Mg^{++}, Mn^{++}, Ca^{++}, Zn^{++}, Cd^{++}, and Sr^{++}. Below 150°C, the virtual negative charge of a cation vacancy binds the majority of the vacancies to the divalent impurity ions to form complexes. The reorientation of these dipolar complexes is observed in the present experiments as a transient dielectric polarization current occurring immediately after the application of a dc electric field. Below 0°C, the dominant effect is an exponential "fast polarization" due to complexes in which the vacancy is in the nearest sodium-ion site to the impurity ion (except for the case of $NaCl:Mg^{++}$). Also observed is a "very fast polarization" which may be interpreted as due to next-nearest-neighbor impurity-vacancy complexes, plus a "slow polarization" ascribed to vacancies jumping between more distant bound sites. By combining the present measurements with earlier ac measurements, one can obtain particularly accurate values for the jump activation energies of vacancies occupying the nearest-neighbor site to Ca^{++} and Mn^{++} ions in a NaCl crystal. The energies obtained for these two cases are 0.702 ± 0.010 ev and 0.680 ± 0.010 ev, respectively. From the manner in which the relaxation time at a given temperature varies with the radius of the impurity ion, the dominant jump mechanisms can be inferred. The major reason for the decrease in relaxation time with decreasing radius of the impurity ion appears to be the strong dependence of the jump rate of the impurity ion on ionic radius.

Digital Computer Equipment for an Advanced BNMGS, T. B. Lewis, *Proceedings of the IRE*, **49,** No. 1, 313-318 (January, 1961).

Transistorized, high-speed, general purpose digital computing equipment has been designed as the airborne calculating element for an advanced bombing, navigation and missile guidance system. Because of the critical nature of the primary application, the characteristics of reliability, maintainability and flexibility have received the utmost consideration and inclusion in every design phase. Maximum reliability is achieved through the use of a powerful and versatile main computer operating in parallel with a minimal but adequate emergency computer. A new approach to fault location enhances computer maintainability and permits inflight repair, while flexibility is achieved by means of unique, high speed input-output processing equipment.

Digitale Schnellspeicher mit sehr dünnen Magnetschichten (Digital High-Speed Memories Using Very Thin Magnetic Films), W. E. Proebster, *Neue Technik*, **2,** 110-113 (February, 1961).

Magnetic films some hundred atom layers thick have many advantages as elements for high-speed digital memories with respect to speed and energy consumption in comparison to conventional ferrite cores with rectangular hysteresis loop. Following a description of the preparation of thin magnetic films the various switching processes are discussed. Particular emphasis is put on the coherent rotation of the magnetization lasting about 10^{-9} sec. For thin magnetic film memories, the construction and operation of which are discussed in some detail, cycle times of some 0.1 μsec have already been achieved.

Ein digitales Verfahren zur Beobachtung von Signalen mit sehr hohem Störpegel (A Digital Method for Observing Signals in the Presence of Very Strong Noise), K. E. Drangeid, *Neue Technik*, **2,** 96-101 (February, 1961).

An instrument to measure voltage pulse of very short duration and with low signal-to-noise ratio is described. The method is based on the sampling principle, and can, therefore, be used only to measure repetitive signals. Each point of the pulse curve is measured a certain number of times, and the average value of the measurements is plotted on an X-Y plotter.

The signal is sampled with a sampling oscilloscope, and the output of the sampling oscilloscope is digitized. The digitized values are added in a digital circuit and when the prescribed number of measurements are executed, the average digital value is converted into a dc signal which drives the Y deflection of the X-Y plotter. When the prescribed number of measurements is executed for one point, a ONE is added in a counter which, via a digital-analog converter, controls the X deflection of the X-Y plotter and the sampling

251

oscilloscope. The instrument is built up with IBM-SMS cards, which are small printed circuits made as pluggable units. On each card there are two to three gates. In the digital circuit there are about 800 transistors. In the paper it is shown how the signal-to-noise ratio is increased by the number of samples per point.

EJCC Program Highlights, W. P. Heising, *Datamation*, 7, No. 2, 36-38 (February, 1961).

Several papers of the 1960 EJCC are briefly summarized. Specific mention is made of papers on (1) programmed voice recognition, (2) BMEWS checkout data processor, (3) tabular language, (4) binary machine for commercial data processing, (5) a magnetostrictive storage computer and (6) STRETCH instruction unit.

Edge Effects in Superconducting Films, R. B. DeLano, Jr., *Solid-State Electronics, 1*, 381-387 (September, 1960 – circulated January, 1961).

This paper discusses the effect that edges of typical evaporated tin films have on their magnetic and temperature transitions and the importance of these effects on thin-film cryotron characteristics. Practical methods for eliminating the edge effect are mentioned.

Effect of Quenching on the Grain Boundary Relaxation in Solid Solution, A. S. Nowick and C. Y. Li, *Transactions of the Metallurgical Society of AIME, 221*, 108-109 (February, 1961).

It is demonstrated that quenching from an elevated temperature accelerates the grain boundary relaxation in two solid solutions (αAg-Zn and αCu-Al). This result is consistent with the proposal that, in solid solutions, grain boundary relaxation occurs by a mechanism of self-diffusion. Nevertheless, an alternative possibility, that quenching introduces vacancies into the boundary itself, must also be considered.

Effect of Residual Gases on Superconducting Characteristics of Tin Films,* H. L. Caswell, *Journal of Applied Physics, 32*, No. 1, 105-115 (January, 1961).

A special, oil-free, ultra-high-vacuum system has been used to deposit tin films at pressures less than 10^{-9} mm of Hg onto room temperature substrates. These films have been compared with films deposited in reduced vacuum obtained by bleeding in a specific gas. In this manner, the influence of O_2, N_2, H_2O, H_2, CH_4, C_3H_8, C_5H_{12}, A, CO, CO_2 in determining superconducting properties has been obtained. The critical, external magnetic field required to switch a film from the superconducting to normal state was found to be sensitive to the presence of oxygen, water vapor, and carbon dioxide. For example, the critical field extrapolated to $0°K$ increased from 370 oe for a pure film to 490, 590, 820 oe as the ratio of oxygen molecules striking the substrate increased from 0.0 to 3, 6, 9% respectively. From an analysis of the critical field and residual resistance data of the various films, the vacuum requirements necessary for obtaining high purity films with sharp magnetic transitions occurring at predictable field values were ascertained. An ultra-high-vacuum system is not required if the partial pressure of critical gases is maintained below specified values.

Der Einfluss von lokalen Anisotropieschwankungen auf das magnetische Verhalten von dünnen Ni-Fe-Schichten (The Influence of Local Anisotropy Variations on the Magnetic Behavior of Thin Ni-Fe Films), S. Middlehoek, *Zeitschrift für angewandte Physik, 13*, No. 3, 151-154 (March, 1961).

The influence of the anisotropy variations on the reversal processes in the hard direction as well as on the wall coercive force in the easy direction are examined. When the film is reversed in the hard direction, the anisotropy direction variations cause a splitting-up of the film in very fine domains. This splitting-up leads to the occurrence of remanence and irreversible processes. The anisotropy variations also contribute to the wall motion coercive force in the easy direction.

The variations of the anisotropy constant cause a coercive-force term which does not depend on the average anisotropy constant, whereas the variation in the anisotropy direction leads to a coercive-force term which decreases when the average anisotropy constant increases.

Electrical Resistivity of Liquid Sodium, Liquid Lithium and Dilute Liquid Sodium Solutions, James F. Freedman and William D. Robertson, *Journal of Chemical Physics, 34*, No. 3, 769-780 (March, 1961).

The three factors of atomic size, ion core potential and charge, which contribute to the increment in electrical resistivity produced by solutes in metallic solutions, have been separated and experimentally evaluated in liquid sodium. The results may be expressed in a semi-empirical relationship defining the increment in resistivity of a monovalent solution:
$\Delta\rho_{microhm-cm/at. \%} = 0.063(\Delta \text{ Atomic Number}) + 0.53(\Delta V/V)^2$
where $\Delta V/V$ is the fractional difference in atomic volume of solute and solvent and the first term involves the absolute value of the difference in atomic number of sodium and the solutes lithium, potassium, cesium, rubidium, silver and gold.

Energy and Momentum Relaxation Processes of Electrons in N-Type Germanium, T. N. Morgan, *Bulletin of the American Physical Society, 6*, No. 2, 137 (March 20, 1961).

We have measured dc resistivity and its dependence on the electric field with 3 cm microwaves in n-type germanium samples having between 2×10^{13} and 3×10^{15} ions per cc. The variation of resistivity with temperature and the resistivity changes produced by weak microwave fields are sensitive to ion concentration, the former approaching a $T^{1.75}$ dependence for the purer samples. Both agree with a theory based on temperature-independent effective masses, acoustical phonon scattering, Brooks-Herring ion scattering, and optical phonon scattering with a coefficient of 0.55 times acoustical. The variation of this resistivity change with the microwave frequency used, interpreted in terms of effective energy relaxation times, are in reasonable agreement with theoretically predicted values between 77° and 300°K.

Exchange Interaction Between Conduction Electrons and Magnetic Shell Electrons in Rare-Earth Metals, S. H. Liu, *The Physical Review, 121*, 451-455 (January 15, 1961).

The interaction Hamiltonian for the Coulomb exchange effect between conduction electrons and magnetic shell electrons in rare-earth metals is derived from first principles. The approximations under which the interaction can be represented by the product of electron and ion spin vectors are exhibited.

Extended Manipulation of Logic Expressions, R. B. Hurley, *Electronic Equipment Engineering,* **9,** No. 2, 79-82 (February, 1961).

Boolean expressions can be placed in eight different standard forms. These forms can be initially reduced via ordinary map techniques. Concern is with algebraic manipulation after initial reductions have been achieved. In particular, interest is in factoring, gating, and the removal of primed variables.

Ferrite Toroid Core Circuit Analysis, G. Bishop and R. Betts, *IRE Transactions on Electronic Computers,* **EC-10,** No. 1, 51-56 (March, 1961).

A toroid core made from a magnesium ferrite material (IBM 103) has been used as a basis for experiment. The core was wound with input and output windings, and the open circuit response of the core to a step input current was used as a basic characteristic of the core.

Equations governing the behavior of the core when used in a simple RC circuit have been developed, and a comparison between predicted and experimental results shows good agreement for the particular core used.

Ferroelectric Properties of the System $(NH_2CH_2CO OH)_3$ $H_2(PO_3F SO_4)$, T. G. Dunne and M. L. Wang, *Journal of the Electrochemical Society,* **108,** 111-112 (January, 1961).

A partial substitution of $PO_3F^=$ for $SO_4^=$ has been made in the ferroelectric triglycine sulfate. Ferroelectric properties are observed up to a $PO_3F^=$ mole fraction of 0.135 with a marked lowering in Curie point.

Field Dependence of Nuclear Magnetic Spin Absorption Spectra, A. G. Anderson, *Proceedings of the VIIth International Conference on Low Temperature Physics,* G. M. Graham and A. C. Hollis Hallett, Eds., University of Toronto Press, pp. 59-60 (1961).

Nuclear spin absorption in lithium metal has been experimentally observed in an ac magnetic field, H_1, over a range of dc magnetic fields, H_0, from zero to fifteen oe. The nuclear spins are subject to the Zeeman interaction with H_0, an internal magnetic dipole-dipole interaction between spins, and a weak coupling to the lattice through the nuclear spin-conduction electron interaction. According to the theory each of the lines has a mean square width of order $\gamma^2 \langle \Delta H^2 \rangle_{av}$, where $\langle \Delta H^2 \rangle_{av}$ is the Van Vleck second moment in gauss²; each of the lines, other than $\gamma H_0/2\pi$ line in perpendicular field $(H_1 \perp H_0)$, arises from matrix elements of the dipole-dipole interaction and has an intensity which decreases as H_0^{-2} or H_0^{-4}. In the case of $H_1 \perp H_0$ the experimental details of the spectra are in reasonable agreement with theory, while in the case of $H_1 | | H_0$ only the "zero frequency" line appears to be unusual.

Field Solution for a Thin-Film Superconducting Strip Transmission Line, J. C. Swihart, *Journal of Applied Physics,* **32,** 461-469 (March, 1961).

Using London's equations, the two-fluid model, and the classical skin effect for the normal component of the current, a sinusoidal wave solution is found for a superconducting transmission line. This solution gives a slow mode of propagation which is dependent on the ratios of the dielectric and superconducting film thicknesses to the penetration depth. At low temperatures and frequencies where the losses are low, the velocity is dispersionless even though there is a component of electric field in the direction of propagation. The solutions for velocity and attenuation vary continuously as one passes through the critical temperature into the normal state. The solutions are interpreted in terms of lumped-circuit characteristics.

Flow Table Logic, P. R. Low and G. A. Maley, *Proceedings of the IRE,* **49,** No. 1, 221-228 (January, 1961).

Microminiature systems have been proposed which will use packing densities on the order of 10^6 active elements per cubic foot. With these packing densities in mind, the authors have suggested that a complete new theory of machine organization be found. One such method is suggested, whereby rather large sequential circuits are implemented directly from their flow table representations. This method does require more active elements, but the interconnection problem is greatly reduced.

Zur Frage der Vorzeichenumkehr des Magnetfeldes beim Meissnereffekt, I. Spiegelnde Oberflächenstreuung (On the Possibility of Sign-Reversal of a Magnetic Field Penetrating a Superconducting Layer, I. Specular Reflection), R. Sommerhalder and H. Thomas, *Helvetica Physica Acta,* **34,** No. 1, 29-35 (March, 1961).

The penetration of a longitudinal magnetic field through the wall of a superconducting hollow cylinder is calculated for an arbitrary nonlocal theory, assuming specular reflection of the electrons at the surfaces. Numerical analysis for the case of Pippard's kernel predicts opposite signs of the magnetic fields inside and outside the cylinder above a certain wall thickness, which depends on the coherence length. The calculated field attenuation ratio should allow experimental observation of this sign reversal for evaporated films, thus providing a direct proof of the nonlocal relation between vector potential and density of the supercurrents.

Freie und erzwungene Schwingungen der Magnetisierung in dünnen Permalloy-Schichten (Free and Forced Oscillations of the Magnetization in Thin Permalloy Films), P. Wolf, *Zeitschrift für angewandte Physik,* **13,** No. 3, S154 (March, 1961).

Free oscillations of the magnetization ranging from 500 to 1100 Mc/sec have been excited in thin permalloy films by a pulse field with a risetime less than $0 \cdot 35$ nsec, and observed with a sampling oscilloscope. The eigenfrequencies and the damping constants of these free oscillations are compared with the resonance frequencies and the damping constants of forced oscillations obtained in ferromagnetic resonance experiments. Perpendicular and parallel orientation of the magnetization with respect to the easy direction of the induced uniaxial anisotropy of the film are considered. The results show reasonable agreement with theoretical values gained from the Landau-Lifshitz equation.

Frequency-Dependent Hall Effect in Normal and Superconducting Metals, P. B. Miller, *The Physical Review,* **121,** 435-451 (January 15, 1961).

The Hall current flow occurring in a normal and a superconducting metal when both a static magnetic field and an electromagnetic wave are applied on the metal is calculated. The primary emphasis is on the microwave frequency range.

253

Frequency Factors in the Thermally Activated Process, R. Landauer and J. Swanson,* *Physical Review,* **121,** No. 6, 1668-1674 (March 15, 1961).

Discussions of the rate $\nu e^{-U/kT}$ for thermally activated processes are usually based on the phase-space distribution function for thermal equilibrium. Kramers has gone beyond this and for the particle in a bistable one-dimensional well has treated the relaxation to equilibrium as a Brownian motion problem in which the one-dimensional motion is coupled to a reservoir through a viscosity. Kramers' arguments are readily extendable to many dimensions. In the overdamped case the reaction rate is reduced below the value derived from thermal equilibrium theory by the factor ω_s/η, where ω_s is the angular frequency associated with the direction of steepest descent at the saddle point and η the viscosity. In the underdamped case equilibrium theory is valid for many-dimensional systems, except for extreme degrees of underdamping.

*Deceased.

Functions With a Mean Value Property, L. Flatto, *Indiana Journal of Mathematics and Mechanics,* **10,** No. 1, 11-18 (January, 1961).

In this paper we characterize those functions which satisfy a mean value property; i.e., $f(x) = \int_Y f(x+ty)d\mu(y)$. Y denotes a fixed N-dimensional set endowed with a measure μ. x, y stand for $(x_1,\ldots,x_n)$, $(y_1,\ldots,y_n)$. It is shown that this condition is equivalent to having f satisfy an infinite set of homogeneous partial differential equations of increasing order; the first equation being second-order elliptic. When Y is the sphere and μ the Euclidean measure, the higher order equations have vanishing coefficients and the first one becomes Laplace's equation. Finally, we find necessary and sufficient conditions for the finite dimensionality of the solution space.

High-Density Digital Magnetic Recording Techniques, A. S. Hoagland and G. C. Bacon, *Proceedings of the IRE,* **49,** No. 1, 258-267 (January, 1961).

The merit of any high-density detection method is ultimately dependent on the "resolution" characteristic of the magnetic recording components. Justification of readback waveform synthesis through "single pulse" superposition is given. A comprehensive, yet general readback simulation program is described which will automatically, for any characteristic pulse, simulate all possible readback signal patterns and test them for specified reading logic as a function of bit density. Amplitude, phase, peak, etc., sensing are compared and the influence of parameter variation on performance indicated. Good correlation with experiment has been realized and has greatly reduced time at the bench. The significance of pulse waveform is clearly revealed and this study has provided a guide to head design (ring and probe), permitting the optimization of a total recording system for high-density storage.

High-Speed Arithmetic in Binary Computers, O. L. MacSorley, *Proceedings of the IRE,* **49,** No. 1, 67-91 (January, 1961).

Methods of obtaining high speed in addition, multiplication, and division in parallel binary computers are described and then compared with each other as to efficiency of operation and cost. The transit time of a logical unit is used as a time base in comparing the operating speeds of different methods, and the number of individual logical units required is used in the comparison of costs. The methods described are logical and mathematical, and may be used with various types of

circuits. The viewpoint is primarily that of the systems designer, and examples are included wherever doing so clarifies the application of any of these methods to a computer. Specific circuit types are assumed in the examples.

High-Speed Automatic Diode Tester, E. V. Marrott and V. S. Zucco, *Electronics,* **34,** No. 2, 93-95 (January 13, 1961).

Ten diode parameters are tested by plug-in test packs and faulty diodes are rejected immediately following detection.

The Hygroexpansivity of Cellulose Papers, T. D. Callinan, J. S. Crimi, P. Schwartz, and L. H. Wirtz, *Annual Report, Conference on Electrical Insulation, NAS-NRC,* Publication 842, 177-179 (1961).

The hygroexpansivity of paper is important to the manufacturer of capacitors, transformers and cables because the dimensional changes which the paper undergoes during fabrication of the electrical unit affects appreciably the operational characteristics of the equipment. The results of an extensive study on the nature of hygroexpansivity and the factors which affect it are reported.

The Hyperfine Structure of ^{209}Bi, R. S. Title and K. F. Smith,* *Philosophical Magazine,* **5,** 1281-1289 (December 1, 1960).**

The hyperfine structure (H.F.S.) of the $J=3/2$ ground state of ^{209}Bi has been found by the atomic beam magnetic resonance method. Two of the three H.F.S. intervals were measured directly, giving $(W_{50}-W_{60})/h=2884.7 \pm 0.2$ Mc/s and $(W_{40}-W_{50})/h=2171.5$ 0.1 Mc/s. These results are consistent with a magnetic dipole interaction constant A of -446.97 ± 0.04 Mc/s and an electric quadrupole interaction B of -303.3 0.3 Mc/s. The latter yields an uncorrected nuclear electric quadrupole moment of -0.34 barns, and the field dependence of $\Delta F=0$ transitions gives -1.6433 ± 0.0002 for the groundstate g_J value. The results are discussed in terms of the intermediate coupling theory of Breit and Wills.

*Cavendish Laboratory, Cambridge.
**For the period October 1 through December 31, 1960.

On Internal Variable Assignments for Sequential Switching Circuits, R. Bianchini* and C. V. Freiman, *IRE Transactions on Electronic Computers,* **EC-10,** 95-96 (March, 1961).

In a recent paper, McCluskey and Unger developed the number of nondegenerate equivalence classes of state assignments which exist when v binary variables are used to designate r states. In this note, we present a method of obtaining a representative of each of these nondegenerate equivalence classes which does not require that any pair of assignments ever be tested for equivalence.

*Ford Instrument Company.

On Lagrange Multipliers and Inequalities, W. S. Dorn, *Operations Research,* **9,** 95-104 (January-February, 1961).

Necessary and sufficient conditions for minima (maxima) of nonlinear functionals subjected to linear constraints are derived. Two classes of functionals are considered: (a) convex (concave) functionals for which necessary and sufficient con-

ditions for global minima (maxima) are obtained, and (b) more general functionals possessing continuous second derivatives for which necessary and sufficient conditions for local optima are obtained. In the first case the theorems presented here are special cases of the well-known Kuhn-Tucker theorems. Some simple examples are included.

Magnetic Analysis of the Precipitation of Iron From Beta-Brass, A. E. Berkowitz and P. J. Flanders,* *Acta Metallurgica*, **8,** 823-832 (December, 1960).**

Single crystals of beta-brass containing 0.07 wt. % iron were annealed at 300°C and 400°C to precipitate the iron. At various stages in the anneals, magnetization curves, hysteresis loops and torque curves were measured. These magnetic data were analyzed in terms of the concepts of fine-particle ferromagnetism to derive size and shape distributions of the iron precipitate particles and the orientations of their crystallographic and shape symmetry axes.

In the superparamagnetic size range average diameters were determined up to 140 Å. These particles showed no shape anisotropy, and had the same saturation magnetization and magnetocrystalline anisotropy symmetry as bulk iron. The crystal habit of the particles coincided with that of the beta-brass matrix. With further annealing single-domain properties appeared, and the particles showed increasing elongation in the ⟨100⟩ directions as determined by analysis of the torque data. Distributions of shapes and sizes of the single-domain particles were calculated from remanent torque data. These calculations were consistent with the conclusions from remanence measurements. Electron micrographs of replicas gave qualitative confirmation of the conclusions from the magnetic analysis.

*The Franklin Institute, Philadelphia.
**For period October 1 through December 31, 1960.

Magnitude of the Zener Relaxation Effect — I. Survey of Alloy Systems, A. S. Nowick and D. P. Seraphim, *Acta Metallurgica*, **9,** 40-48 (January, 1961).

This paper is the first of a series dealing with the stress-induced ordering phenomenon in substitutional solid solutions, known as the "Zener relaxation effect." A brief review of the two proposed mechanisms for this phenomenon, viz., the pair reorientation theory of Zener and the directional short-range order theory of Le Claire and Lomer, is presented. It is then shown that the best test of any theory will come from a study of the magnitude of the relaxation strength and its dependence on various parameters.

With the aid of the assumption that one can assign characteristic bond lengths AA, AB and BB bonds in solid solutions, it is shown that the pair-reorientation theory predicts a relaxation strength which varies as the square of the deviation from Vegard's law. To test this prediction, data for the relaxation strength, Δ_G, of polycrystalline samples from nineteen alloy systems are compiled, together with appropriate information from lattice-parameter data. For solid solutions of the noble metals it is shown that there is no relation between Δ_G and the size factor, but that there is a rough correlation between Δ_G and the magnitude of the deviation from Vegard's law.

Magnitude of the Zener Relaxation Effect — II. Temperature Dependence of the Relaxation Strength in α Ag-Zn., A. S. Nowick and C. Y. Li, *Acta Metallurgica*, **9,** 49-58 (January, 1961).

The dependence of the magnitude of the Zener relaxation effect on temperature, T, is measured on polycrystalline samples of αAg-Zn of three compositions. The experimental results for the relaxation strength, Δ_G, are found to obey the equation: $\Delta_G = T_0/(T-T_c)$, where T_0 and T_c are constants. This equation, originally derived by Zener, is rederived here under more general assumptions. The quantity T_c, which is interpreted as the critical temperature for self-induced ordering of the alloy, is found to be equal to 175°K, 140°K and 97°K for alloys containing 33.5, 30.2 and 24.2 at. % Zn, respectively.

Magnitude of the Zener Relaxation Effect — III. Anisotropy of the Relaxation Strength in Ag-Zn and Li-Mg Solid Solutions, A. S. Nowick and D. P. Seraphim, *Acta Metallurgica*, **9,** 85-97 (February, 1961).

The anisotropy of the Zener relaxation effect is determined in face-centered cubic Ag-Zn and body-centered cubic Li-Mg solid solutions from measurements made on oscillating single crystal rods both in flexure and in torsion. The effect is found to have a high anisotropy, such that the relaxation strength Δ_G is greater for ⟨111⟩ than for ⟨100⟩ oriented crystals. This direction of the anisotropy applies to both the fcc and bcc solid solutions. The relaxation strength for a given orientation varies very nearly as the square of the solute concentration for the Ag-Zn alloy up to 30 at. % Zn. Finally, the existence of dilatational relaxation is demonstrated for the Li-Mg alloy.

Neither the pair-reorientation theory nor the directional ordering theory, which are based solely on nearest neighbor interactions, is capable of explaining the observed anisotropies. In fact, it is shown that an important role must be assigned to relaxations involving next-nearest neighbor atom pairs in order to explain the observed effects.

Magnitude of the Zener Relaxation Effect — IV. Anisotropy of the Relaxation Strength in Al — 4% Cu, B. S. Berry, *Acta Metallurgica*, **9,** 98-105 (February, 1961).

The important parameters controlling the anisotropy of the Zener relaxation in quenched and reverted Al-4% Cu (1.8 at. % Cu) have been determined from internal friction measurements in torsional and transverse vibration on ⟨100⟩ oriented single crystal specimens. A new flexure pendulum apparatus, devised for the measurements in transverse vibration, is described briefly. The results show that the anisotropy is not only much larger than is predicted by the theory of Le Claire and Lomer, but that the maximum tensile relaxation strength occurs in the ⟨100⟩ orientation, for which this theory predicts a minimum value. The pair-orientation theory of Zener is also applied to the results from this dilute alloy, and is shown to fail in the same way as Le Claire and Lomer's theory. So far, only the suggestion of Seraphim and Nowick, that the relaxation involves primarily the reorientation of second neighbor pairs, appears to be capable of explaining the observed results.

New Tables of Howland's and Related Integrals, C. W. Nelson, *Mathematics of Computation,* **15,** 12-18 (January, 1961).

This paper presents $9D$ values of four infinite integrals called Howland's integrals and $18D$ values of certain of these integrals which are useful in Hankel transform solutions of elasticity problems involving axially-symmetric loading of a thick plate of infinite radius. An $18D$ table of values of another infinite integral is included since the latter values are the starting point for computing some of the Howland integrals. An example is given to illustrate the application of Howland's integrals in evaluating a less basic integral which arises in computing the stresses in a certain elasticity problem. **255**

Neuere Untersuchungen auf dem Gebiet digitaler mechanischer Steuerungs – und Rechenelemente, (Recent Investigations in the Field of Digital Mechanical Control and Computer Components), H. H. Glaettli, *Elektronische Rundschau,* **15,** No. 2, 51-53 (February, 1961).

Performing logic operations with the aid of hydraulic elements has several interesting aspects: speed is about the same as attained by relays. As to its logic power a simple valve is superior to a transistor, but somewhat inferior to a relay. Use of plastic materials and molding technique are likely to lower the costs to a level, where multiplexing becomes feasible to increase speed. Problems to be solved by further research and development arise from certain hydrodynamic effects and requirements. The predominant role of inertia calls for careful physical layout.

Nickel-Chromium Plated Aluminum Sheet, R. C. Spooner* and D. P. Seraphim, *Metal Finishing,* **59,** No. 1, 37-41 (January, 1961).

Panels of 3S aluminum alloy, plated with bright chromium (Cu/Ni/Cr deposit) by the zincate, Vogt, and phosphoric acid anodizing preplating processes were exposed outdoors in semi-rural and severe industrial atmospheres for up to two years. Good performance, particularly in freedom from blistering or flaking was shown by panels treated by phosphoric acid anodizing, although minimum nickel thicknesses were only 1.0 mil or less. The panels processed by the zincate and Vogt techniques with nickel thicknesses less than 1.5 mils failed within a year of industrial exposure, because of severe blistering. Improved weathering resistance was shown by panels plated by all three procedures as the nickel thickness was increased. Panels for severe industrial exposure conditions require a minimum of 1.5 mils nickel. Application to aluminum alloys of recently developed nickel and superior corrosion resistance should improve considerably the service performance of chromium-plated aluminum alloys.

*Aluminum Laboratories, Ltd., Ontario.

Normal Mode Interpretation of the Sound Propagation in Whispering Galleries,* Y. Sato, *Nature,* **189,** No. 4763, 475-476 (February 11, 1961).

There are two ways of interpreting the wave propagation in a channel. Since the phenomenon of whispering galleries must be attributed to the sound propagation in a channel, there are two different interpretations, one of which was prepared by Lord Rayleigh and is given in his "Theory of Sound." His explanation is, to use present-day terminology of elastic surface waves, based on "ray theory," while another way of describing so-called "normal mode theory" is possible, and is in accord with Lord Rayleigh's interpretation.

If the velocity potential is assumed to have a form referred to polar coordinates $R \cdot \theta$ and φ

$$\phi = ([p/c]R)^{-1/2})n + \tfrac{1}{2}([p/c]R)Y_n(\theta, \varphi)\exp(ipt),$$

the solution for the case of rigid spherical boundary is approximately

$$(p/c)a = (n+0.5) + 0.79(n+0.5)^{1/3}$$

for large values of n.

The theoretical intensity distribution of sound is calculated from the above expressions and agrees well with the author's auditory observation in St. Paul's Cathedral, London. Namely, if the ear is moved about 10 inches from the wall the intensity does not change much, but after that it falls off rapidly.

*Work done at Lamont Geological Observatory, Piermont, N. Y.

Nuclear Magnetic Resonance of Fe⁵⁷ in Unenriched Fe, J. I. Budnick, L. J. Bruner, R. J. Blume, and E. L. Boyd, *Journal of Applied Physics,* **32,** No. 3, 120S-121S (March, 1961).

The nuclear magnetic resonance of Fe^{57} has been observed in Fe specimens in the form of powders of various sizes, foils, and whiskers. Our results are consistent with previously reported work of Gossard, Portis and Sandle on enriched iron, and with the work of Robert and Winter on natural iron. We find that the resonant frequency varies slightly among nominally pure iron specimens taken from different sources, suggesting that it is somewhat sensitive to impurity content. Prestrain of the specimen has a marked effect, the resonance in cold-rolled foil being very broad and weak compared to that observed in annealed foils. Observations of nuclear magnetic resonance in iron whiskers oriented both axially and transversely in the rf coil offers interesting confirmation of the domain-wall enhancement mechanism put forth by Gossard and Portis. The temperature dependence of the Fe^{57} resonance has been investigated in the range 77°K to 785°K.

Nuclear Magnetic Resonance of Ni⁶¹ in Metallic Nickel, L. J. Bruner, J. I. Budnick, and R. J. Blume, *Physical Review,* **121,** No. 1, 83 (January 1, 1961).

The nuclear magnetic resonance of Ni^{61} in unenriched metallic nickel has been observed. The results provide the first experimental measure of the internal field at the nucleus in nickel. The resonance occurs at a frequency of 26.02 Mc/sec at room temperature, yielding an estimate of 170 kilogauss for the internal field.

Nuclear Resonances in Cubic, Hexagonal, and Mixed Phase Cobalt Powders and Thin Films, W. A. Hardy, *Journal of Applied Physics,* Supplement to Vol. **32,** No. 3, 1225 (March, 1961).

A number of nuclear resonances in ferromagnetic cobalt are reported and identified as originating in HCP crystallographic structure and in associated fault structure. A tentative assignment of these lines has been made to possible stacking fault symmetries by correlating the observed resonances with metallurgical sample treatments.

Operation and Analysis of Planar Cryotrons and Simple Cryotron Circuits, G. B. Rosenberger, *Solid-State Electronics,* **1,** No. 4, 388-398 (December, 1960).*

Simple cryogenic loops containing two drive cryotrons and a number of sensing cryotrons have been constructed. Some of the operating characteristics of the individual cryotrons and the reproducibility of cryotrons with these characteristics are discussed. The speed with which current can be transferred from one branch of the loop to another has been both measured experimentally and calculated theoretically from the dimensions and various measured parameters of the loop and its cryotrons. There is found to be good agreement between theory and experiment. The loops have been run dynamically in an effort to detect thermal effects associated with heat dissipation in the resistive cryotron elements. The upper limit to the dynamic operation is currently set by the viewing equipment and, to date, no adverse heating effects have been observed.

Operation and Logic of Diode-Transistor Switching Circuits, R. B. Hurley, *Electronic Equipment Engineering,* **9,** No. 3, 196-108 (March, 1961).

Four basic types of diode-transistor logic circuits are treated for their operation mode and building-block logic. Through examples, both cascade and single-stage logic plans are illustrated.

Operation and Logic of Resistor-Transistor Switching Circuits, R. B. Hurley, *Electronic Equipment Engineering,* **9,** No. 1, 65-68 (January, 1961).

Resistor-transistor switching circuits are economical because of the low cost of resistors. They lead to building-block simplicity in logic systems because all three basic needs (mixing, inversion, and amplification) are met by a single circuit. Four basic type of RT circuits are treated for their modes of operation and their logical behavior.

Optimal Synthesis of a Communication Net, O. Wing* and R. T. Chien, *IRE Transactions on Circuit Theory,* **8,** No. 1, 44-49 (March, 1961).

This paper gives solutions to the problem of realizing a communication network at minimum cost. The network is composed of a set of nodes connected by a set of branches. Every branch has associated with it a capacity. The required amount of flow between every pair of nodes is specified. The unit costs of the branch capacities are given. The problem is to find the network and the branch capacities such that the total cost is minimum. The set of branch capacities and the set of terminal demands are shown to satisfy a set of linear inequalities. Linear programming is used to obtain the optimal solution. In the case of identical unit costs, several realizations are given which require fewer branches than previously reported.

*Now at Dept. of Electrical Engineering, Columbia University.

Order-Disorder Model Theory for the Ferroelectric Effect in the Dihydrogen Phosphates, M. E. Senko, *The Physical Review,* **121,** 1599-1604 (March 15, 1961).

A term in polarization energy is added to the Slater-Takagi model of ferroelectricity in $KH_2PO_4(KDP_H)$. This free-energy function relates the shift in Curie-point temperature due to deuteration of the compound with the measured change in saturation spontaneous polarization. The dielectric constant ε_c obtained by numerical differentiation of the free-energy function has a sharp maximum at the Curie temperature. With a change of parameters, the model also reproduces some of the details of antiferroelectric behavior.

Oscillations in the Longitudinal Tunnel Current of Tunnel Diodes, R. R. Haering and P. B. Miller, *Physical Review Letters,* **6,** No. 6, 269-271 (March 15, 1961).

The oscillations in the longitudinal tunnel current of tunnel diodes observed at low temperatures in InSb are shown to arise from the oscillation of the Fermi level in a magnetic field.

The Paradox of Education in Industry, Yates M. Hill, *IRE Transactions on Education,* **E-4,** No. 1, 3-5 (March, 1961).

Engineering education has been introduced in industry to help the engineer find a satisfying division of effort between pursuing immediate job goals and longer-term knowledge objectives. When one considers the economic objectives of industry, the objectives and responsibilities of engineers, and the effects of scientific and technological progress, the continued broad education of engineers seems a necessity.

The discussion is intended to be helpful to individual engineers in determining their own knowledge objectives in connection with "engineering" their own personal development.

Pattern Recognition Using Autocorrelation, L. P. Horwitz and G. L. Shelton, Jr., *Proceedings of the IRE,* **49,** No. 1, 175-185 (January, 1961).

A class of techniques for character recognition is described. These techniques are characterized by the property that the only parameters of the input which are used are those which are independent of the position of the character; that is, these techniques are registration invariant.

In Section I of this paper, we describe the registration-invariant mathematical formalism which underlies these techniques, and in Section II we describe in more detail the physical realization of several recognition schemes based on these concepts. Some results from our computer simulation of these procedures are given.

Photoconductivity of CdS-Type Photoconductors in the Vicinity of the Absorption Edge, N. N. Winogradoff, *Journal of Applied Physics,* **32,** No. 3, 506-509 (March, 1961).

The marked drop in photoconductivity on the high-energy side of the absorption edge in high-quantum-yield photoconductors cannot be explained satisfactorily in terms of the models based on the trapping of the free holes produced in band to band excitations. In the model described, the photocurrent is assumed to arise mainly through the excitation of electrons from discrete levels very close to the valence band. The trapped holes formed in this process are in an excited state and drop to a ground state further away from the valence band, where they are relatively stable against thermal ionization and give rise to high quantum yields.

The Physical Properties of Several II-V Semiconductors, W. J. Turner, A. S. Fischler, and W. E. Reese, *Physical Review,* **121,** 759-767 (February 1, 1961).

The physical properties of single crystals of the noncubic II-V semiconducting compounds Zn_3As_2, $ZnAs_2$, $ZnSb$, Cd_3As_2, $CdAs_2$ and $CdSb$ have been investigated. Energy gaps in these materials vary from approximately 0.13-1.0 ev. Mobilities at $297°K$ range from 10 to 15,000 cm^2/volt sec and increase at low temperature. Resistivity and mobility anisotropy have been investigated in detail for $CdAs_2$. Except for the $A_3{}^{II}B_2{}^V$ compounds high optical transmission has been observed from the intrinsic edge to approximately 30 microns.

Possible Application of Molecular Beam Techniques to the Measurement of Surface Temperature, J. H. McFee,* Paul M. Marcus, and I. Estermann,** *Review of Scientific Instruments,* **31,** 1013-1014 (September, 1960).†

Recent measurements with a precision velocity analyzer of the velocity distribution in beams of potassium atoms reflected from a surface, provide a way of measuring the surface temperature. The procedure is illustrated by a tungsten surface at $1988°K$. It could be useful for checking on pyrometric

257

methods above 2000°K, since it has the advantage of not requiring black body corrections, and for determining surface temperatures of poorly conducting materials.

*Bell Telephone Laboratories, Murray Hill, N. J.
**U. S. Office of Naval Research, London.
†For period July 1 through September 30, 1960.

Properties of Hydraulic Circuits Using Valves, H. H. Glaettli, *Digest of Technical Papers,* (Digest of the 1961 International Solid-State Circuits Conference), pp. 36-37 (February, 1961).

A simple valve represents a three-input, one-output device. It is logically superior to a transistor but inferior to a relay. The response time is in the order of magnitude of 1 to 2 msec and does not depend upon viscosity and volumetric efficiency over a wide range; it is, however, affected by the linear size and by branching. The fact that the carry propagation time is larger than the time determined by geometry and sound velocity is another consequence of the increase of the response time by branching. Cavitation represents a major limitation for the maximum repetition frequency. It is a typical nonlinear effect having no analog in electronic circuits. Other differences (inertial impedance, resistance, etc.) are mainly quantitative.

Reinterpretation of the Reaction Kinetics of Nickel Ferrite, R. C. Turnbull, *Journal of Applied Physics,* Supplement to Vol. **32,** No. 3, 3805 (March, 1961).

Recent work on the kinetics of formation of nickel ferrite has been analyzed in terms of an equation developed by Jander. He employed as a model a sphere of one component surrounded by spheres of a second component and calculated the reaction as interdiffusion of the components assuming that diffusion through the product layer was the rate determining step and as such was inversely proportional to the layer thickness. When Jander's equation is applied to experimental data, a poor fit is found both in the initial and final stages of the reaction process.

The Relation of Transition Parameters for Linear Processes to Measurable Parameters In Ferrimagnetic Resonance, P. E. Seiden, *Journal of Physics and Chemistry of Solids,* **17,** 259-266 (January, 1961).

Expressions are derived for linear processes that relate the fundamental transition parameters for relaxation in ferrimagnetic resonance to measurable parameters such as linewidths and relaxation times. These calculations include the effect of the reaction of spinwaves back onto the uniform precession. Previous calculations by others have neglected this effect and the consequences of its neglect are discussed.

Resonant Frequency Curves for Vibrating Annular Plates, W. C. Orthwein, *Machine Design,* **33,** No. 5, 121-122 (March 2, 1961).

Curves are presented for the rapid evaluation of the lowest resonant frequencies for a large class of annular plates subject to either clamped or simply supported edge conditions.

A Saturable-Core Modulation Integrator, R. C. Barker* and A. J. Gruodis, *Communication and Electronics,* **53,** 13-17 (March, 1961).

In signal transmission systems employing suppressed-carrier modulated signals, it is often desirable to operate on the modulation in order to stabilize the system or alter its performance. The circuit discussed in this paper (an illustration of techniques employing saturable-core reactors that may be used for operating directly on the modulated carrier) is based on the ability of a saturable-core reactor to convert a voltage integral to a magnetic flux and store it until called for. The experimental circuit is an integrator with a direct voltage gain of approximately 100 and a time constant of 4 seconds. In the particular circuit presented in this paper, ordinary precautions were taken to obtain a reasonable design, but no special effort was made to meet any particular specifications. The integrating circuit described herein has many features in common with other magnetic amplifier circuits. Some of the included coupling schemes may be of much wider application than in circuits designed to integrate.

*Yale University.

Semiconductor Capacitor-Input Filter Power Supplies, L. P. Hunter, *The Solid State Journal,* **2,** No. 2, 19-23 (February, 1961).

In designing a semiconductor power supply, the semiconductor power rectifier must be treated differently from a vacuum tube rectifier because semiconductor power rectifiers break down very easily from power surges. In sudden surges of current, the junction region melts and, hence, the rectifier is destroyed. Proper initial designing to limit destructive surges will protect the power rectifier from the extremely rapid fusing action caused by sudden surges. It is the maximum permissible temperature of the semiconductor junction that limits its surge rating, and diffused rectifiers have better surge tolerance than alloy rectifiers. Through the use of the curves and graphs in this article, both full-wave and half-wave rectifiers (capacitor-input filter) can be designed with protection against destructive power surges.

A Simple Arrangement for Evaporating Multilayer Films Through Masks in Ultra High Vacuum, J. P. Hoekstra and P. White, *Review of Scientific Instruments,* **32,** 362-363 (March, 1961).

A technique is described for preparation of multilayer films by evaporation through different masks in ultra-high vacuum. The masks are changed by positioning an external magnet and can be baked to 450°C without sliding surfaces binding.

The Specific Heat of the Exchange System of Some Free Radicals between 1.6° K and 4.2° K, * J. P. Goldsborough, M. Mandel,** and G. E. Pake,** *Proceedings of the VIIth International Conference on Low Temperature Physics,* G. M. Graham and A. C. Hollis Hallett, Eds., University of Toronto Press, pp. 702-706 (1961).

The contribution of the exchange system to the specific heat is measured and values of the exchange integral are estimated. In α,α-bisdiphenylene β-phenyl allyl a broad specific heat maximum at about 3°K was found. In the other free radicals the data indicated maxima at temperatures below the range investigated.

*Work done at Stanford University.
**Department of Physics, Stanford University.

Start-Oscillation Conditions in Modulated and Unmodulated O-type Oscillators, J. E. Rowe* and H. Sobol,**

IRE Transactions on Electron Devices, **ED-8,** No. 1, 30-38 (January, 1961).

The starting conditions for the O-type backward-wave oscillator are computed for large values of C, QC and d, using both digital and analog methods. A general method of solving complex polynomials called the "downhill" method is applied both to the secular equation and then to the rf voltage equation to obtain starting conditions. The analog computer is used to solve simultaneously, by trial and error method, the linear circuit and ballistic differential equations. The analog method is applied to the modulated BWO in order to determine the effects of modulations on the starting conditions. Extensive calculations of BWO starting conditions have been made for a wide range of C, QC and d.

*Electron Phys. Lab., Dept. of Elec. Engineering, University of Michigan.
**Formerly with Dept. of Elec. Engineering, University of Michigan.

Statistical Analysis of Certain Binary Division Algorithms, C. V. Freiman, *Proceedings of the IRE,* **49,** No. 1, 91-193 (January, 1961).

Nondeterministic extensions of the nonrestoring method of binary division have been described by MacSorley. One extension requires that the magnitudes of the divisor and partial remainders be "normal," i.e., in the range (0.5, 1.0). This leads to time improvement of more than two, relative to conventional nonrestoring methods. Other extensions involve the use of several divisor multiples (or trial quotients). A Markov chain model is used here to analyze these methods. Steady-state distributions are determined for the division remainder and performance figures based on both this steady-state distribution and a random distribution are calculated. These are compared with the results of a computer simulation of 2^{14} randomly-chosen division problems using two specific methods of division.

A Study of Switching in Thin Magnetic Films, W. Dietrich and W. E. Proebster, *Digest of Technical Papers* (Digest of the 1961 International Solid-State Circuits Conference), pp. 66-67 (February, 1961).

The requirements on the thin magnetic film in high-speed memory application have been investigated for two operational schemes. In the first, parallel driving fields are employed, and in the second, perpendicular driving fields. It has been found that two effects limit the parallel field mode, namely incomplete rotational switching and "creeping." For the perpendicular mode no such restrictions exist.

On Sum of Independent Random Variables with Infinite Moments and Fair Games, Y. S. Chow and Herbert Robbins,* *Proceedings of the National Academy of Science,* **47,** No. 3, 330-335 (March, 1961).

Let $x, x_1, x_2, \ldots$ be a sequence of identically distributed, independent random variables with $E|x| = \infty$. If $s_n = x_1 + \ldots + x_n$, then there exists no sequence (b_n) of real numbers satisfying the equation:

$$P\left(\lim \frac{s_n}{b_n} = 1\right) = 1.$$

This is interesting in the sense that for the Petersburg random variable x there does exist a sequence of positive numbers such that

$$\lim \frac{s_n}{b_n} = 1 \qquad \text{in probability.}$$

*Columbia University.

A System for Generating "Pronounceable" Names Using a Computer,* A. L. Leiner and W. W. Youden,** *Journal of the Association for Computing Machinery,* **8,** 97-103 (January, 1961).

In the spring of 1957, when the detailed logical design of the NBS PILOT was begun, the need arose for choosing a satisfactory set of names for the more than 15,000 internal signals generated throughout the machine. Finding a satisfactory system for selecting these names was particularly important because automatic techniques were to be used for converting the logical design into fabrication plans. The nomenclature system had to be compatible with these automatic techniques; at the same time, it had to conform to the existing habits of the logical designers. A compromise system, in which pronounceable names were generated by a formula on a computer, was developed and used successfully at NBS for the past three years.

*Written at Bureau of Standards.
**Bureau of Standards.

Temperaturabhängigkeit magnetischer Eigenschaften in dünnen Permalloy-Schichten (Temperature Dependence of Magnetic Properties in Thin Permalloy Films) A. Segmüller, *Zeitschrift für angewandte Physik,* **13,** No. 3, S154-157 (March, 1961).

On thin evaporated films of 80% Ni-20% Fe the temperature dependence of the coercive force for wall motion and of the uniaxial anisotropy was measured. It was shown that the fast magnetic annealing described earlier in the literature is due to the high amount of imperfection and impurities in the film. After short annealing at a temperature above 400°C the film shows the same magnetic annealing kinetics as bulk permalloy.

Theoretic Curves of Drift Transistor Current Gain, G. E. Terner, *IRE Transactions on Electron Devices,* **ED-8,** No. 1, 13-15 (January, 1961).

Intrinsic common-base, short-circuit current gain analysis of drift transistors may be aided by means of a simplified approximation equation developed herein. The accuracy of the equation may be controlled by the investigator. A graphic solution for determining this parameter (current gain) of moderate drift transistors may be obtained by using the arcs of circles. The interrelation between the graphic analysis and the theoretic approximation provides a flexible, yet accurate, method of analyzing this parameter.

Theory of Solubility of Interstitial Impurities in Germanium and Silicon, K. Weiser, *Journal of Physics and Chemistry of Solids,* **17,** No. 1/2, 149-161 (January, 1961).

A theory of solubility is developed which is based on estimating the change in free energy when an impurity is placed in an interstitial site in the lattice. Two distinct cases are considered, namely the case of the impurity remaining electrically neutral, and the case of the impurity becoming an ionized donor. The species which results in the greater gain in free energy will be predominant in the lattice.

On the Theory of Word Frequencies and on Related Markovian Models of Discourse, B. Mandlebrot, *Proceedings of Symposia on Applied Mathematics: Sympo-*

259

sium on the Structure of Language and its Mathematical Aspects, **12,** 190-210 (March, 1961).

The paper is principally devoted to a variety of topics related to our model for the law of word frequencies of Estoup and Zipf. In particular, it is shown that the model can be re-worded in synchronic terms. A section is devoted to criticism of certain attempts to apply the lognormal probability distribution to data on word frequencies. The final section is devoted to a discussion of the scope of the term "linguistics."

Transient Analysis of Cryotron Networks by Computer Simulation, M. K. Haynes, *Proceedings of the IRE,* **49,** No. 1, 245-257 (January, 1961).

A general method is derived for transient analysis of complicated nonlinear dynamical systems by use of a digital computer programmed to perform tensor transformation and numerical integration. Tensor methods, adapted from Kron's techniques, are used for converting circuit data into a form for transient simulation by numerical integration.

An IBM 704 program has been written for simulation of cryotron networks. This simulator has been used to study switching speeds of cross-latched cryotron flip-flops; five-stage, free-running, ring circuits; and a three-bit, self-timing, self-checking, binary, parallel adder. The adder circuit contains 233 circuit elements, including 93 cryotrons arranged in 55 meshes. Results of these studies are included.

Transistorisierter Analog-Digital Konverter für hohe Tastfrequenzen (Transistorized Analog-Digital Converter for High-Impulse Frequencies), K. Grieder, *Elektronische Rundschau,* **14,** No. 10, S401-402 (October, 1960).*

An analog-digital converter for a maximum impulse frequency of 40 kc is described. In order to convert the measured analog signal into a digital value, the length of a pulse is modulated proportional to the voltage to be measured. Modulation takes place by comparing a sawtooth-voltage with the signal to be measured in a comparator. The length of the pulse is counted out, in the recognized manner, by means of a generator which in our case has a frequency of 8 Mc/s. Signals were measured between $+2$ v and $+12$ v with a tolerance of $\pm 1\%$, whereby the maximum measuring time of the sawtooth is 20 μsec.

*For period October 1 through December 31, 1960.

Unidirectional Properties in Iron-Iron Sulfide System, I. M. Croll, J. H. Greiner, and M. Sulich, *Journal of Applied Physics,* Supplement to Vol. **32,** No. 3, 188S-189S (March, 1961).

In a study of unidirectional properties, iron particles, formed by decomposition of the formate, were reacted with H_2S at 350°C. Compacts of the powder, when cooled in a magnetic field, displayed sin θ variation of the torque and a non-vanishing rotational hysteresis for applied magnetic fields $>2K/I_s$. Subsequent investigations have been made on the temperature dependence of the sin θ term, maximum torque, and rotational hysteresis as a function of increasing field. Torque curves were measured for applied fields up to 7,000 oe at temperatures between 25° and -196°C. Maximum torques of 10^6 to 10^7 dyne-cm/cm^3 of Fe were measured at -196° and 7,000 oe.

Two interesting effects occur at the higher temperatures with high fields: (1) the sin θ term disappears with a large

rotational hysteresis remaining, and (2) the unidirectional axis can be rotated from the original direction obtained by cooling in a magnetic field. These two features, which are different from other reported systems, will be discussed in the light of previous theories. A model is proposed to explain the observed behavior in the iron-iron sulfide system based on a rotation of the Fe-FeS coupled spins at the higher temperatures.

Unit Cell and Space Group of $NiK_2(SO_4)_2 \cdot 6H_2O$, J. E. Weidenborner, I. Tsu and L. E. Godycki, *Acta Crystallographica,* **14,** Part I, 63 (January, 1961).

The unit cell and space group are reported, and powder diffraction data are tabulated, for $NiK_2(SO_4)_2 \cdot 6H_2O$, one of the tutton salts. X-ray single crystal methods were employed in the space group determination. Weisenberg and precision photographs indicate monoclinic symmetry; space group $P2/c - C^5 2h$, with lattice constants $a = 6.30 \pm 0.002$Å, $b = 12.185 \pm 0.004$Å, $c = 8.991 \pm 0.002$Å, and $\beta = 104°59^1 \pm 3^1$. The axial ratios calculated from these data are 0.5031:0.7379.

Use of a Superconducting Transmission Line for Measuring Penetration Depths, D. R. Young, J. C. Swihart, S. Tansal, and N. H. Meyers, *Solid-State Electronics,* **1,** 378-380 (September, 1960).*

In a transmission line using superconducting films in which the thicknesses are comparable to the penetration depth, the penetration effect markedly influences the characteristics of the line. The theoretical predictions are given for this effect. The results of preliminary measurements using this effect to measure the penetration depth in a superconductor are also given.

*For period July 1 through September 30, 1960.

Visible Luminescence of Rare-Earth Yttrium Gallium Garnets, S. P. Keller and G. D. Pettit, *The Physical Review,* **121,** 1639-1648 (March 16, 1961).

Yttrium gallium garnet ($Y_3Ga_5O_{12}$) has been prepared with small percentages of different rare earths substitued for yttrium. Garnets activated with Pr, Sm, Eu, Tb, Dy, Ho, Er, and Tm are all luminescent. The emission and excitation spectra of the samples have been measured at 77°K. The data have been analyzed in terms of the atomic energy levels of the impurity ions and the effects of crystalline field and of phonon interactions. Wherever possible, comments are made about whether the crystal field can be treated as possessing cubic or lower symmetry.

Voltammetric Determination of Cobalt and Nickel in Hard Magnetic Alloys, R. D. DeMars, *Analytical Chemistry,* **33,** 324-344 (March, 1961).

A rapid, accurate, and extremely precise method for the simultaneous determination of nickel and cobalt in hard magnetic alloys using the techniques of voltammetry with continuously varying potential is described. The current-voltage curves in solutions containing pyridine and potassium chloride were obtained with an all-purpose voltammetric instrument based on analog computer amplifiers. The method was applied to the analysis of mixtures of cobalt and nickel in standard and unknown solutions.

260