

January through March 1960

IBM Technical Papers Published in Other Journals

Coercive Force of Pure Iron Films Evaporated in Ultra-High Vacuum, R. Jaggi and C. Schüller, *Helvetica Physica Acta*, **32**, 486-487 (November/December, 1959). (In German.)

In a vacuum of about 10^{-9} mm Hg spectroscopically pure iron is evaporated on a glass substrate. The coercive force is measured by means of a BH-loop tester at 50 cps. A Barkhausen spectrum is observed for all thicknesses between 100 Å and 1300 Å. If the measurements are taken in air, the coercive forces pass through a maximum between 400 Å and 600 Å; with increasing substrate temperature, the coercive forces decrease. The domain structure is complicated; single-domain behavior is not observed. Experiments to measure the magnetic and structural properties of films during evaporation are in preparation.

Computer Design for Reliability, W. N. Carroll, *Electronic Equipment Engineering*, **1**, 69-72 (January, 1960).

This article describes the basic circuits which are used in the RTA Computer which has been built by the Federal Systems Division of IBM. This computer, employing 20,000 high-speed PNP transistors and having three-volt signal levels and 35 μ sec pulses, is designed to operate at a 6.23-Mc clock rate and handle instructions at a rate of 300,000 to 500,000 per second.

A brief resume is presented of the computer characteristics, and the reliability, packaging and other factors which influenced the circuit design are described. The two basic circuits, pulse and saturating dc circuits and their modifications are described in detail. Inverters, flip-flops, pulse gates, slave gates, OR pulse amplifiers, and pulse amplifiers are discussed. Circuit schematics are presented along with a detailed description of the operating and design characteristics. The article also describes the operation of these circuits in a logic application.

Detailed Study of Switching Current in BaTiO₃, M. E. Drougard, *Journal of Applied Physics*, **31**, 352-355 (February, 1960).

The polarization reversal process in ferroelectrics up to now has been characterized solely by the total switching time and the maximum value of the switching current. The work presented in this paper was aimed at determining how the instantaneous value of the switching current in single crystals of BaTiO₃ depends on the applied field, the state of net polarization of the crystal, and possibly other factors. It has been found that the switching current density can be expressed as the product of a function of the polarization $\phi(p)$, and a function of the electric field, $\exp(-\alpha/E)$. The form of the function $\phi(p)$ indicates a predominance of sideways expansion of 180° domains, with an exponentially increasing domain-wall velocity. This last result is shown to be in agreement with a picture of domain-wall motion by nucleation of new domain-wall layers. This interpretation, together with some details of the switching current pattern, suggests that a crystal, although apparently single-domain, may always retain some small domains of opposite polarization.

The Dielectric Constants and Loss Factors of Some Natural Waxes, T. D. Callinan and A. M. Parks, *Annual Report Conference on Electrical Insulation, NAS NRC*, **756**, 45-49 (1959).

Measurement of the dielectric constants and loss factors at frequencies of 100 to 100,000 cps and at temperatures of -60°C to 100°C has established the essential structure of carnauba, montan and ouricuri waxes. The data indicate that the ω -hydroxyacid esters of which the waxes are largely composed are extended and strongly hydrogen bonded at room temperature. As the temperature is increased, the hydroxyl groups become sufficiently separated so that rotation about the long axis may occur without destroying the crystal form. When finally the melting temperature is reached, the chains break apart. A direct relationship between increasing dielectric constant and decreasing hardness in the waxes is indicated. Dielectric measurements are used to distinguish between different samples of the same wax.

Eddy Current Dynamometer for Testing Small Components, B. A. Kohler, *Machine Design*, **32**, 140-143 (February 18, 1960).

This article describes the design considerations, function, and application of an eddy current dynamometer for life testing of small shaft components. By varying the magnetic field, different loads can be applied to components while operating according to life-test specifications.

Effect of Hydrostatic Pressure on the Ferroelectric Properties of Tri-Glycine Sulfate and Selenate,* F. Jona and G. Shirane,** *Physical Review*, **117**, No. 1, 139-142 (January 1, 1960).

The Curie temperatures of tri-glycine sulfate and isomorphous tri-glycine selenate are raised linearly by the application of hydrostatic pressures up to 2,700 atm. The Curie-Weiss law is unaffected by pressure except for the shift in Curie temperature. The results are discussed in terms of the thermodynamic theory of ferroelectrics.

*Work done at the Westinghouse Research Laboratory.

**Westinghouse Research Laboratory.

EJCC Impressions, M. Grems, *Datamation*, **6**, No. 1, 23-25 (January/February, 1960).

The various activities connected with the recent 1959 Eastern Joint Computer Conference in Boston are described. A few highlights of the conference such as the evening discussion groups and the Award dinner are discussed. The article reflects the opinion of the audience toward these and other activities. Communication is one of the difficult problems associated with any conference; therefore feedback from the audience is important to help guide the planning of future programs.

The Electrical Properties of Select Fractions of Cellulose Pulps, T. D. Callinan, *Annual Report Conference on Electrical Insulation, NAS-NRCC*, **756**, 51-55 (1959).

The study reported here is concerned with the variations in electrical properties observed on sheets of paper made from different lengths of fiber taken from the same pulp. It is also concerned with differences in the electrical properties of sheets of paper made from the same size fibers taken from different pulps.

Each pulp was fractionated in a Bauer-McNett separator according to TAPPI standard T233sm-53. Handsheets were prepared from the pulp fractions of a Noble and Wood sheet machine; the pulp was dispersed by means of a Waring blender with a minimum of attrition. The electrical properties of the handsheets were determined from capacitance, dissipation factor and dc resistance measurements using an Endicott cell.

These studies suggest that the variation in electrical properties of cellulose papers arise from variations in the sizes of the constituent fibers (as well as from more classical differences in chemistry).

Electron Spin-Lattice Relaxation in Phosphorus-Doped Silicon,* A. Honig† and E. Stupp, *Physical Review*, **117**, No. 1, 69-83 (January 1, 1960).

Electron spin-lattice relaxation in phosphorus-doped silicon has been investigated over a magnetic field range of 0 to 11,000 oersteds, a temperature range of 1.25° to 4.2°K, and a concentration range of 10^{14} P/cc to 3×10^{16} P/cc. Three distinct τ_s ($\Delta m_s = \pm 1$, $\Delta m_l = 0$) relaxation mechanisms have been identified, and their functional dependences on magnetic field, temperature, and concentration have been determined.

The theoretical origins of the mechanisms are discussed. A theory is proposed to explain the concentration-dependent τ_s mechanism, according to which rapidly relaxing close pairs of phosphorus atoms, which are few in number, relax in the spins of the large number of isolated phosphorus atoms via a spin diffusion process. Experiments supporting this hypothesis are presented.

*Research performed at Syracuse University.

†Syracuse University.

The Execute Operations — A Fourth Mode of Instruction Sequencing, F. P. Brooks, *Communications of the ACM*, **3**, 168-170 (March, 1960).

Instruction sequencing modes include normal sequencing, branching, interruption, and use of Execute operations whereby an addressed instruction is executed out of its normal sequence. Execute operations essentially serve as calling sequences for one-instruction subroutines, and this property suggests a variety of applications. The two Execute operations provided in the STRETCH computer are described.

Far Infrared Electron-Ionized Donor Recombination Radiation in Germanium, S. H. Koenig and R. D. Brown, III, *Physical Review Letters*, **4**, No. 4, 170-173 (February 15, 1960).

Long-wavelength infrared radiation ($\sim 10\mu$) resulting from the recombination of "hot electrons" in the conduction band of germanium with ionized donor impurities has been detected by observing the photoconductive response of a second sample of germanium.

Geometrical Representation of the Maxwell Field in Minkowski Space, E. S. Lowry, *Physical Review*, **117**, No. 2, 616-618 (January 15, 1960).

The electromagnetic field tensor of a classical charged particle is associated with the orientation and density of a family of two-dimensional surfaces radially distributed about the world line of the particle in Minkowski space.

High Speed Magnetic Film Logic, W. E. Proebster and J. J. Oguey, *Digest of Technical Papers — 1960 International Solid State Circuits Conference, Philadelphia*, pp. 22-24 (February, 1960).

Thin permalloy films with uniaxial anisotropy can be switched in about 1 μ sec by moderate pulse fields. An all-magnetic switching system is proposed, based on pulse-signal amplification by the film itself. The operation of the basic cell, of shift registers and logical circuits are discussed.

Information Gaps and Traps in Engineering Papers, H. B. Michaelson, *IRE Transactions on Engineering Writing and Speech*, **EWS-2**, No. 3, 89-92 (December, 1959).

An analogy to the energy band structure in semiconductors is given. An "information gap" corresponds to the forbidden gap in semiconductor theory and an "information trap" corresponds to the trapping states of impurity atoms. Illustrative examples of gaps in manuscripts are poor reader orientation, lack of proper information in illustrations, and inadequate conclusions. Examples of traps are semantic confusions, superfluous illustrations which obscure the issues, and critical points of the paper which are "buried" in the manuscript.

Infrared Absorption in n-Type Aluminum Antimonide, W. E. Reese and W. J. Turner, *Physical Review*, **117**, No. 4, 1003-1004 (February 15, 1960).

The optical absorption constants of tellurium- and selenium-doped n-type AlSb have been determined in the spectral region 0.7-38 microns at 300° and 78°K. A 4.3-micron band exists at 300°K for which the absorption constant varies linearly with electron concentration. This band may be explained by a 0.3 ev spin-orbit split off conduction band or alternatively by a multivalleyed conduction band with a central minimum 0.3 ev above the lowest minima. A transition from the highest valence bands to the lowest conduction level could account for the observed absorption starting at 1.33 ev. At wavelengths greater than 8-10 microns free carrier absorption exists with a λ^2 dependence and a calculated effective mass of 0.3 m. Lattice bands are present at 11.2, 13.5, 16.5, 22.5, 28 and 29.6 microns.

Magnetic Fields of Square-Loop Thin Films of Oblate Spheroidal Geometry, H. Chang, *IRE Transactions on Electronic Computers*, **EC-8**, No. 4, 458-464 (December, 1959).

Thin films of Ni-Fe alloy may be prepared to be anisotropic and exhibit square-loop M-H characteristics. In films that are single-domained with flux changes involving only rotation of intrinsic magnetization, controlled by cross-magnetization fields, very fast switching action can be obtained for storage and logic functions.

Problems of coupling to the flux changes and interaction in an array of such films require study of the magnetic-field distribution. In the treatment given, a circular single-domain thin-film is represented by a very flat oblate spheroid. The field distribution outside the spheroid is found assuming that

the magnetic properties are characterized by an intrinsic magnetization M , which is constant in magnitude but varies in direction depending on field and energy considerations.

Calculation of the field distribution is given for a typical film with diameter-to-thickness ratio of 10^5 . From the regions over which field changes are most significant, conclusions are drawn as to the proper size of sensing loops and spacing to avoid interaction during switching in film arrays.

Markovian, Non-Additive Stable Processes with a Non-Symmetric Stable Law, in Continuous Time, Benoit Mandelbrot, *Comptes Rendus de l'Académie des Sciences, Paris*, **250**, 451-453 (January 18, 1960). (In French.)

The previous work of the author on stable non-additive stochastic processes is generalized from a discrete to a continuous time variable. The importance of infinitely divisible laws in this context is emphasized. These processes fall outside of the most general available theory of random functions and have a great importance in economics. In a final section, the behavior of a stable, maximally skew probability distribution is investigated in the region of large negative values.

Means, Methods and Possibilities of Data Processing, A. P. Speiser, *Bulletin des Schweizerischen Elektrotechnischen Vereins*, **2**, 312 (January 30, 1960). (In German.)

Electronic data processing machines consist of simple basic circuits using vacuum tubes, transistors and magnetic cores. They contain storage devices which can register 10^7 and more binary digits. It is to be expected that, in the future, the fastest machines will have a pulse frequency of the order of 1000 Mc, and will include basically new elements, such as the cryotron. Besides mathematical problems, non-numerical applications are becoming increasingly important, such as, for example, the retrieval of stored information. The current demands on programmers can be reduced to a bearable degree only by means of automatic programming.

Measurement of Lattice Constants of Stressed Samples with a Seemann-Bohlin Focusing Geiger Counter Diffractometer, Armin Segmueller* and Peter Wincierz, *Archiv fuer das Eisenhuettenwesen*, **30**, No. 9, No. 2025, 577-580 (September, 1959). (In German.)

The precipitation in a supersaturated 2% copper-iron alloy was investigated by X-ray measurement of lattice constant. Because the sample was quenched after homogenization and annealing treatment, stresses were generated. The lattice distance was elongated in the direction perpendicular to the surface, and shortened parallel to the surface. There is a line of zero distortion between both of these directions. In a Seemann-Bohlin camera, the angle of incidence on the sample can be changed without loss of focusing conditions. Therefore a geiger-counter diffractometer according to this focusing principle is most suitable for measuring lattice constants without distortion. Measurements are made with a precision of 0.0001 Å.

*Work performed at the Metallurgical Department of the Bergakademie (Institute of Technology for Mining and Metallurgical Engineering), Clausthal, Germany.

Measurement of the Penetration Depth of Magnetic Fields in Superconducting Tin Films, R. Jaggi and R. Sommerhalder,* *Helvetica Physica Acta*, **33**, 1-20 (January, 1960). (In German.)

The penetration depth of magnetic fields in superconducting tin films was measured. The films, 400-2000 Å thick, were evaporated *in vacuo* and had the form of hollow cylinders. A magnetic field was externally applied parallel to the axis of the cylinder, and the magnetic field which penetrated through the films into the interior of the hollow body was detected. It is found that there are departures from the law

$$\lambda(T) = \lambda(0) [1 - (T/T_c)^4]^{-1/2}$$

which is in agreement with Lewis' extension of the Casimir-Gorter two-fluid model and with the theory of Bardeen, Cooper, and Schrieffer. The absolute value of the London penetration depth at $T=0^\circ\text{K}$ is found to be $\lambda(0) = 700 \pm 100$ Å for the thickest films, and increases with decreasing film thickness.

*Work performed at the Physics Department, ETH (Swiss Federal Institute of Technology), Zurich.

Millimicrosecond Magnetization Reversal in Thin Magnetic Films, W. Dietrich and W. E. Proebster, *Elektronische Rundschau*, **14**, No. 2, 47-49 (February, 1960). (In German.)

A special pulse equipment including a pulse sampling oscilloscope with an overall response time of 0.35 nsec (10^{-9} sec) for the observation of the millimicrosecond flux reversal in thin permalloy films is described. Output signals as short as 1 nsec have been obtained and are discussed with respect to the underlying reversal processes. Inverse switching times versus driving field curves have slopes of about 10^8 per oe-sec. Coherent rotation and oscillation of the magnetization have been clearly detected by picking up the flux change transverse to the driving field.

Minority Carrier Current in a Linearly Graded Drift Field, D. P. Kennedy, *Journal of Applied Physics*, **31**, No. 1, 218-219 (January, 1960).

Investigations have been made into the influence of a linearly graded drift field upon the magnitude of hole current in an n -type semiconductor. The hole current is established for a field directed to aid or oppose the current resulting from diffusion alone. Further, this current is shown, for each direction of field, when the source of minority carriers is located at the point of maximum drift field and at the point of minimum drift field.

In an aiding field, it is shown that a significantly larger magnitude of hole current exists when the minority carrier source is located at the point of maximum drift field. In an opposing drift field, however, an approximately equal magnitude of minority carrier current results whether the minority carrier source is located at the point of minimum or maximum drift field.

A New Device Using the Tunneling Process in Narrow p - n Junction, L. Esaki and Y. Miyahara,* *Solid-State Electronics*, **1**, No. 1, 13-21 (March, 1960).

The design, fabrication and electrical characteristics are discussed of a new device, the "Esaki diode" or "tunnel diode," made of heavily doped Si or Ge for use as an active circuit element. The device is essentially a single, narrow p - n junction made by alloying techniques, and the dc negative resistance in its characteristic arises from a tunneling process across the junction, which makes the device inherently capable of working at very high frequencies.

*Sony Corporation, Tokyo.

Nonideal Diodes and Practical Function Generators, E. J. Galli, *Control Engineering*, 7, No. 2, 107-109 (February, 1960).

Basic circuits for electronic function generation utilizing diodes have been described in an earlier article ("How Diodes Generate Functions," March 1959, pp. 109-115), which considered the diodes as having ideal characteristics. This article discusses the effects of the nonideal diode characteristics and describes the most important universal diode function generators available commercially.

A Note on Smooth Interpolation, T. J. Rivlin, *SIAM Review*, 2, 27-30 (January, 1960).

In a previous paper (*SIAM Review*, 1, 60-63) a method was suggested for interpolation by polynomials of increasing degree which minimized oscillation and which we called "smooth interpolation." In this paper it is proved that this process converges to straight-line interpolation.

Nuclear Spin-Lattice Relaxation in Metals, A. G. Anderson and A. G. Redfield, *Physical Review*, 116, No. 3, 583-591 (November 1, 1959).

The nuclear spin-lattice relaxation time, T_1 , has been measured in the range of 1.1° to 4.2°K for the metals lithium, sodium, aluminum, and copper. A combination of nuclear magnetic resonance at fixed frequency and adiabatic variation of the magnetic field was used to measure T_1 as a function of field between zero and 1000 gauss. At fields of between 100 and 1000 gauss T_1 is independent of magnetic field and inversely proportional to temperature, in agreement with theory. The experimental values of the relaxation time multiplied by absolute temperature in sec°K are 44 ± 2.0 for Li⁷; 5.1 ± 0.3 for Na²³; 1.80 ± 0.05 for Al²⁷; 1.27 ± 0.07 for Cu⁶³. These values are in good agreement with previous experimental data at room temperature and above. At fields comparable with the nuclear magnetic dipole-dipole fields, T_1 is a function of applied field. The theory of relaxation in low fields is presented in an elementary form. Qualitative agreement with theory is obtained for Al²⁷ and Cu⁶³; detailed agreement is obtained for Li⁷ and Na²³.

Observation of the Energy Gap by Low-Temperature Penetration Depth Measurements in Lead, M. Sarachik, R. L. Garwin and E. Erlbach, *Physical Review Letters*, 4, No. 2, 52-55 (January 15, 1960).

By a sensitive measurement of the penetration of 2.2-Mc/sec magnetic fields through thin superconducting lead films, we have been able to demonstrate the effect of the existence of an energy gap on the low-temperature behavior of the penetration depth. The data are compared with curves predicted by the BCS theory and indicate a gap greater than $4.9 kT_c$. This value is compared with the value of $3.5 kT_c$ predicted by the BCS theory and the value of $4.1 kT_c$ obtained by more direct measurements.

On Coefficients of Polynomials in Network Functions, S. L. Hakimi and W. Mayeda, *IRE Transactions on Circuit Theory*, CT-7, 40-44 (March, 1960).

This paper presents a study of the relationships between the missing powers of polynomials in network functions and the network geometry. The elementary transformation of trees and the 2-trees of a network are introduced to obtain the necessary and sufficient conditions for polynomials in network functions to have missing powers. It is shown that the poly-

nominal in the numerator of the transfer function of a grounded two-terminal-pair RLC network cannot have two successive missing powers unless some common factors of the numerator and the denominator are cancelled. This result is useful in topological synthesis where one must usually restore all the necessary surplus factors before deciding on the minimum number of vertices and the geometry of the network.

On the Nature of Electrical Conductivity in Germanium at Low Temperatures; Non-Equilibrium Bulk and Contact Phenomena, S. H. Koenig, *Solid State Physics in Electronics and Tele-Communications*, 1, pt. 1, 422-431 (1960).

The response, below 10°K, of a sample of *n*-germanium to a time dependent applied voltage (e.g., sinusoid or step function) can be understood when it is realized that the energy that an electron may gain, between collisions, from a relatively small (~ 1 volt/cm) applied electric field can be greater than the average energy loss per collision, so that the electron distribution can readily acquire a mean energy $\geq 100^\circ\text{K}$. Since the binding energy of Group V donors is $\sim 100^\circ\text{K}$, the possibility exists of a significant amount of impact ionization of neutral donors by these "hot" electrons, producing more carriers.

The electron distribution function follows changes in electric field in a time $< 10^{-9}$ sec, which is much smaller than the time constant for change of carrier density, so that the response of a sample for longer times is determined by the time rate of change of carrier density only.

The nature of a typical soldered contact is such as to cause a time delay in attaining "breakdown" currents, this delay varying from 10^{-8} to 10^{-3} sec according as the over-voltage that is applied. The delay appears to be associated with a rate-limiting process at the negatively biased contact (for *p*- or *n*-type material) which prevents more than a small, temperature dependent, initial current from flowing until an appropriate change occurs in the space charge distribution at the contact. A physical model is presented in terms of which the phenomena discussed above and their variation with donor and acceptor density and temperature may be readily understood. In addition, various modes of operation of a two-terminal sample are discussed to demonstrate the many novel circuit elements that may be achieved by such operation.

On the Possibility of Hydraulic Digital Control Elements, H. H. Glaettli and H. R. Mueller, *Zeitschrift fuer angewandte Mathematik und Physik (ZAMP)*, 11, 73-75 (January, 1960). (In German.)

Representative figures for hydraulic logic elements are given. A valve compares favorably with a transistor as to its logic power, and is slightly inferior to a relay. The dependence of the response time on the geometric size and the influence of the viscosity are discussed.

On Unequal Partitions of Integers, Iwao Sugai,* *Mathematics Magazine*, 33, No. 3, 129-138 (January, 1960).

This is an extension of Pythagoras' idea to express i^2 (i : positive integer) as the sum of i odd numbers. A slightly generalized idea is to express i^n (n : positive integer) as the sum of i distinct positive integers, say $A_{n,i,m,s}$ which have zero n -th finite differences with respect to m and i when m runs from 1 to i , and i runs from 1 to infinity for a fixed n . Under such conditions which include Pythagoras' case, the total number of ways of partition of i^n in i parts is 3.2^{n-3} , ($n \geq 3$).

*Now at ITT Laboratories, Nutley, N. J.

The Optimum Reject Allowance Problem, R. E. Levitan, *Management Science*, **6**, No. 2, 172-186 (January, 1960).

The problem of specifying an allowance for defects in a production lot is that of balancing the cost of producing too many items against the risk of not having enough to meet requirements. A model of these costs is here proposed.

Sufficient conditions are developed on the probability distribution of defectives for total cost to have a single minimum with respect to the allowance. A sequential algorithm is investigated and shown to produce an optimum allowance if certain further conditions on the probability are met. Next, it is shown for a special class of probability distributions that the above conditions are satisfied. This class is that for which the probability of an item being defective is independent of previous defects in the lot, and includes the binomial distribution. Finally some computational aspects of this algorithm are discussed, and an easily computable starting value is given.

Parametric Amplification Along Nonlinear Transmission Lines, R. W. Landauer, *Journal of Applied Physics*, **31**, No. 3, 479-483 (March, 1960).

A pump signal propagating along a dispersionless transmission line with a distributed nonlinear capacitance is subject to deformation, since different parts of the signal move with different velocities. This process of deformation will eventually result in the formation of an electromagnetic shock wave. The deformation will affect the parametric amplification process. If a small signal consisting of a positive pulse, short compared to the pump cycle, is added to the pump signal at the input end, then it is shown that the small signal at the output must be non-negative. All other small signals, including in particular those with sinusoidal time variation, can be regarded as superpositions of these short pulses. As a consequence it is shown that, in general, a sinusoidal signal will not be increased in its fundamental frequency component by traveling down the line together with the pump signal. There are certain exceptional frequencies, multiples of one-half the pump frequency, where a suitably phased small signal may be increased at its fundamental frequency but not by a sufficient amount to be of practical interest.

Partial Switching, NDRO, Storage Systems, W. L. Shevel, Jr., and O. A. Gutwin, *Digest of Technical Papers—1960 International Solid-State Circuits Conference*, pp. 62-63 (February, 1960).

The partial switching technique, rotational switching mode, and a NDRO technique are employed using ferrite toroids to yield word-oriented storage systems characterized by high NDRO rates and short clear-write cycle times. Experimental arrays are discussed which have cycle times as short as 50 μ sec and one/zero nondestructive readout ratios of three.

Permanent Magnet for Atomic Beam Focusing, R. L. Christensen and D. R. Hamilton,* *Review of Scientific Instruments*, **30**, 356 (May, 1959).

A compact six-pole permanent magnet useful for focusing of atomic beams is described, together with the equations of motion of atoms in its field as used in its design. The method of construction, magnetization, and measurement of its field are discussed.

*Princeton University.

Pressure Dependence of the Current-Voltage Characteristics of Esaki Diodes, S. L. Miller, M. I. Nathan, and A. C. Smith,* *Physical Review Letters*, **4**, 60-62 (January 15, 1960).

Measurements of the pressure dependence of the current-voltage characteristics of germanium Esaki diodes are reported. For diodes which show predominantly phonon-assisted tunneling, it is found that the tunneling current varies exponentially with the first power of the energy gap. For diodes with non-phonon-assisted tunneling the dependence of the tunneling current on band structure appears to be more complicated. Measurements of the "ordinary diode current" in the forward direction indicate that the pressure variation of the energy gap is approximately the same for degenerate material and pure germanium.

*Massachusetts Institute of Technology, Cambridge.

A Proposal for Character Code Compatibility, R. W. Bemer, *Communications of the ACM*, **3**, No. 2, 71-72 (February, 1960).

A method is suggested for phasing out the many old character code sets in existence. This is vital to the adoption of a new logical code set, particularly for data processing. The concept is to have parallel standards, such as Baudot, Fieldata, IBM, et cetera, but to be able to move dynamically from one standard to another by reserving in each set a single character which has no other function but to signal an "escape" mode. The subsequent character (although it normally has other significance in the set) then identifies the particular standard which is to be in force. It is thus possible to have 2^T different sets of 2^T characters in a T -track code.

Pseudodipolar Anisotropy in Cubic Ferromagnets at Low Temperatures,* S. H. Charap** and P. R. Weiss, *Physical Review*, **116**, No. 6, 1372-1380 (December 15, 1959).

The first-order anisotropy constant, K_1 , of a cubic ferromagnet with spin $1/2$ per atom is calculated as a function of temperature at low temperatures. The source of this anisotropy is taken to be the nearest neighbor pseudodipolar spin-spin interaction and the spin-wave approach of Dyson is used. It is shown that K_1 varies as the tenth power of the magnetization, itself a function of the temperature. In order to explain the experimental value of K_1 for nickel at $T=0$ the strength of the dipolar interaction must be ~ 300 times the classical value. Previous calculations by Van Vleck, Van Peipe, and Tessman are compared with the present work on the ground state. Only the work of Van Peipe accounts properly for the exchange and is in complete agreement with the present investigation. The perturbation scheme of Van Peipe is shown to be rigorously correct, the wave function converging to an exponential form.

*This work was supported in part by the Rutgers Research Council, The Office of Naval Research and Radio Corporation of America.

**Based on Ph.D. thesis, Rutgers University. Now at IBM Research Laboratory, Poughkeepsie.

Riccati's Nonlinear Differential Equation, Iwao Sugai,* *American Mathematical Monthly*, **67**, No. 2, 134-139 (February, 1960).

There has been only one transform for a generalized Riccati's nonlinear differential equation which appears often in W.K.B. method, non-uniform transmission line and in aerodynamic problems. The transform due to Count Riccati is in essence a logarithmic derivative of an arbitrary function. A new trans-

form has been uncovered which is in essence the inverse of the old transform. However, this new transform is more advantageous in dealing with nonhomogeneous, higher degree, first-order differential equations. These two transforms are superior to the transform by Libnitz for the Bernoulli's nonlinear differential equation.

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Ripple-Type Time-Delay Networks Using Elliptic Functions, J. R. Kiseda and D. G. Ford, *Communications and Electronics* **46**, 996-1002 (January, 1960).

This paper presents methods whereby time-delay networks may be designed on the basis of a criterion set up in the frequency domain. The network is selected to have a gain-magnitude characteristic which is constant with frequency and a group-delay characteristic which ripples about the ideal constant value in a prescribed manner. The design methods permit the group delay to assume virtually any ripple-type function. Since the ripples are to be considered small in relative magnitude, the phase angle may be assumed to possess a ripple characteristic similar to the group delay. As an example, an elliptic-type function is presented.

Sampling Oscilloscope for Millimicrosecond Pulses at a 30 mc Repetition Rate, A. S. Farber, *Review of Scientific Instruments*, **31**, No. 1, 15-17 (January, 1960).

A sampling oscilloscope with a rise time of 3×10^{-10} sec is described. It may be used with carrier or noncarrier periodic signals having a high, fixed repetition rate. A novel coincidence circuit employed in the device for displaying the envelope of 1-m μ sec bursts of 10-kMc energy is also presented.

A Sampling Scope for $4 \cdot 10^{-10}$ sec Rise Time, H. P. Schlaeppli and H. P. Louis, *Helvetica Physica Acta*, **32**, 328-331 (September, 1959). (In German.)

A sampling scope for triggered operation with a maximum repetition frequency of 50 kc is briefly described. The concept is according to R. Sugarman, *Rev. Sci. Instr.*, **28**, 933 (1957), but the instrument has been improved in rise time by a factor of 3. This is achieved by double differentiation of a high-speed pulse generator output, thus reducing the effective length of the strobing pulse. Application is for weak signals which are within background noise.

Sensitive Flux Measurement of Thin Magnetic Films, H. J. Oguey, *Helvetica Physica Acta*, **32**, 487-490 (November/December, 1959). (In French.)

The two main difficulties encountered in the design of a sensitive hysteresis loop tracer for thin magnetic films are the flux calibration and the reduction of noise. The aim of this paper is to examine their nature and to show the possible solution for the design of very sensitive hysteresis loop tracers. The study of the flux distribution around a thin magnetic film specimen permits determination of the merits of various pick-up coil configurations, as well as the form which optimizes the signal-to-noise ratio. The various disturbing voltages and the ways to eliminate them are examined. Optimization of the amplifier noise figure, proper choice of the integrating network, dc restoration and hum synchronization are described for the reduction of the output noise after integration and amplification. Two instruments built according to these principles are outlined. The first one has a single wire pick-up and is well suited for measurement of the flux distribution around a thin magnetic film and for experiments in

vacuum at elevated temperatures. The second one is more flexible and sensitive. By using different pick-up coils covering a frequency range from 50 cps to 10 kc, its sensitivity is sufficient to measure flux values of $2 \cdot 10^{-12}$ volt-sec at a frequency of 500 cps.

Solid-Vapor Equilibria for the Compounds Cd_3As_2 and CdAs_2 , V. J. Lyons and V. J. Silvestri, *Journal of Physical Chemistry*, **64**, 266-269 (February, 1960).

Cd_3As_2 and CdAs_2 are shown to thermally dissociate according to the reactions; (1) $\text{Cd}_3\text{As}_2 \rightleftharpoons 3 \text{Cd} + \frac{1}{2} \text{As}_4$ and (2) $\text{CdAs}_2 \rightleftharpoons \frac{1}{2} \text{Cd}_3\text{As}_2 + \frac{1}{2} \text{As}_4$. Dissociation pressures were measured by a dewpoint technique and by a direct pressure method employing a quartz Bourdon gauge. The dissociation of Cd_3As_2 in the gas phase was observed through a comparison of the data obtained from the two methods, and from this the identity of the gaseous species was deduced. The experimental data may be represented by the equation $\log P_{mm} = -6600/T + 9(\Delta H = 106 \text{ Kcal/mole})$. In contrast to Cd_3As_2 , thermal dissociation of CdAs_2 is readily observed. The compound dissociation pressures measured by the two techniques were in good agreement and the data may be represented by the equation

$$\log P_{mm} = -\frac{7100}{T} + 11$$

($\Delta H = 11 \text{ Kcal/mole}$).

Solving Structural Mechanics Problems on Digital Computers, H. J. Greenberg, *Structural Mechanics, Proceedings of the 1st Symposium on Naval Structural Mechanics*, Pergamon Press, 1960, pp. 533-556.

A short, critical survey of the current applications of digital computers to solving problems in structural mechanics, including a brief description of typical medium and large-size computing systems (IBM 650 and IBM 704); a list of standard mathematics problems to which structural mechanics problems commonly reduce for which adequate codes exist together with a list of these codes for both machines; an informal survey of mechanics codes completed and under development at representative centers; a detailed discussion of three advanced computer applications; and recommendations for future work in this field.

The Stefan Problem for a Nonlinear Equation, W. L. Miranker and J. B. Keller,* *Journal of Mathematics and Mechanics*, **9**, No. 1, 67-70 (January, 1960).

The Stefan problem is a mathematical model for change of phase phenomena. Its linear version has long been known to possess a $t^{1/2}$ -time dependent solution. In this paper we produce an existence theorem for the nonlinear Stefan problem, i.e., the coefficient of thermal conductivity is allowed to be a function of the temperature. We show that the nonlinear problem likewise possesses a $t^{1/2}$ -time dependent solution.

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Submicrosecond Core Memories Using Multiple Coincidence, H. P. Schlaeppli and I. P. V. Carter, *Digest of Technical Papers—1960 Solid State Circuits Conference*, Philadelphia, pp. 54-55 (February, 1960).

Memories using toroidal ferrite cores with cycle times below 1 μ s are described; multiple coincidence is used to increase the selection ratio. Switching problems which thereby arise are

elegantly solved by means of the "two-core switch." Details of memory models with oscillograms for 3:1 and 7:1 selection ratios are given.

The Superconductivity of Dilute In-Hg Alloys,* M. D. Reeber, *Physical Review*, **117**, No. 6, 1476-1482 (March 15, 1960).

Measurements were made of the critical magnetic field for the transition from the superconducting to the normal state in polycrystalline rods of the substitutional solid solution In-Hg, containing 0 to 7 at. % Hg. The treatment given these alloys was designed to assure homogeneity in composition, in which case the transitions to the normal state were found to be similar to those for pure elemental superconductors. It was, moreover, possible to distinguish between properties that are characteristic of the ideal alloy system and properties which arise from structure within the specimen. The transition temperature at zero field T_c was measured as a function of composition and was found initially to decrease (up to a concentration of 1.75 at. % Hg) after which it began to increase with added Hg concentration. The width of the transition to the normal state, as measured by the variation of specimen resistance in a longitudinal magnetic field, was found to show a regular dependence upon composition, and also reached a minimum value at 1.75 at. % Hg. The superconducting properties of pure indium were measured and used as a standard. For indium it was found that:

$$T_c = 3.407 \pm 0.002^\circ \text{K}; H_0 = 293 \pm 2\% \text{ oe};$$

$$\text{and } \left. \frac{dH_c}{dT} \right|_{T_c} = -155.5 \pm 3\% \text{ oe}/^\circ \text{K}.$$

*This work was supported in part by the Department of Defense.

System Reliability as a Function of System Age: Effects of Intermittent Component Usage and Periodic Maintenance, B. J. Flehinger, *Operations Research*, **8**, No. 1, 30-44 (January-February, 1960).

This paper is concerned with the analysis of the reliability of complex systems in which components are used intermittently and which are maintained in operating condition by component replacement. The idea that a failed component causes system failure only when it is called into use is expressed mathematically. Based on component failure distributions and usage properties, the system reliability and expected time to system failure are derived as functions of system age for two different maintenance policies. With both policies, a component is replaced whenever it causes a system failure. In the first, this is the only maintenance, while in the second, system check-outs are conducted at fixed intervals and all components which have failed without causing system failure are replaced. The two policies are compared and, for the second, the dependence of system reliability on the maintenance interval is determined.

The Technical Motion Picture as a Means of Communication, M. T. Brislin, *Journal of the Society of Motion Picture and Television Engineers*, **69**, 45-46 (January, 1960).

Development of new techniques for the production of low-budget, fast-process motion pictures has made the use of film

of practical importance to business firms for interdepartmental communiques, presentation of reports and other purposes. The use of technical films by IBM is discussed.

Theory and Application of Thermally Stimulated Currents in Photoconductors, R. R. Haering* and E. N. Adams, *Physical Review*, **117**, No. 1, 451-454 (January 15, 1960).

The theory of thermally stimulated currents is investigated in the limits of slow and fast retrapping. A method of obtaining the ionization energy E of the relevant traps is discussed. This method depends on the shift of the conductivity maxima with heating rate and does not involve prior knowledge of the trapping cross sections or of the heating rate.

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Vendor Rating: Get the Quality You're Paying For, R. A. Hafer and H. J. Umhauer, *Purchasing*, **48**, No. 4, 82-85 (February 15, 1960).

This article describes the application and use of the Purchased Product Quality Conformance Report, a system used to rate and advise suppliers as to how well their products have conformed to specifications when tested in Receiving Inspection. The article also describes how a series of suppliers' seminars was conducted.

Wave Propagation in a Liquid Layer, D. T. Liu, *Geophysics*, **24**, No. 4, 658-666 (October, 1959).

In many areas offshore, the conventional seismic record has the appearance of a series of sine waves or simple odd harmonic combinations of sine waves, with a fundamental wavelength four times the water depth. Burg et al, in a ray-theory treatment, ascribe this oscillatory phenomenon to guided energy traveling in the water layer.

A solution of the pressure wave equation for a point source in the water layer has been obtained. It allows one to examine not only the frequency dependence with the depth, but also the transient amplitude response with depth and time.

It is concluded that in most actual situations, the phenomenon cannot be wholly explained by the assumed mechanism, because the theory indicates too rapid a decay of the energy.

X-Ray, Dielectric and Optical Study of Ferroelectric Lead Metatantalate and Related Compounds,* E. C. Subbarao,† G. Shirane,† and F. Jona, *Acta Crystallographica*, **13**, pt. 3, 226-231 (March 10, 1960).

Studies of single crystals of PbTa_2O_6 have revealed that the symmetry of the ferroelectric phase is orthorhombic pseudotetragonal, the polar axis being perpendicular to the shortest lattice parameter. The crystals remain biaxial above the Curie temperature at 265°C . The solid solution systems $\text{Pb}(\text{Ta}, \text{Nb})_2\text{O}_6$, $(\text{Pb}, \text{Ba})\text{Nb}_2\text{O}_6$ and $(\text{Pb}, \text{Sr})\text{Ta}_2\text{O}_6$ have also been investigated.

*Work done at the Westinghouse Research Laboratory.

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