

IBM Technical Papers Published Recently in Other Journals

Absorption Properties of Aggregated (Dimeric) Chlorophyll, S. Brody and M. Brody,* *Biochimica et Biophysica Acta*, **54**, 495-505 (December, 1961).

The absorption spectrum of an aggregated form of chlorophyll *a* in ethanol is given. This aggregate, which could be a dimer, has major absorption maxima at 682, 648, and 455 m μ . A geometry is suggested for it, based upon the spectral changes which result from aggregation. The shape of the red band of the dimer, and an estimate of dimer concentration (relative to total chlorophyll) is given for two different kinds of algae. There is good correlation between the absorption properties of the aggregate and the light-induced changes in absorption observed in photo-synthetic material.

*Professor of Biophysics at Hunter College, New York.

Accurate Partition Functions in the Determination of the C₂ Abundance,* E. Clementi, *The Astrophysical Journal*, **133**, No. 1, 303-308 (January, 1961).

Recent theoretical and experimental data on the diatomic carbon molecule make feasible an accurate calculation of the partition function at high temperatures. All the excited states which contribute to the partition function have been considered. A table of thermodynamic functions in the temperature range 2000°-6000°K is given. The results so obtained are used in the recalculation of the molecular abundance, *S*, as defined by Russell, Roach, and Hunaerts. In the solar reversing layer the molecular abundance was found to be $\log S = 12.83$. The rotational lines of the 0-0 band in the Swan system are used to obtain the molecular abundance. The oscillator strength of the Swan system was taken as $f = 0.04$ and the molecular excitation temperature as $T = 4500^\circ\text{K}$. Our results indicate the importance of accurate partition-function calculations in the determination of the molecular abundance.

*Work performed at the Department of Chemistry and Lawrence Radiation Laboratory, University of California, Berkeley.

Action Spectra for Sensitization of Light Emission from Monomeric and Aggregated Chlorophyll at Physiological and Liquid Nitrogen Temperatures, S. S. Brody and M. Brody,* *Archives of Biochemistry and Biophysics*, **95**, 521-25 (December, 1961).

In this paper are shown action spectra for excitation of fluorescence from the monomer and aggregate of chlorophyll *a* in vivo and concentrated ethanolic solutions of methyl chlorophyllide *a*, both at 293° and 77°K. Differential transfer from the phycobilins to these chlorophyll species lends support to the concept of pigment complexes in vivo.

*Professor of Biophysics at Hunter College, New York.

Analysis of the Statistical Density Matrix, K. M. King and L. H. Thomas, *The Physical Review*, **124**, 785-792 (November 1, 1961).

This paper discusses the calculation of the density matrix for Cu⁺ corresponding to a Thomas-Fermi-Dirac field and the analysis of this matrix to find the number of electrons in each state and the corresponding wave function. This calculation reveals an oscillation in the sign of the charge in high angular momentum states and the cause is traced to the form of the off-diagonal elements in the statistical density matrix. It is shown that a more general form for the off-diagonal elements in the statistical density matrix can be chosen in a manner consistent with the fundamental assumptions of the theory and that this leads to a generalized statistical field which includes the Thomas-Fermi and Thomas-Fermi-Dirac fields as special cases. Statistical fields with exchange are found which behave like the Thomas-Fermi field at the boundary.

Annealing of Residual Stress in Silicon Monoxide Films, J. Priest and H. L. Caswell, *British Journal of Applied Physics*, **12**, 580-581 (October, 1961).

Vacuum-evaporated silicon monoxide films possess tensile stresses of the order of 1×10^9 d/cm² for source temperatures less than 1200°C. It is shown that this tensile stress will vanish and a compressive stress will develop if the films are annealed at temperatures above 120°C and in the presence of a high partial pressure of water vapor or oxygen.

Apparatus for the Measurement of Stress in Vacuum Evaporated Films, J. R. Priest, *The Review of Scientific Instruments*, **32**, No. 12, 1349-1351 (December, 1961).

An apparatus suitable for the measurement, in vacuum, of the residual stress in evaporated metal or dielectric films has been built and tested. The substrate on which the film is deposited is clamped at one end to form a cantilevered beam. When the substrate is bent as a result of the film stress, the force required to restore the beam to its initial position is measured. The stress is then calculated from a knowledge of the restoring force, the beam dimensions, and the film thickness. A stress of 5×10^7 d/cm² can be easily detected and measured with this apparatus.

Approximations to Distributed Speed-up Capacitance, Richard B. Hurley, *Electronic Equipment Engineering*, **9**, No. 12, 49-52 (December, 1961).

In integrated semiconductor switching circuits, speed-up capacitors are frequently distributed across a resistance region. A rigorous analysis of such a combination leads to equations that are difficult to use. Instead, a simple convergence technique provides useful approximations that are easy to apply in circuit design.

An Automatic Sample Changer, G. J. Sprokel, *Nuclear Instruments and Methods*, 13, No. 3, 330-334 (October, 1961).

The instrument described permits automatic assay of any number up to 40 radioactive samples. It may be programmed to record the number of the sample being assayed, the accumulated radiation count, and the elapsed time. Complete design data and circuit diagrams are included.

Bending Vibrations of a Disk Subjected to Gyroscopic Forces, L. Meirovitch, *Journal of the Astronautical Sciences*, VIII, No. III, 88-93 (Fall, 1961).

The rigid body assumption in the solution of motion of bodies in space, though good as a first approximation, has certain limitations. To explain certain phenomena, such as energy dissipation, one has to extend the analysis and consider elastic deformations. Using expressions for gyroscopic forces derived from the rigid body assumption, an elastic solution for the vibration of a disk is obtained. Analytical expressions for the deflection, bending moment in the radial direction, and vertical force were derived and plotted as a function of the radial distance.

Composition of Cobalt-Nickel Films, I. Tsu, *Plating*, 48, No. 11, 1207-1210 (November, 1961).

Many factors influence the magnetic characteristics of electroplated cobalt-nickel films. One of these is film composition. It is governed by the $\text{Co}^{++}/\text{Ni}^{++}$ ratio in the plating bath, the addition agents, the bath pH, and the use of superimposed ac/dc. The results of this investigation indicate that the optimum magnetic properties are found in films composed of 20 to 40 per cent nickel. Because of factors other than film composition, the magnetic properties of electroplated cobalt-nickel films vary from bath to bath.

Control System Error Study—Applied to Production Control, R. H. Shaw, *Transactions of American Society for Quality Control*, 16th Midwest Quality Control Conference, St. Louis, Missouri, 74-80 (October, 1961).

Characteristically, analysis must precede synthesis. With synthesis in mind, the statistical analysis of a production control system is defined in a general manner to lend itself both to extension and to application. Total system error is decomposed by control source (e.g., forecasting, scheduling, discipline). The application of the analysis of covariance is suggested as a method of associating sources with their contributions to the total error.

Critical Component Lot Identification and Control, R. A. Hafer, *Automatic Control*, 15, No. 6, 58-60 (December, 1961).

The component lot identification procedure now in use at IBM's Space Guidance Center at Owego is described. The procedure is designed to facilitate corrective action programs on critical components during in-process operations and field usage of completed systems. It identifies by part and lot number the critical components used in assemblies, units, and systems. Failed components can be traced to the supplier and date of manufacture; all assemblies, units, and systems possessing components from the questionable lots can be quickly identified. Data processing equipment is employed to provide rapid access to the information compiled.

Demountable High Vacuum Seal for Use at Liquid Helium Temperatures, M. D. Reeber, *Review of Scientific Instruments*, 32, No. 10, 1150-1151 (October, 1961).

A technique for making demountable vacuum-tight joints that withstand low temperatures is described. A flange design is shown and suitable clearances and sealing materials are described.

Design and Operation of a High-Speed Increased Capacity Magnetic Drum, R. R. Schaffer and D. W. Gill, *1961 IRE International Convention Record, Part 2*, 128-134 (October, 1961).

A magnetic-drum memory technology is described which is directed toward satisfying data storage requirements between high-speed core arrays and low-speed disk and tape files. With the techniques presented in this paper, the capacity range of the drum memory extends into the megabit region with data processing speeds of 750 kc. Qualitative design concepts are developed and their usefulness demonstrated, both in the evaluation of the interaction of magnetic recording with solid state circuit logic and their effects on magnetic drum memory performance. A unique "tear drop" magnetic recording head was used in conjunction with a 30 microinch cobalt nickel drum surface resulting in a recording density of 400 bits per inch at 0.0004-inch head-drum spacing and a 50-ma write current. This approach permitted the utilization of fixed mounted magnetic heads and low-current transistor drivers and switching diodes. A differential-type sense amplifier is described which has a frequency response from dc to a megacycle. Solid state circuits are also shown for the spatial selection of the recording heads, and block diagrams are depicted for the input/output translators.

Distribution of the Anderson-Darling Statistic, P. A. W. Lewis, *The Annals of Mathematical Statistics*, 32, No. 4, 1118-1124 (December, 1961).

T. W. Anderson and D. A. Darling have proposed the use of the statistic

$$W_n^2 = n \int_{-\infty}^{\infty} \frac{[G_n(x) - G(x)]^2}{G(x)[1 - G(x)]} dG(x),$$

where $G_n(x)$ is the empirical distribution function defined on a sample of size n , for testing the hypothesis that the sample of size n has been drawn from a population with a specified continuous cumulative distribution function $G(x)$. This paper considers the problem of determining and tabulating the distribution function, $F(z; n) = \Pr(W_n^2 \leq z)$, of this statistic.

The Drag Coefficient of a Sphere in Liquid Helium II,* M. W. Dowley and A. C. Hollis Hallett,** *Proceedings of the VIIth International Conference on Low Temperature Physics*, G. M. Graham and A. C. Hollis Hallett, Eds., University of Toronto Press, 1961, 464-465.

The force exerted on a small sphere (2 mm diameter) in a stream of liquid helium II has been measured over a velocity range 1 cm/sec to 10 cm/sec and a temperature range of 2.17°K to 1.3°K, in a wind tunnel of circular geometry.

*Work performed at the University of Toronto and supported by the National Research Council of Canada and the Ontario Research Foundation.
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On the ${}^3E_{1u}-{}^1A_{1g}$ Intercombination in Benzene,[†] E. Clementi, *Journal of Molecular Spectroscopy*, **6**, No. 5, 497-508 (May, 1961).

The lifetime and the oscillator strength for the ${}^3E_{1u}-{}^1A_{1g}$ intercombination has been calculated. The perturbing singlets for the ${}^3E_{1u}$ state are the ${}^1E_{1u}(\pi, \pi^*)$ and two ${}^1A_{2u}(\sigma, \pi^*)$. One of the ${}^1A_{2u}$ perturbing singlets is obtained by promotion of one electron from a σ bonding molecular orbital of the carbon-carbon bonds, the other ${}^1A_{2u}$ perturbing singlet is obtained by promotion of one electron from a σ bonding molecular orbital of the carbon-hydrogen bonds. The one-electron part and the two-electron part of the spin orbital Hamiltonian are both considered in the calculation. The electric field acting on the electrons is obtained following the approximation introduced by Hammett. The two center integrals were computed in the cases where the one center integrals are vanishing and are otherwise neglected. The results of the calculation show that the ${}^3E_{1u}$ transition has an f value of $\sim 2 \times 10^{-10}$ and lifetime $\tau \cong 20$ seconds; consequently the ${}^3E_{1u}$ transition is too weak to be identified with the system of weak bands observed in liquid benzene spectra and crystal benzene spectra in the 2600-Å region. The oscillator strength of the ${}^1A_{2u}-{}^1A_{1g}$ transitions is estimated to be in the range $f = 2 - 5 \times 10^{-2}$, the more definite value depending on the still unknown location of the ${}^1A_{2u}$ perturbing states.

[†]Work performed at the Laboratory of Molecular Structure and Spectra, Department of Physics, University of Chicago, and supported by the National Science Foundation.

Effect of Residual Gases on the Properties of Indium Films, H. L. Caswell, *Journal of Applied Physics*, **32**, No. 12, 2641-2645 (December, 1961).

Indium films have been deposited at pressures less than 10^{-9} mm Hg and at higher pressures of specific residual gases. N_2 , H_2 , CH_4 , A , CO , and CO_2 were found to have no measurable effect on the electrical or superconducting properties of these films when present in partial pressures of 10^{-5} mm Hg. For oxygen, a pronounced effect was observed when K (the ratio of oxygen molecules to indium atoms striking the substrate) exceeded 3%. The room-temperature resistivity increased from $9.0 \mu\text{ohm-cm}$ to $14 \mu\text{ohm-cm}$; the critical temperature decreased from $(3.402 \pm 0.005)^\circ\text{K}$ to $(3.389 \pm 0.002)^\circ\text{K}$; and the effective magnetic penetration depth increased from $630 \pm 100 \text{ Å}$ to over 1000 Å . For $10^{-3} < K < 3 \times 10^{-2}$, a larger apparent penetration depth was observed for films deposited through a mask due to edge effects. It was shown that indium films could be deposited at 100 Å/sec on clean, baked substrates at 10^{-5} mm Hg with characteristics indistinguishable from those of films deposited in ultra-high vacuum provided the partial pressures of oxygen and water vapor were below 10^{-7} and 10^{-5} mm Hg, respectively.

Effects of Saccharin on the Structural and Magnetic Properties of Iron-Nickel Films, R. S. Smith, L. E. Godycki,* and J. C. Lloyd, *Journal of the Electrochemical Society*, **108**, No. 10, 996-998 (October, 1961).

The effects of saccharin (soluble species, sodium salt of O-benzoic sulfimide, $C_6H_4\text{CONNaO}_2$) on the structural and magnetic properties of electrodeposited iron-nickel films are explored. It is found that small amounts of saccharin in the plating bath reduce coercive force (H_c), surface roughness and gas entrapment. In addition, crystal size becomes independent of pH.

*Now with Electro-Optics, Inc.

Eine Elektronenbeugungsapparatur zur Untersuchung dünner Schichten im Ultra-Hochvakuum (An Electron-Diffraction Apparatus for Investigating Thin Films in Ultra-High Vacuum), C. Schüller, *Helvetica Physica Acta*, **34**, Fasc. 5, 397-398 (1961).

The communication describes briefly the construction of an all-glass electron diffraction camera, which operates at 75 kv acceleration potential. It was found possible to obtain pictures of the clean surface of thin gadolinium films evaporated at a residual gas pressure of 10^{-9} mm Hg inside the camera, and to follow the oxidation process taking place at somewhat higher pressure.

Eine Maschine zur Uebersetzung von Sprachen (A Machine for the Translation of Languages), A. P. Speiser, *Neue Zuercher Zeitung*, **4189**, 3-8 (November, 1961).

A description of the automatic language translation machine, Mark II, is given. Longest match and ρ -stuffing are outlined, and the photo-store is explained.

Elaboration Automatique des Documents d'Etude de Calculateurs Electroniques (IBM Design Automation System Applied to SMS Technology), G. L. Mars, *Radio Electronique Professionnelle*, 14-16 (November-December, 1961).

The paper is a brief description of the IBM Design Automation System applied to SMS technology. It starts with basic ideas about computer design and some fundamental facts about SMS. The general organization of the Design Automation system is then given (circuits description, logic diagram processing, errata listing, and engineering changes).

As a conclusion, the future possibilities of this new technique are investigated.

Electronic States in the C_4 Molecule,* E. Clementi, *Journal of the American Chemical Society*, **83**, No. 22, 4501-4505, (November, 1961).

An S.C.F.-L.C.A.O.-M.O. ground state wave function for the lowest ${}^3\Sigma_g^-$ and for an excited ${}^1\Sigma_g^+$ state of C_4 is reported. All twenty-four electrons are considered in this computation. The internuclear distance assumed for all the states is 1.28 Å for the three bonds of C_4 , following some earlier prediction. Diagrams are presented which give a pictorial representation of the molecular orbitals obtained. An L.C.A.O.-M.O. computation was done for the ${}^1\Delta_g$ and ${}^1\Sigma_g^+$ states and for a second ${}^1\Sigma_g^+$ excited state. A discussion is given on the expected bond variation for the different excited states, as compared with the ground state. Estimates are made of the centers of gravity for the two lowest ${}^3\Pi$ and ${}^1\Pi$ states. It is concluded that the ${}^3\Sigma_g^-$ should be the ground state as earlier suggested by Pitzer and the author.

*Work performed at the Laboratory of Molecular Structure and Spectra, Department of Physics, University of Chicago, and supported by the National Science Foundation.

Etude Statistique de l'erreur de calcul dans les sommes de n nombres écrits en virgule flottante (Statistic Study of the Sum of n Numbers Written with a Floating Decimal Point), E. Gorog, *Chiffres*, **4**, 70-80 (June, 1961).

The author has made a statistic study of the computation error in the case of the sum of n numbers written with a floating decimal point. Two cases have been systematically treated: the truncation error and the round-off error.

Ferromagnetic Domains in Thin Ni-Fe Films, S. Middelhoek, *Drukkerij Wed. G. Van Soest N.V.*, Amsterdam, 7,163 (1961).

The theory and experiments concerning domains in thin Ni-Fe films are treated. The reasons why thin films are so appropriate for the investigation of the domains are discussed. Also a comparison of the thin films is made with the bulk material.

The description of the domains in thin Ni-Fe films is divided into three parts. The first part treats the different domain configurations. For example at the edges of the films the so-called closure domains occur to reduce the stray field energy. Circular holes in a thin film lead to special magnetization distributions, which are calculated. Except for the induced uniaxial anisotropy in thin Ni-Fe films residual crystal and stress anisotropies also occur. These anisotropies lead to a certain angular dispersion of the easy axis. This dispersion is especially perceptible in the domain configuration, which occurs after saturation of the film in the hard direction.

In the second part, the walls which separate the domains from each other are described. One finds, that as a result of the large contribution of the stray field energy to the total wall energy another type of wall, the so-called Néel wall becomes stable in very thin films. For the known Bloch wall and the Néel wall the energy and wall width are calculated as a function of the film thickness and the angle, through which the magnetization in the wall rotates. Experimentally also a third type of wall, the so-called "cross-tie" wall is found, for which the energy is approximately calculated with the help of a suitable model.

In the last part the reversal processes in thin Ni-Fe films are discussed, as they occur in static experiments. Reversal in a thin film very often takes place by wall motion. A theory of the critical field for wall motion is developed, which shows, that the surface roughness and the angular dispersion of the easy axis give the greatest contribution to the critical field. The agreement between the theory and the experiments, however, is moderate. Special forms of the reversal processes, e.g. wall nucleation, wall creeping and partial rotation are also discussed.

Forcing Circuitry: Sequential Building Blocks for Logical Design, R. M. Meade, *Communications and Electronics*, 80, No. 57, 522-531 (November, 1961).

The paper first reviews the current-switching circuits which were developed to solve the problem of integrating storage with logical transformation and of stabilizing data for storage. Radical improvements are then introduced in the form of the forcing circuits, which reduce the delays and cost and increase the logical power of the sequential elements. The sequential characteristics of the forcing circuits are analyzed and a number of applications are described.

Geometric Mapping of Switching Functions, M. E. Arthur, *IRE Transactions on Electronic Computers*, EC-10, No. 4, 631-637 (December, 1961).

The geometric map is presented as a graphic representation of switching functions capable of (1) working with seven or more variables, (2) working with well known techniques, such as Boolean Algebra, the Quine-McCluskey minimization chart, or Huffman's flow table, etc., and (3) a degree of flexibility not possessed by other maps. It is not intended to stand alone, but is most effective when used with all other techniques at the user's command, giving added efficiency to them.

Ground-State Wave Functions for Linear Molecules,* E. Clementi, *Journal of Chemical Physics*, 34, No. 4, 1468-1469 (April, 1961).

The LCAO-MO-SCF wave functions for the $^1\Sigma_g^+$ ground states of the molecules C_2 , N_2^+ , NO_2^+ , and HF_2^- are reported.

*Work performed at the Laboratory of Molecular Structure and Spectra, Department of Physics, University of Chicago.

The Group of Automorphisms of the Holomorph of a Group, N. C. Hsu, *Pacific Journal of Mathematics*, 11, 999-1012 (Fall, 1961).

The study deals with automorphisms of a relative holomorph of some uncomplicated groups. A generalization of Yu. A. Golfund's result* can be easily obtained. As applications of the results, the automorphism group of the holomorph of a symmetric group of degree $n \geq 3$, $n \neq 4$ and $n \neq 6$ and the automorphism group of the holomorph of a non-zero subgroup of the additive group of rational numbers are mentioned.

*"On the Group of Automorphisms of the Holomorph of a Group," *Rec. Math. (Math. Sbornik)*, 27, 333-350 (1950).

A Harmonic Analysis of Saturation Recording in a Magnetic Medium, B. Kostyshyn, 1961 *IRE International Convention Record, Part 2*, 112-127 (October, 1961).

A single write-read head coupled with saturation recording techniques is commonly used to store digital information. Because of the experimental difficulty in determining the contribution of individual parameters in the system, a theoretical equation describing the output of a system in terms of the physical, magnetic, and electrical parameters of the system has been developed and programmed for the IBM 704. When applied to an experimental NRZ system, excellent agreement between observed and calculated results was obtained. The phenomena of peak or phase shift and amplitude shift occurring for an isolated pair of adjacent "ones" at high bit densities is demonstrated and discussed. The calculated dependence of the zero-to-peak output and the peak-and-amplitude shifts is shown for variations in the thickness, retentivity, coercivity and squareness of the storage medium, and for variations in the write current, the head-to-medium spacing, and the pole-gap dimensions.

High-Speed Master Cams Generated Mechanically, R. E. Cheney, *Machinery*, 68, No. 2, 93-99, 148 (October, 1961).

High-speed cams, operating in ranges in excess of 2000 rpm, require tolerances accurate to four decimal places. This paper describes a method developed at the IBM Endicott Development Laboratory to generate the precision master cams required in IBM data processing systems where reliability, life, accuracy, and freedom from vibration are essential. This is a mechanical generating method which does not require a skilled craftsman to execute. A brief survey of traditional master cam generating methods is given, and the technique currently used at IBM is described. The cam cutting technique and equipment is discussed and illustrated, and photographs of a special-purpose high-precision master cam grinder are included.

High Temperature Phase Relations in the Ferrite Region of the Ni-Fe-O System, M. W. Shafer, *Journal of Physical Chemistry*, 65, 2055-2062 (November, 1961).

Thermogravimetric analysis and quenching experiments have been used to determine phase equilibria in the ferrite region of the Ni-Fe-O system. The area where single phase-nickel ferrite spinel exists has been determined for oxygen pressures of 10^0 , $10^{-0.7}$, and 10^{-2} atmosphere at 1400°, 1500°, and 1600°C. Liquidus temperatures and compositions have also been determined and are presented in terms of the ternary system Ni-Fe-O.

How to Make a Larger Ultrasonic Grinding Tool, G. E. Wright, *Ceramic Industry*, **77**, No. 4, 75-76, 89-90 (October, 1961).

Ultrasonic grinders are used in the processing of parts from the new glass and ceramic materials too brittle for ordinary machining. The manufacturers of these grinders advertise certain size maximums at which their equipment will perform. At the IBM Development Laboratory tooling was developed to machine a pattern over an area larger than the recommended maximum. The premise on which the whole design is based is that any tool and tool holder combination will work to a certain degree if resonance can be effected. The paper describes the calculations and methods used to design a one-quarter larger tool.

Hydrated and Anhydrous Bisethylenediamine Copper (II) Sulfate, L. V. Gregor, J. J. Fritz,* and P. E. Field,* *Journal of Physical Chemistry*, **65**, 1904-1905 (October, 1961).

Hydrated bisethylenediamine copper (II) sulfate, readily prepared by evaporation of an aqueous solution of copper sulfate and ethylenediamine followed by cooling in ice, is an extremely water-soluble, blue-violet crystalline compound which loses water readily at room temperature to give anhydrous bisethylenediamine copper (II) sulfate, which is light violet-blue. The hydrate composition corresponds to the formula $\text{Cu}(\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2)_2 \text{SO}_4 \cdot 4\text{H}_2\text{O}$.

Phase equilibrium studies indicated that the tetrahydrate is the only stable hydrated phase between 0° and 40°C, and that there is a transition point between this hydrate and the anhydrous material at 43°C. At 25°C the decomposition pressure of the tetrahydrate is 16.3 ± 0.3 mm Hg; the heat of dehydration is 49,200 calories (for four moles of water).

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IBM's Thomas J. Watson Research Center, G. L. Evans and W. Reuter, *Arcs and Sparks*, **7**, No. 4, 8-10 (December, 1961).

A very brief description, with photographs, of the optical emission spectrographic laboratory is given. Its relation to the Analytical Research Group and to the Research Center is outlined.

The Importance of Professionalism for the Special Librarian, M. Griffin, *Special Libraries*, **52**, No. 8, 462-463 (October, 1961).

The special librarian shares with other professionals in business and industry a dual loyalty—allegiance to his profession and to his company. He is obligated to uphold the standards learned during his training, to attain technical competence and to grow on the job. The special library is company-oriented; the nature and size of its collection may require that traditional ways of library organization be discarded or modified.

Insulating Films and Fibrous Materials, A. M. Parks, *1960 Digest of Literature on Dielectrics*, National Academy of Sciences, National Research Council **24**, 917, 235-258 (1961).

This chapter is a digest of the advances in theoretical understanding and practical application of insulating films and fibrous materials which were described in the literature during 1960. All publications are briefly described without critical

comment or edification. The purpose is to provide a handy reference or survey of the work being done in this field. After an introduction, which describes in the author's opinion the most significant developments and trends, the areas covered include cellulose, paper, textile and inorganic fibers, and plastic films such as the polyolefins and epoxies. There are also sections on new preparations, applications to wire insulation, capacitors and transformers, and stability. Only those references which describe electrical properties and applications as electrical insulation are discussed. A bibliography of 110 references is given.

Integration of Quality and Reliability Functions, J. D. Fernbach, *Industrial Quality Control*, **18**, No. 5, 14-18 (November, 1961).

After analyzing industry's trend of increased emphasis on reliability, the author outlines a plan for integrating quality and reliability functions into a single operation.

Interband Scattering in *n*-Type Germanium,* M. I. Nathan, W. Paul,** and H. Brooks,** *The Physical Review*, **124**, No. 2, 391-407 (October 15, 1961).

The pressure dependence of the electrical conductivity of *n*-type germanium has been measured to pressures of 30,000 kg/cm² at temperatures between 273° and 350°K. A satisfactory explanation of the results requires the existence of two different types of minima in the conduction band, separated by between 0.15 and 0.21 eV at 350°K with the lower range of values slightly preferred. The higher energy minima lie in the [100] direction in reciprocal space, and are similar in properties to the lowest set of minima in silicon. The changes in position of the two minima with pressure are determined. For the minima that are lowest at atmospheric pressure, $d(E_{111} - E_v)/dP = (4.9 \pm 0.5) \times 10^{-6}$ eV/kg-cm⁻², and for the [100] set, $d(E_{100} - E_v)/dP = (0.2 \pm 0.1) \times 10^{-6}$ eV/kg-cm⁻². The change in average electron mobility with pressure is explained in terms of a sharing of electrons between states in the two sets of minima, and an additional relaxation process that scatters carriers from one type of minimum into the other. The effect of pressure on the effective masses, the elastic constants, and the deformation potential is briefly considered.

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An Introduction to Speed-Independent Circuit Theory, R. E. Miller, *Proceedings of the Second Annual Symposium and Papers from the First Annual Symposium on Switching Circuit Theory and Logical Design* (AIEE), S-134, 87-93 (October, 1961).

An elementary description of speed-independent circuit theory is presented. First, some basic assumptions about the circuit structure and behavior are made. These assumptions lead to some basic properties and theorems for these circuits which describe speed-independent circuits. With speed independence introduced, two subclasses of speed-independent circuits, called semimodular and distributive circuits, are considered which are amenable to detailed analysis and synthesis. Finally, the synthesis aids of "change chart" and "flow chart" are introduced.

Least-Squares Refinement of the Structure of Gadolinium-Iron Garnet, $\text{Gd}_3\text{Fe}_2\text{Fe}_3\text{O}_{12}$, J. E. Weidenborner, *Acta Crystallographica*, **14**, 1051-1056 (October, 1961).

X-ray diffraction photographs of gadolinium-iron garnet, $\text{Gd}_3\text{Fe}_2\text{Fe}_3\text{O}_{12}$, show Laue symmetry *m3m*, and systematic extinctions indicate *Ia3d* as the most probable space group.

There are eight formula weights per unit cell with $a = 12.470 \pm 0.005$ Å. Positions of all ions except O^{2-} are fixed by the space group. The least-squares method has been applied to refine the oxygen coordinates, using only 75 structure factors with significant oxygen contributions. The final values obtained for the coordinates are $x = -0.0269$, $y = 0.0550$, and $z = 0.1478$. Inter-ionic distances and angles calculated from these coordinates are nearly identical to the corresponding distances and angles in yttrium-iron garnet, as predicted by magnetic data. Difficulties were encountered in the least-squares refinement of the structure. The use of limited numbers of structure factor data gave rise to large interactions between the temperature factors of the metal ions. A separate refinement with additional data was necessary to evaluate these thermal parameters.

A Linear Programming Approach to the Cutting Stock Problem, P. C. Gilmore, *Operations Research*, **9**, 849-859 (November-December, 1961).

The cutting stock problem is the problem of filling an order at minimum cost for specified numbers of lengths of material to be cut from given stock lengths of given cost. When expressed as an integer programming problem, the large number of variables involved generally makes computation unfeasible. This same difficulty persists when only an approximate solution is being sought by linear programming. In this paper, a technique is described for overcoming the difficulty in the linear programming formulation of the problem. The technique enables one to compute always with a matrix which has no more columns than it has rows.

Low-Temperature Specific Heat of Germanium,* C. A. Bryant and P. H. Keesom,** *The Physical Review*, **124**, 698-700 (November 1, 1961).

Electronic and lattice contributions to the specific heat are reported for several n -type degenerate Ge ingots. The electronic effective mass, calculated on the assumption of a parabolic conduction band, is not strongly dependent on donor concentration in Ge. The Debye temperature decreases as donor or acceptor impurities are added, from 371°K for pure Ge to 362°K for the most heavily doped ingot. However, this marked decrease did not occur in silicon-doped Ge. It is suggested that the effect is due to screening of long-range lattice forces by free electrons or holes.

*Supported by a Signal Corps Contract.

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Magnetic Thin Films Prepared by Sputtering, E. Kay, *Journal of Applied Physics*, **32** Supplement, No. 3, 99S-101S (March, 1961).

Experimental study of magnetic thin films prepared by sputtering in a glow discharge environment showed that crystal structure and chemical purity, as well as particle size and surface morphology, can be controlled. Different physical properties, including B - H characteristics, can be reproducibly obtained by varying the location of the collecting substrate with respect to the characteristic zones of the glow discharge; e.g., Crookes dark space, negative glow, positive column. This is the result of variations in deposition rate and energy distribution of the material arriving at the substrate, as well as variations in intensity of electron bombardment and the consequent temperature of the substrate. Typical results on nickel and iron films are reported. In contrast to several reports in the literature, ferromagnetic fcc nickel films were deposited directly by sputtering. Completely unoriented, polycrystalline bcc Fe films were prepared in which $Br/B_s \sim 1$, $H_c \sim 250$ oe, and $Br \sim 20,000$ oe; i.e., the magnetic characteristics were quite different from those obtained by high vacuum evaporation.

A Martingale System Theorem and Applications, Y. S. Chow and H. Robbins,* *Proceedings of 4th Symposium on Mathematical Statistics and Probability*, **1**, 93-104 (December, 1961).

Let $x_1, x_2, \dots$ be a sequence of independent and identically distributed random variables with $E(x_1) < \infty$. We observe $x_1, x_2, \dots$ sequentially and can stop with any $n \geq 1$. If we stop with x_n we receive the reward $m_n = \max(x_1, \dots, x_n)$, but the cost of taking the observations $x_1, \dots, x_n$ is some strictly increasing function $g(n) \geq 0$. The net gain in stopping with x_n is $y_n = m_n - g(n)$. The decision whether to stop with x_n or to take the next observation x_{n+1} must be a function of $x_1, \dots, x_n$ alone.

Problem: What stopping rule maximizes the expected value $E(y_s)$, where s is the random sample size defined by the stopping rule? The paper gives the solution of this problem.

*Columbia University

Mathematical Models for Time-Domain Design of Electrohydraulic Servomechanisms, P. K. C. Wang, *Applications and Industry*, **57**, 252-260 (November, 1961).

It is shown that an electrohydraulic valve-controlled actuator can be represented by reasonably simple and accurate models by making suitable assumptions. The basic model is shown to be a multiple-mode nonlinear system. Simple results are derived for step and pulsed-valve motor-current inputs, and their applications are discussed. Finally, the adequacy of the models for time-domain studies is substantiated by experimental studies of a physical model and its corresponding mathematical model simulated by an analog computer.

On the Mechanics of Wire Drawing,* C. T. Yang, *Journal of Engineering for Industry, Transactions of the ASME, Series B*, **83**, No. 4, 523-530 (November, 1961).

A split-die technique was adopted to find the coefficient of friction in wire drawing directly from experiment. Simple dynamometers with wire resistance strain gages were used for measuring separating force and drawing force instead of cumbersome equipment used by former researchers. Reasonably good results were obtained.

The effect of the land or parallel portion in the die on the coefficient of friction was indicated in the results. Its importance was emphasized.

A theoretical equation of the drawing stress with the effect of land considered was derived. Using the coefficient of friction obtained by the split-die method, drawing stresses were calculated from the derived equation. A comparison of the theoretical and experimental drawing stresses was made. Results were tabulated and plotted.

It was concluded that including the land in the analysis of wire drawing is important and further research in analyzing the shear deformation must be pursued in order to obtain a close agreement between theoretical analysis and experimental results.

*Based on work performed by the author when he was Associate Professor of Mechanical Engineering at the University of Michigan.

Melting Kinetics of Quartz and Cristobalite*, N. G. Ainslie, J. D. Mackenzie** and D. Turnbull**, *Journal of Physical Chemistry*, **65**, 1718-1724 (October, 1961).

The melting of quartz single crystals and polycrystalline cristobalite has been investigated by the use of a microscopic technique. Melting was heterogeneous even at the highest superheating attained, which was 300° for quartz and 40° for cristobalite. It began at the free surfaces and grain boundaries,

but never within a crystal, and propagated inward. The rate of propagation of the quartz-fused silica interface was measured as a function of superheating. It was independent of time at constant temperature, and the form of its variation with temperature was about the same as that of the relation calculated from the viscosity of fused silica. However, the observed relation was higher, in growth rate, than the calculated relation by an approximately constant factor of 40.

*Work performed at General Electric Research Laboratories, Schenectady.
**General Electric Research Laboratories.

On a Method by D. H. Lehmer for the Generation of Pseudo Random Numbers, W. Liniger, *Numerische Mathematik*, 3, Fasc. 4, 265-270 (October 11, 1961).

A power method modulo $(10^8 + 1)$ or $(2^{31} - 1)$, for generating decimal or binary pseudo random numbers, respectively, has been proposed by D. H. Lehmer.* In the present paper it is shown that the cycle of the decimal process depends on the initial value. A suitable starting number is given for which this cycle is a maximum. A few primitive roots modulo the Mersenne prime $(2^{31} - 1)$ are also indicated, any one of which generates a cycle of maximum length, $(2^{31} - 2)$, if used as a basis for the binary method.

*"Mathematical Methods in Large-scale Computing Units," *Proc. Sec. Symp. on Large-scale Digital Calculating Machinery*, Harvard University Press, Cambridge, Mass., 1951, pp. 141-146.

Microwave Measurement of Mobility: Analysis of Apparatus,* S. H. Liu, Y. Nishina,** and R. H. Good, Jr., *The Review of Scientific Instruments*, 32, No. 7, 784-789 (July, 1961).

The microwave mobility in a semiconductor can be obtained by mounting a sample in a bimodal cavity with an applied static magnetic field and then measuring the power transfer which is produced by the Faraday rotation in the sample. This paper gives an analysis of the effect based on the field distributions in the cavity and the wave propagation in the sample. The dependence of the power transfer on the static applied magnetic field, on the mobility and conductivity of the sample, and on an effective sample size is obtained.

*This research was done in the Ames Laboratory of the U.S. Atomic Energy Commission.

**Present address: Magnet Laboratory, Massachusetts Institute of Technology, Cambridge.

Minimum-Volume Design of Discs, T. C. Hu and R. T. Shield,* *Zeitschrift für angewandte Mathematik und Physik*, 12, No. 5, 414-433 (Sept.-Oct., 1961).

The minimum-volume design of discs (plane stress), composed of a rigid, perfectly-plastic material obeying Tresca's yield condition, is discussed, and it is shown that four types of solution arise. Several examples of minimum-volume designs are given.

*Department of Applied Mathematics, Brown University, Providence, Rhode Island.

Multi-Terminal Network Flows, R. E. Gomory and T. C. Hu, *Journal of SIAM*, 9, No. 4, 551-570 (December, 1961).

A network is a set of nodes N_i connected by branches with branch capacities b_{ij} which indicates the maximum amount of flow that can pass through the branch from N_i to N_j . Given all b_{ij} , there is a maximum flow f_{ij} from N_i to N_j using all branches. The three problems solved in this paper are: 1) What are the necessary and sufficient conditions in order that a given set of numbers represent maximum flow f_{ij} in some network. 2) Given all b_{ij} , find all f_{ij} . This is done by solving only $n-1$ flow problems for an n -node network. 3) Given a set of numbers r_{ij} , construct a network with minimum $\sum b_{ij}$ such that $f_{ij} \geq r_{ij}$ for all r_{ij} .

A Note on the Formation of Concept and of Association by Information-Theoretical Correlation Analysis, S. Watanabe, *Information and Control*, 4, No. 2-3, 291-296 (September, 1961).

This paper points out that the method of information-theoretical correlation analysis* provides a powerful tool in producing mechanizable models of various kinds of cognitive and recognition processes.

*IBM Journal of Research and Development, 4, No. 1, 66 (January, 1960).

Note sur les méthodes élémentaires en statistique quantique avec application à la température de Curie d'un alliage (Elementary Approximations in Quantum Statistics with Application to Ferromagnetic Metals), M. C. Gutzwiller, *Helvetica Physica Acta*, 34, Fasc. 5, 514-519 (1961).

The statistical description of a many-particle system without using its correlations is investigated. The single particle states and their occupation numbers are obtained by minimizing the total free energy. This approximation is applied to study a model of a ferromagnetic alloy, in which the interaction between localized electrons (such as the $3d$ electrons) is of the Heisenberg type, and their number depends on the composition of the alloy. The Curie temperature is a parabolic function of the composition. By forming Bloch functions out of the localized orbits, the free energy can be lowered provided the exchange coupling constants in the Heisenberg model are sufficiently complicated functions of distance.

Nuclear Quadrupole Interaction in Pure Metals,* T. P. Das** and M. Pomerantz, *The Physical Review*, 123, No. 6, 2070-2076 (September 15, 1961).

Calculations of the ionic part of the electric field gradient at the nuclei of certain metals are combined with available experimental data to obtain information about the electronic structures of the metals, or estimates of nuclear quadrupole moments. The metals considered are Be, Sc, Re, La, Mg, Co, Zn, and Cd, which have the hexagonal close-packed structure, and indium, which has a centered tetragonal structure. Some comparison is made with other information about the shapes of the Fermi surfaces and a pertinent experiment on Zn is suggested.

*Supported by U.S. Air Force and Atomic Energy Commission.

**Present address: Physics Department, University of California, Riverside, California.

Nuclear Quadrupole Moment of Fe^{57m} , G. Burns, *The Physical Review*, 124, No. 2, 524-526 (October 15, 1961).

A value for the nuclear quadrupole moment of the excited state of iron, Q^{57m} , is obtained using published values for eQq/h in the octahedral and tetrahedral sites in $\text{Y}_3\text{Fe}_2(\text{FeO}_4)_3$ (YIG) and in Fe_2O_3 , along with recent values for the atomic coordinates in these compounds. The value of Q^{57m} is definitely positive and $\approx +0.4 \times 10^{-24} \text{ cm}^2$.

Numerical Analysis of Gas Lubricating Films, W. A. Gross, *Proceedings of the First International Symposium on Gas-Lubricated Bearings*, October 26-28, 1959, pp. 193-223, ACR-49, Office of Naval Research—Department of the Navy, Washington, D.C. (July, 1961).

Numerical approximation methods are discussed. By the use of one of these methods, the Reynolds differential equation for a laminar gas lubricating film is replaced by a difference equation

which is then applied to self-acting gas bearing films. A method of numerical solution of this difference equation is described, and agreement between experimentally determined and computed data is discussed and presented in graphical form. Detailed treatment is given the properties of self-acting plane, tapered land, and step slider bearing films, such as the effects of slenderness and film thickness ratios, and of driving surface velocity upon bearing load. Some friction and center-of-pressure results are also given. Shown finally are the consequences of changes in tangential surface velocity and minimum film thickness upon pivoted sliders.

Operations on Finite Automata, C. C. Elgot and J. D. Rutledge, *Proceedings of the Second Annual Symposium and Papers from the First Annual Symposium on Switching Circuit Theory and Logical Design* (AIEE), S-134, 129-132 (October, 1960).

An attempt is made to promote the unification of various points of view that have been adopted in the treatment of the synthesis of finite automata, both synchronous and asynchronous. Incompletely specified machines and, more generally, non-deterministic machines are used as vehicles for expressing conditions on input-output sequences. The set of all complete machines (up to equivalence) satisfying a given condition is expressed as a one-parameter family. Bounds are obtained for the length of sequences necessary to distinguish two (possibly incomplete) machines with respect to: (1) an arbitrary regular set, (2) their common domains of "meaningful" input sequences, and (3) certain sets significant for asynchronous circuits. Various new operations on sets of sequences are shown, by direct machine constructions, to preserve regularity. More general operations such as the transformation of a set of sequences of ordered pairs to the corresponding set of ordered pairs of sequences and the inverse of this transformation are effected by direct machine constructions.

Optimization of Process Performance, L. Lapidus,* E. Shapiro, S. Shapiro, and R. E. Stillman, *American Institute of Chemical Engineers Journal*, 7, No. 2, 288-294 (June, 1961).

The growing availability of fast, large-memory digital computers has made it practical to consider the physical implementation of control system designs incorporating appropriate strategies for automatic process optimization. The control system is taken to consist of the process to be optimized together with the interconnected digital computer. The control strategy is realized in the program of the digital computer. In the present paper a number of such programs or algorithms are discussed for carrying out a search of the possible settings of the process input (independent) variables in such a way as to locate an extremal of the possible values of a chosen objective function. The magnitude of these variables is determined from measurements taken of the dependent variables in the process. It is shown that for the particular process used as an example it is desirable to alter the search strategy as the optimization proceeds in order to locate the extremal in a minimum amount of time. The emphasis at the beginning of the search is on speed in moving towards the optimum and at the end on accuracy.

Further, a computational technique is described whereby the dynamic response of the process to the various search steps (or settings) is under time-optimal control. This procedure is important for the fast execution of the search programs and consequent rapid location of the extremal of the chosen objective function.

*Princeton University.

Optimum Nonlinear Filters for Quantized Inputs,* F. Tung and R. J. Schwarz,** *IRE Transactions of the Professional Group on Information Theory*, IT-7, No. 4, 257-265 (October, 1961).

Optimum least-square filters belonging to Zadeh's nonlinear class $\mathfrak{M}_1$ are considered. Attention is restricted to those systems whose present output is influenced only by a portion of the past input. The input signal consists of a message and noise, both of which are stationary random processes. It is assumed that the amplitude of the input time series is bounded and takes on discrete values at all times. This assumption leads to a nonlinear filter which can be realized as a quantizer or amplitude selector followed by a parallel set of linear filters. The system becomes optimum when the impulse responses of the linear filters satisfy a system of integral equations of the Wiener-Hopf type adapted to finite memory filters. By virtue of the assumptions made concerning the joint probability density functions of the message and noise processes, it is found that the Fourier transforms of the kernels of these equations are rational functions. A method is developed for the solution of this set of integral equations. This method is illustrated by an example, and the mean-square error of the nonlinear filter so obtained is compared with the best linear filter.

*Work performed at Columbia University and supported by Air Force Contracts.

**Department of Electrical Engineering, Columbia University.

The Optimum Response of Second-Order, Velocity-Controlled Systems with Contactor Control,* I. Flugge-Lotz** and M. Yin, *Transactions of the ASME*, 83, Series D, No. 1, 59-64 (March, 1961).

This paper is concerned with the optimum control problem for plants described by second-order differential equations with constant coefficients and with velocity control. Emphasis is placed on the case where the characteristic equation of the system has one zero root and two complex conjugate roots. The problem is studied in terms of the motion of the phase point in a three-dimensional phase space. An iteration method is developed to obtain the optimum trajectory, which in turn gives the optimum response.

*Work performed at Stanford University, Stanford, California, and supported by the United States Air Force through the Air Force Office of Scientific Research of the Air Research and Development Command.

**Professor of Aeronautical Engineering and Engineering Mechanics, Stanford University.

Parallel Sequencing and Assembly Line Problems, T. C. Hu, *Journal of Operations Research*, 9, No. 6, 841-848 (Nov.-Dec., 1961).

This paper deals with a new sequencing problem in which n jobs with ordering restrictions have to be accomplished by men of equal ability. Assume every man can do any of the n jobs. The two questions considered in this paper are: 1) How to arrange a schedule that requires the minimum number of men so that all jobs are completed within a prescribed time T ; 2) If m men are available, what is an optimum schedule that completes all jobs at the earliest time.

Partial Rotation in Permalloy Films, S. Methfessel, S. Middelhoek and H. Thomas, *Journal of Applied Physics*, 32, No. 10, 1959-1963 (October, 1961).

Magnetization reversal at an angle to the easy direction has been studied on Permalloy films with different values of coercive force H_c and anisotropy field H_K . The hysteresis properties

show that "inverted" films ($H_c > H_K$) do not represent a special case, but that every film exhibits inversion in a certain sector of field direction. In the inversion sector, two critical field values are observed. The corresponding Bitter patterns make it evident that the lower critical field is due to a partial rotation process which is accompanied by a splitting of the film into many fine domains, while the higher one is due to wall motion. The observed processes can be understood qualitatively if the dispersion of the local values of the anisotropy field and anisotropy direction, as well as the internal exchange and stray field coupling are taken into account.

Photo-Image Storage—Its Role in Modern Business, John H. Veyette, Jr., *Business Automation*, 6, No. 4, 16-21 (October, 1961).

This article describes the IBM WALNUT photo-image and retrieval system which provides storage capacity for millions of printed or typed pages and drawings, any one of which can be retrieved within five seconds. A hypothetical corporation (Better and Best Electronics Manufacturing Company) is used to show how the system would benefit R & D, Materials, Reliability and Environmental Test, Manuals and Handbook Preparation and Manufacturing Control functions. It is pointed out that WALNUT was designed for a specific purpose and is not commercially available. However, the technology employed in the system would be applicable for informational support in many corporations with problems similar to the ones presented by BBEM Co. Photo-image technology shows promise of becoming a powerful tool for the storage and retrieval of information.

Physicists in American Industries, H. Gamo, *Nippon Buturi Gakkai-shi*,* 16, No. 11, 703-707 (November, 1961).

Physicists in American industries are explained, based on published statistical data. Their functions in research, development, and management, and the freedom of research in industries are discussed in comparison with those in Japan.

*Corresponds to *Physics Today*, published by the Physical Society of Japan.

The Power of Words in Technical Communication, E. P. Odescalchi, *The Technical Writer*, 1, No. 3, 11-12 (September, 1961).

Language is the most common vehicle for transmitting information. The relationship between word power and intelligence is well documented. Intelligence evaluations rely heavily on vocabulary tests because words are the tools for thinking and ideas do not exist in the mind apart from them. Statistical data are presented to show the relationship between vocabulary size and degree of achievement in society. People with more words at their command can present their ideas and arguments with greater skill and ultimately win out in the competition with others. All words, even the most complex ones, have very concrete origins. The entire vocabulary of English can theoretically be derived from 461 Indo-European roots. Seventeen master words, mostly Latin, and twenty prefixes which hold the key to about 100,000 words in the unabridged dictionary are compiled and the former illustrated with examples.

A Preplanned Approach to a Storage Allocating Compiler, R. W. O'Neill, *Communications of the Association for Computing Machinery*, 4, No. 10, 417 (October, 1961).

The paper describes the storage allocation problem and briefly considers the advantages of using a compiler to solve this problem.

Pressure Dependence of the Elastic Shear Constants of Li,* A. L. Jain, *The Physical Review*, 123, No. 4, 1234-1238 (1961).

The elastic shear constants $C = C_{44}$ and $C' = \frac{1}{2}(C_{11} - C_{12})$ of lithium have been measured as a function of pressure at room temperature. The measured values of $d \ln C / d \ln r$ and $d \ln C' / d \ln r$ are -4.1 and -2.8 , respectively. This inequality of the two pressure variations is contrary to the situation found in sodium, where the two coefficients were equal. Theoretically, the two coefficients are expected to be the same, if only the electrostatic interaction between the electrons and the ions is responsible for the elastic stiffness of metal. The different behavior in lithium can be understood in terms of the extra contribution to the shear constants arising due to the change in the Fermi energy of the electrons on shearing.

*Work done while author was at Case Institute of Technology, Cleveland.

Principles of Limiting Absorption and Limiting Amplitude in Scattering Theory, I. Schroedinger Equation, II. Wave Equation, F. M. Odeh, *Journal of Mathematics and Physics*, 2, 974-802 (1961).

Three principles which are used to characterize the solutions of a scattering problem are shown to be equivalent in the two cases of Schroedinger's Equation and the wave equation in an inhomogeneous medium.

Quantized Probability Design: Part II, Richard B. Hurley, *Electronic Equipment Engineering*, 9, No. 10, 65-68 (October, 1961).

A technique for designing transistor logic circuits is based on statistical probability. A set of quantized rules is used for the actual design, and statistical methods are used only for checking. Quantized probability design, although a worst-case technique, employs more optimistic tolerance limits than does Taylor's Worst Case.

Quantum Theory of Free Carrier Absorption, W. P. Dumke, *The Physical Review*, 124, 1813-1817 (December 15, 1961).

The theory of free carrier absorption has been investigated to determine the adequacy of the current quantum theory at large photon energies, and the necessity of a quantum theory at small photon energies. It is found that even at appreciable photon energies, virtual states in higher bands make a negligible contribution to the free carrier absorption. It is shown that the quantum theory becomes equivalent to the classical Boltzmann theory of free carrier absorption for photon energies that are small compared to the carrier energies, which is therefore a condition for the validity of the classical theory. The classical theory may, however, give reasonably good agreement with experiment over a much wider range of photon energies, since the inaccuracies involved in the classical theory of free carrier absorption tend to compensate each other. Hot electron effects on free carrier absorption are also discussed.

Rayleigh Disk Response to Pure Superflow,* T. R. Koehler and J. R. Pellam,** *Proceedings of the VIIth International Conference on Low Temperature Physics*, University of Toronto Press, 1960, pp. 573-576.

Classical hydrodynamics predicts that a disk immersed in an ideal fluid of density ρ moving with a uniform velocity v at infinity experiences a torque of magnitude (apart from geometrical factors) proportional to ρv^2 . Such a Rayleigh disk also responds properly to the internal convection at heat flow (and second sound waves) in liquid helium II. An experiment conducted with a 3-mm diameter disk suspended by a fine quartz wire and placed in a "superfluid wind tunnel" established the fact that pure superfluid, flowing through a stationary normal fluid background, exerts by itself the torque expected from classical theory.

*Work performed at the California Institute of Technology and supported in part by the Alfred P. Sloan Foundation, Inc., and the National Science Foundation.

**California Institute of Technology, Pasadena.

The Relative Effectiveness of Document Titles and Abstracts for Determining the Relevance of Documents in a Selective Dissemination System, A. Resnick, *Science*, **134**, No. 3484, 1004-06 (October 6, 1961).

An experiment was conducted to compare the relative information content of titles as opposed to abstracts for dissemination purposes. Individuals who were recipients of notifications from a Selective Dissemination of Information System were asked to determine the relevance of these notifications to their work interests. These notifications contained either a title or a title and an abstract. The results indicate that there was no significant difference between titles and abstracts when utilized for this purpose.

Relaxation Equations for Two-Magnon and Magnon-Phonon Processes in Ferrimagnetic Resonance, P. E. Seiden, *The Physical Review*, **124**, 1110-1112 (November 15, 1961).

Equations which give the relaxation behavior of the magnetization in the case of ferrimagnetic resonance are derived from quantum mechanical rate equations for spin-wave magnons. It is shown that the concept of a unique relaxation time for a particular component of magnetization is not in general valid.

Reliable Data Transmission Through Noisy Media—A Systems Approach, C. M. Melas, *Communication and Electronics*, **57**, 501-504 (November, 1961).

Error control techniques are becoming increasingly important in data transmission systems, since they allow reliable communications over media where the interference is high. Transmission errors can be corrected either by adding redundancy bits to the information to generate an error correcting code, or by automatically retransmitting the message when erroneously received. The relative merits of the two techniques are discussed in terms of both error control and systems compatibility. A class of powerful and easily implemented cyclic error detection and correction codes was recently developed which, in combination with automatic retransmission, should give effective error protection. Once the system reliability requirements are realistically gauged, and the characteristics of the channel interference are known, it is possible to determine a cyclic code best suited to that interference, and to determine a message length for the maximum transfer of information.

Representation of Power Series in Terms of Polynomials, Rational Approximations and Continued Fractions, K.

Spielberg, *Journal of the Association for Computing Machinery*, **8**, No. 4, 613-627 (October, 1961).

The first part of this paper is devoted to a discussion of a digital computer program, developed for the IBM 704 computer, which furnishes polynomial approximations with accuracy up to 16 digits for power series on other polynomials. The method used is essentially the economization procedure proposed by C. Lanczos, R. C. Minnick and others. In the second part of the paper a method of obtaining efficient rational approximations is developed. It presupposes the existence of the program described in the first part and probably constitutes a novel approach to the problem, well suited for computer programming. Finally, a computer program based on the ideas of Part Two is described and an application to the function $\log_2 x$ is given.

Scientific Sensors for Space Vehicles, J. J. Leybourne, *Astronautics*, **6**, No. 11, 36-37 (November, 1961).

A survey of a number of instruments used or being developed for scientific measurements in space is presented in compact chart form and includes information on class of experiments, intrinsic signal form, range, mode of operation, signal after processing, satellite and space-probe environments, and comments. The chart is accompanied with introductory text.

Self-Consistent Nuclear Model,* B. Rozsnyai, *The Physical Review*, **124**, No. 3, 860-867 (November 1, 1961).

A Hamiltonian proposed by Duerr is applied to carry out self-consistent calculations for atomic nuclei. Average exchange forces, calculated from a plane-wave model, are included in the Hartee potential. In order to obtain agreement with the empirical data, two coupling constants and one constant representing the range of the interaction have to be adjusted. The range turns out to be 3.23×10^{-14} cm. Because this range is very short, the calculations may not be justified and must be considered as a formal procedure. Having adjusted the three parameters, reasonable neutron and proton binding energies and nucleon densities are obtained for the nuclei O^{16} , Ca^{40} , Ce^{140} , and Pb^{208} .

*This work was supported in part by the U.S. Army Office of Ordnance Research and by the National Science Foundation.

Based on Ph.D. thesis, University of California, Berkeley. Now at IBM General Products Division Development Laboratory, San Jose, California.

A Semi-Automatic Storage Allocation System at Loading Time, W. P. Heising and R. A. Larner, *Communications of the Association for Computing Machinery*, **4**, No. 10, 446-449 (October, 1961).

The method described assumes that a complex application is compiled (or assembled) in a number of semi-independent modules. After the parts are individually checked out, the user then decides on the overlay segmentation, and via a few control cards directs the loader which does a complete storage allocation. Provisions for automatically bringing in new program segments as needed during execution are given. An outline of the loader operating logic is also given.

Simulation and Analysis of Biochemical Systems, I. Representation of Chemical Kinetics, D. Garfinkel,* J. D. Rutledge, and J. J. Higgins,* *Communications of the Association for Computing Machinery*, **4**, No. 12, 559-562 (December, 1961).

This is the first of three papers describing a system, programmed for Univac I, which sets up and simulates biochemical systems described in standard chemical notation. This paper describes the input language, compiler, and parts of the simulation program.

*Johnson Foundation for Medical Physics, University of Pennsylvania.

Some Remarks on the Integral Equations of Statistical Mechanics, E. W. Montroll, *Fundamental Problems in Statistical Mechanics*, North-Holland Publishing Company, Amsterdam, 1961, pp. 230-249.

This paper has two aims. The first is to derive and exhibit the integral equations which form the basis for much of the recent work in statistical mechanics of many interacting particles. The second is to show how an exact differential equation can be derived for diagonal elements of the density matrix. For an arbitrary time when it is known that time T equals zero, the density matrix is diagonal.

Some Thoughts on Digital Components and Circuit Techniques, A. W. Lo, *IRE Transactions on Electronic Computers*, EC-10, No. 3, 416-425 (September, 1961).

Signal standardization and control directivity are emphasized as the basic physical requirements in considering components and circuit techniques for the handling of digital information. The significance and the ways and means of meeting these requirements are most revealing when illustrated by the operations of the parametric phase-locked oscillator and the tunnel diode. A categorical listing of digital-gain elements, accompanied by illustrative components, is presented to offer a unified viewpoint on digital components and circuit techniques in connection with present-day practice and prospective future development.

Stable Paretian Random Functions and the Multiplicative Variation of Income, B. Mandelbrot, *Econometrica*, 29, 517-543 (October, 1961).

A model of the variation of income is constructed with the help of the stochastic process obtained from the Gaussian process by replacing the Gaussian variables by many-dimensional stable paretian variables. In this way, the classical principle of random multiplicative change is reduced to novel assumptions, very different from the usual ones.

The Strain Dependence of the Acceptor Binding Energy in Diamond Type Semiconductors, P. J. Price, *The Physical Review*, 124, 713-716 (November 1, 1961).

It is shown that if the acceptor binding energy be expanded in inverse powers of the strain amplitude, $W(\epsilon) = W(\infty) + W_1/\epsilon + \dots$, then the product $E_S W_1/\epsilon$, where E_S is the strain-induced splitting of the band edge, may be equated to a certain (constant) quantity, Z_0 , which is readily calculable in terms of the infinite-strain acceptor ground state. Z_0 is calculated for germanium with an uniaxial (1, 0, 0) compression. A provisional value of W_1 , obtained from the existing data for this case, then gives the result $b = 2.9$ ev for the applicable deformation potential constant. An approach to the calculation of W for arbitrary ϵ is suggested.

A Supersonic Navigation System, J. H. Crenshaw, *Navigation*, 8, No. 2, 105-111 (Summer, 1961).

The paper describes the features of navigation systems which have been developed by IBM for military aircraft, both subsonic and supersonic. The functions of the Doppler radar, inertial

platform, star tracker, digital computer and ground mapping radar are discussed. The need for operator aids and some specific provisions to eliminate routine and time-consuming activities are described. Built-in test features are discussed.

Theoretical Interpretation of Carbon-13 Hyperfine Interactions in Electron Spin Resonance Spectra,* Martin Karplus** and George K. Fraenkel,† *The Journal of Chemical Physics*, 35, 1312-1323 (October, 1961).

A quantitative theory of the isotropic electron-nuclear spin interactions of carbon 13 in pi-electron radicals is presented and applied to the hyperfine splittings observed in the electron spin resonance spectra of these substances. The splittings arise from sigma-pi interactions which polarize both the 1s and 2s electrons. The 1s-orbital spin polarization is shown to contribute a term of negative sign with a magnitude comparable to that from the 2s electrons. For an sp^2 hybridized carbon atom that is bonded to three atoms, X_i ($i = 1, 2, 3$), the hyperfine constant a^C has the form

$$a^C = (S^C + \sum_{i=1}^3 Q_{CX_i}^C) \rho^\pi + \sum_{i=1}^3 Q_{X_i C \rho_i}^C,$$

where ρ^π and ρ_i^π ($i = 1, 2, 3$) are the pi-electron spin densities on atoms C and X_i , respectively. The contribution of the 1s electrons is determined by S^C and that of the 2s electrons by the Q 's, where Q_{BC}^A is the sigma-pi parameter for the nucleus of atom A resulting from the interaction between the bond BC and the pi-electron spin density on atom B. Calculations for a planar CHC_2 fragment model yield $S^C = -12.7$ gauss, $Q_{CH}^C = 19.5$ gauss, $Q_{C'C}^C = 14.4$ gauss, and $Q_{C''C}^C = 13.9$ gauss. The theory predicts both the magnitude and sign of the hyperfine splittings and is readily applied to a variety of compounds. Excellent agreement is obtained with the available experimental data. For the methyl radical, the measured C^{13} splitting is shown to be consistent with a planar model and limits the deviation from planarity to $\leq 5^\circ$. The theory provides a useful criterion for the validity of approximate wave functions and is illustrated by a comparison of various theoretical treatments for the naphthalene negative ion and tri-phenylmethyl. The sigma-pi interaction parameters are shown to depend on the bond length, the type of hybridization (including the angles between sigma bonds), and on the nature of the bonding atoms. For pi-electron systems, the results demonstrate that the magnitude of the sigma-pi exchange energy is a small fraction of the total energy. It is also noted that the proton parameter Q_{CH}^{H-} is somewhat larger in CHC_2 than in CH_3 , which suggests a theoretical justification for some of the variation in the experimental " Q_{CH}^{H-} " required to fit measured proton splittings. The form of the theory is readily extended to the treatment of hyperfine splittings from nuclei other than C^{13} .

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Theory of the Spin and Charge Distribution in Aromatic Ion Radicals; Application to the Naphthalene Negative Ion,* J. C. Schug**, T. H. Brown†, M. Karplus,‡ *The Journal of Chemical Physics*, 35, 1873-1883 (November, 1961).

The valence-bond method is extended to positive and negative ion radicals. General formulae for the required energy, overlap, spin-density, and charge-density matrices are developed and specialized to pi-electron systems. An application of the method to the pi-electrons of the naphthalene negative ion is given. Included in the calculation are all unexcited structures with the negative charge in each of the ten possible positions. When approximate exchange and transfer integrals

are used to determine the coefficients of valence-bond structures, the α to β position spin-density ratio is found to be equal to 2.60, in good agreement with the "experimental" value of 2.65. The magnitudes of the calculated spin densities are such that a Q of 26.3 gauss is required to obtain the measured hyperfine splittings. In order to test the validity of the valence-bond results, their sensitivity to the molecular integral values was examined. Also comparisons with a variety of molecular-orbital calculations are given. It is of considerable interest that the charge distributions obtained from the valence-bond theory and the molecular-orbital theory are very different in spite of the similarity of the spin distributions calculated by the two methods.

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Thermal Evaluation of High Density Electronics Packages, H. C. Kammerer, *Electronic Design*, 9, No. 25, 121-122 (December 6, 1961).

A useful nomograph to determine the design limitations on microminiature packages imposed by thermal factors is presented. An example is included.

The efforts to reduce the size of electronic assemblies has brought about a need for a method to facilitate preliminary thermal evaluations of the resulting equipment. The goal to achieve high component density has resulted in increased power density which in turn places greater demands on the cooling techniques for the package.

A Toroidal Nondestructive Readout Memory Element Using Bias Restoration, M. Teig and J. R. Kiseda, *Proceedings of the 1961 Special Technical Conference on Nonlinear Magnetics*, 137-167 (November, 1961).

The one-core-per-bit nondestructive readout (NDRO) toroidal magnetic memory element described in this paper has distinct advantages over other presently available NDRO devices. It exhibits larger signal-to-noise ratios, larger signal levels and simplicity in writing and wiring. This nondestructive readout technique uses a bias current in a direction that opposes the narrow readout pulse. The magnitude of the bias is below the static threshold of the core and restores any irreversibly switched flux during readout thereby providing very stable information states. The dc bias current may be kept on during both read and write time, when the element is used in a linear selection memory array. Signal levels for a ferrite core during a 100 nanosecond nondestructive read are of the order of 500 millivolts with peak voltage signal-to-noise ratios ranging from 5:1 to 10:1 without using any canceling techniques. Strobed voltage signal-to-noise ratios of 100:1 were measured. Data for metallic tape cores were similar to the results obtained with ferrites.

Transmission Properties of Optical Fibers,* R. J. Potter, *Journal of the Optical Society of America*, 51, No. 10, 1079-1089 (October, 1961).

Equations which describe the flux transmitted and the angular distribution of the emergent light from straight cylindrical fibers of circular cross section have been derived and numerically evaluated. Loss of light due to imperfect reflections, bulk absorption, and Fresnel reflections, are included in the formulation. All skew rays in the fiber have been considered in these calculations. Measurements of the attenuation and angular distribution of the emitted light from plastic scintillating fibers have been made. From the theoretical equations it has been deduced that these fibers are characterized by an internal reflectivity of 0.993 ± 0.002 and an absorption coefficient of

$0.015 \pm 0.003 \text{ cm}^{-1}$. Measurements of the light transmitted by single-clad fibers indicate that these fibers are characterized by an internal reflectivity of 0.993 ± 0.0002 and an absorption coefficient of the order of 10^{-4} cm^{-1} . Some experimental data on glass fiber bundles are included.

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Trends in Dielectric Research During 1960, A. M. Parks, *1960 Digest of Literature on Dielectrics*, National Academy of Sciences, National Research Council, 24, 917, 1-6, (1961).

The most significant developments in the field of dielectric research during 1960 are discussed in the introduction to this volume. The areas discussed include instrumentation and measurements, molecular and ionic interactions, conduction, breakdown, ferro-electric and piezoelectric materials, high polymers, inorganic insulation, insulating films and applications.

Truth Functions Realizable by Single Threshold Organs, C. C. Elgot, *Proceedings of the Second Annual Symposium and Papers from the First Annual Symposium on Switching Circuit Theory and Logical Design (AIEE)*, S-134, 225-245 (October, 1961).

A threshold function is a mapping from $\{0,1\}^n$ into $\{0,1\}$ satisfying: there exist integers $w_1, w_2, \dots, w_n, t$ such that $f(x_1, x_2, \dots, x_n) = 1$ if

$$\sum_{i=1}^n w_i x_i \geq t.$$

Two chains of conditions necessary for a function to be a threshold function are discussed. Early parts of the two chains are equivalent. One chain constitutes a sufficient condition. It is shown that any set of threshold functions of n variables realizable by a common set of weights is included in a maximal chain of threshold functions of length $1 + 2^n$ realizable by a common set of weights. If f depends on at most 5 variables or if f or its dual has at most 4-prime implicants, then f is a threshold function if it is 2-monotonic.

Two Soluble Models of an Antiferromagnetic Chain, E. Lieb, T. D. Schultz, and D. Mattis, *Annals of Physics*, 16, 407-466 (December, 1961).

Two genuinely quantum-mechanical models for an antiferromagnetic linear chain with nearest neighbor interactions are constructed and solved exactly, in the sense that the ground state, all the elementary excitations and the free energy are found. A general formalism for calculating the instantaneous correlation between any two spins is developed and applied to the investigation of short- and long-range order. Both models show nonvanishing long-range order in the ground state for a range of values of a certain parameter λ which is analogous to an anisotropy parameter in the Heisenberg model. A detailed comparison with the Heisenberg model suggests that the latter has no long-range order in the isotropic case but finite long-range order for any finite amount of anisotropy. The unreliability of variational methods for determining long-range order is emphasized. It is also shown that for spin 1/2 systems having rather general isotropic Heisenberg interactions favoring an antiferromagnetic ordering, the ground state is nondegenerate and there is no energy gap above the ground state in the energy spectrum of the total system.