

IBM Technical Papers Published Recently in Other Journals

Analysis of the Frequency and Power Performances of Tunnel Diode Generators, H. J. Oguey, *IEEE Transactions on Microwave Theory and Techniques MTT-11*, No. 5, 412-419 (September, 1963).

This analysis shows the order of magnitude of the highest frequency and power to be expected from a single tunnel diode generator. An optimization on the circuit level indicates how to make the best use of a given device. The influence of the dimensions and the geometry is considered and relates the performances of the circuit with bulk and junction properties of the semiconductor. On the basis of empirical data, a correlation between bulk and junction properties is established and relates all of them to the doping level and the basic semiconductor used. Numerical data show the physical limitations to be expected with germanium and gallium arsenide in relation with two idealized cavity geometries. As dimensions cannot be arbitrarily reduced, nor the impedance be arbitrarily low, they introduce other limitations which prevent in some cases the possibility of optimum performances and show comparable merits of the two geometries. It is concluded that a power output of 5 mW at 30 kMc/sec for a GaAs tunnel diode generator is an optimistic figure close to the technical limit.

Analysis of Sneak Paths and Sense-Line Distortion in an Improved Capacitor Read-Only Memory, D. M. Taub, *Proceedings of the IEEE* 51, 1554-1569 (November, 1963).

The principle of operation of existing capacitor read-only memories is explained and their shortcomings pointed out. An improved type is described and a mathematical analysis made of the factors that limit its performance. These factors are: a) unwanted coupling between sense lines ("sneak paths"), and b) sense-line distortion caused by losses. For the purpose of the analysis, the memory is reduced to a system consisting of two conductors over a ground plane, the conductors being coupled along their length by a distributed admittance. The transmission characteristics of this system are derived in the Appendix.

Anelasticity and Stress-Induced Ordering of Point Defects in Crystals, A. S. Nowick and W. R. Heller, *Advances in Physics* 12, 251-298 (July, 1963).

Point defects may exist in a crystal on a set of crystallographically equivalent orientations or sites. The response of a crystal containing point defects to an externally applied stress takes the form of "stress-induced ordering," or preferential alignment of the defects. Recent experiments have used optical and spin resonance techniques to observe this stress-induced ordering directly. This same process also gives

rise to anelasticity, e.g., to an internal friction peak. In describing such behavior, the concept of a point defect as an "elastic dipole," introduced by Kröner and others, is very useful. The elastic dipole is here defined as a second-rank tensor, the " λ -tensor," equal to the average strain per mole fraction of defects all aligned in a particular orientation. This definition is then used to develop a thermodynamic theory of stress-induced ordering, which includes the interaction among defects and the possibility of a "reaction" or interconversion between two species of defects. Applications of the theory are made to defects of various point symmetries in cubic crystals, and a number of specific examples are discussed to illustrate each type of defect symmetry. The usefulness of the theory is that it enables one to calculate the values of the components of the λ -tensor from experimental information and the defect symmetry. Typical values of these λ -parameters range from 10^{-2} to unity.

Apparatus for Light Efficiency Measurement, G. Cherooff, C. Lanza, and S. Triebwasser, *The Review of Scientific Instruments* 34, No. 10, 1138-1141 (October, 1963).

Motivated by a desire to determine the quantum efficiency of a relatively large number of GaAs injection lasers in order that some understanding of the relation between performance and structural parameters could be derived, a simple system for measuring the total light emission from such devices was sought. The method finally employed is generally applicable to any enclosure in which the walls are reasonably good diffuse reflectors. The calibration of the transfer efficiency of light from the source to a detector is effected by introducing a light absorbing element of known relative absorption coefficient and area.

Azimutalmodulation in der Optik (Azimuth Modulation in Optics), A. Lohmann and B. Morgenstern*, *Optik* 20, 450-455 (September/October, 1963). (In German).

With the normal electrical modulation techniques, a single time frequency serves as carrier whose amplitude, frequency or phase is varied in proportion to the signal. In the optical analogue, a grating (i.e., a single frequency in space) serves as carrier whose amplitude, frequency or phase is varied in proportion to the spatially varying signal (i.e., object). The process is exemplified by thermoplastic recording. Since optical signals are a function, in general of two dimensions (x, y or r, θ), replacing the single time coordinate, t , we have a new type of modulation which we have called azimuth modulation.

The azimuth angle of the grating, i.e., of the carrier, is varied in proportion to the signal amplitude at a given ob-

ject point. The interesting aspect of this type of modulation is that the demodulation process can be controlled in any desired nonlinear manner. This makes possible a type of multiple image recording by means of which several signals (objects) can be simultaneously recorded on a single surface. The demodulation process enables the individual images to be "discriminated."

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Calorimetric Measurements of the Heat of Sorption of Water Vapor on Dry Swollen Cellulose, J. Greyson* and A. A. Levi, *Journal of Polymer Science Part A*, 1, 3333-3342 (November, 1963).

Calorimetric measurements of the heat of sorption of water vapor on a dry, swollen cellulose sample have been made for various swelling states of the sample. The state of swelling was characterized by the surface area of the sample as determined by nitrogen adsorption (B.E.T.). Six runs were made with the surface area varying from 140 m²/g to 2m²/g. The initial heats do not vary significantly with change in surface area and were found to be 15 to 16 kcal per mole of water sorbed. The energetics of water sorption and the water regain, at low water concentrations, are entirely independent of the surface area range (swelling state) of the cellulose. The surface area was found to decrease logarithmically with the quantity of water sorbed on the cellulose. It is concluded that the interaction of water and cellulose is a bulk rather than a surface effect.

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Clustering Effects in Superconducting Aluminum-Zinc Alloys, C. Chiou and D. P. Seraphim, *Transactions of the Metallurgical Society of AIME* 227, 1209-1211 (October, 1963).

The effect of clustering on the superconducting properties of Al-Zn alloys has been studied by the ballistic induction techniques. The superconducting critical temperature, T_c , changes when zinc-rich clusters are formed. The change in T_c depends on the concentration and may be positive or negative, but always correlates with an effective decrease in the solute concentration of the alloy. Reversion after clustering effectively returns a 5 at. % Zn alloy to the quenched state. These methods might be usefully extended to the Al-Mg system, where x-ray data are difficult to obtain.

Comparison of a Momentum Device with a Turbulent Reattachment Device, H. R. Müller and A. E. Mitchell, *Journal of Applied Mathematics and Physics (ZAMP)* 14, No. 6, 758-763 (1963).

The jet profile of a momentum amplifier is used to find the optimum distance between receiver and outlet nozzle, as well as the most favorable receiver width. The receivers are designed for digital operation, so that good discrimination is assured. With the help of the output characteristic and of the control line resistance, the response time can be calculated. With equal discrimination, without considering response time, the boundary layer amplifier allows essentially higher amplification.

A Computer-Operated Laboratory Data-Taking System, H. Cole, Y. Okaya and F. W. Chambers, *IBM Systems Journal* 2, 240-247 (September/December, 1963).

This paper discusses the use of a computer to control data-taking in the laboratory—including the case of "closed-loop" control. Illustration is provided by describing a particular system involving computer control of an x-ray diffractometer.†

† This part of the paper is an abridgment of an article, **Computer-Controlled Diffractometer**, published by the authors in the *Review of Scientific Instruments* 34, 872 (1963). Permission of the American Institute of Physics to reprint from this paper is appreciated. Crystallographers interested in greater detail are referred to the latter paper.

The Computer and Programmed Instruction, W. J. Koppitz, *Datamation* 9, 50-58 (November, 1963).

Although an industrial revolution in education had been predicted 30 years ago, so far no violent changes in teaching methods have occurred. An increasing difficulty of recruiting teachers and instructors together with recent advances in programmed instruction have revived the issue again. Psychological principles underlying programmed instruction and its goals are outlined. Different forms of current applications of this method are discussed. Among the applications, computer based instruction shows the strongest potential for fulfilling the desired goals. It is concluded, however, that future changes in education will hardly be in the form of a revolution; rather, a gradual development is foreseen.

Construction of a Growing Thesaurus by Conversational Interaction in a Man-Machine System, P. Reisner, *Automation and Scientific Communication* (Short Papers contributed to the 26th Annual Meeting of the American Documentation Institute), Part I, pp. 99-100 (1963).

The idea of a "growing" thesaurus, to be augmented by users of a man-machine retrieval system in the course of their own searches, is introduced. A thesaurus system, with a thesaurus and an index both stored in memory and queried via a keyboard console, is described which embodies this idea.

Counting with Nonlinear Binary Feedback Shift Registers, M. Yoeli, *IEEE Transactions on Electronic Computers* EC-12, No. 4, 357-361 (August, 1963).

This paper discusses methods of designing binary nonlinear feedback shift registers with cycles of specified length. First, the cycle structures of the simplest feedback functions, e.g., the circulating shift function, are considered. It is then shown how such structures may be modified, either by joining two suitable cycles into one or by the reverse process of splitting a cycle into two. By properly applying these two methods, namely, cycle joining and cycle splitting, a wide range of binary shift registers having relatively simple feedback logic is easily designed.

Crystal Field Comparisons, Gerald Burns and W. J. Nicholson, *Proceedings of the XIth Colloque Ampère* (Magnetic and Electric Resonance and Relaxation), pp. 461-465 (1962).

One is often interested in the crystal field ($\sum A_n^m r^n Y_n^m$) at an ion that has been added to the lattice for resonance

purposes. In particular, does the added atom see the same crystal field as the host ion? This problem has been looked at by several methods: 1). Measurements have been made of eQq/h of Fe^{+3} (using the Mössbauer technique) and compared with values of eQq/h of the Al^{+3} host atoms in several crystals ($q \propto A_s^6$). 2). The variation of the zero field term in the ESR spin-Hamiltonian, $D[S_z^2 - \frac{1}{3}S(S+1)]$, of Cr^{+3} is compared to eQq/h of the Al and Ga host lattices in several hydrated crystals (alums, etc.). 3). Calculations of A_n^m are compared between isomorphous GdCl_3 and LaCl_3 . 4). The ^6S state ion problem is studied by observing the relation between the axial crystal field seen by Fe^{+3} (measuring eQq/h of Fe^{+3} itself) and its ESR D splitting, which is compared with Watanabe's theory.

Design of an Integrated Programming and Operating System. Part III: The Expanded Function of the Loader, R. Hedberg, *IBM Systems Journal* 2, 298-310 (September/December, 1963).

This paper outlines the structure and operation of the system's loader. The new system functions which affect the loader are related to the additional functions which the loader performs. Descriptions of the algorithms employed by the loader for symbolic unit assignment and buffer allocation are included.

Design of an Integrated Programming and Operating System. Part IV: The System's FORTRAN Compiler, R. Lerner, *IBM Systems Journal* 2, 311-321 (September/December, 1963).

This paper describes the system's 7090/94 FORTRAN compiler. Comment is made on the design problem and objectives. The general structure and operation of the compiler are examined. Indexing procedures for array reference and iteration control within the object programs produced by the compiler are detailed.

Design of an Integrated Programming and Operating System. Part V: The System's COBOL Compiler, R. T. Dorrance, *IBM Systems Journal* 2, 322-327 (September/December, 1963).

The general considerations underlying the design of the system's COBOL compiler are discussed. A brief outline of the operation and structure of the compiler is included. Finally, attention is focused on certain techniques which are incorporated within the compiler.

Deviations from $T^{3/2}$ Law for Magnetization of Ferrometals: Ni, Fe, and Fe + 3% Si, B. E. Argyle, S. H. Charap, and E. W. Pugh, *The Physical Review* 132, 2051-2062 (December 1, 1963).

The variation with temperature of the magnetizations of single crystals of Ni, Fe, and Fe + 3 wt. % Si are studied. New data for Fe and Fe (Si) are presented along with previously reported measurements for Ni. These data were obtained by means of the pyromagnetic effect at various applied fields and in the temperature range 4.2–140, 30 and 120°K for the Fe, Fe (Si), Ni crystals, respectively. The observed departures from $T^{3/2}$ behavior are well described by spin-wave theory. Attempts to ascribe some of the measured variation of the magnetization to Stoner-type excitations or to variation of the moment per atom due to lattice expansion are mainly unsuccessful. The coefficients of the $T^{3/2}$ term

appropriate for zero spinwave energy gap are $C=7.5\pm0.2$, 3.4 ± 0.2 and $4.4\pm0.2\times10^{-6}$ deg $^{-3/2}$ for Ni, Fe and Fe (Si), respectively. The coefficients of the $T^{3/2}$ term for zero gap are determined only for the Ni and Fe crystals as $D = (1.5\pm0.2)\times10^{-8}$ deg $^{-5/2}$ and $(1\pm1)\times10^{-9}$ deg $^{-5/2}$, respectively. The measured variation of the spin-wave energy gap with applied field is consistent with the known g -values of 2.19 and 2.09 for Ni and Fe. The magnitude of the gap at zero field is fully explained by the effects of magnetocrystalline anisotropy and magnetic-dipolar coupling. The values of the C and D coefficients are compared with results from independent experiments and are discussed in relation to theories of ferromagnetism in metals.

Diffused Junction in GaAs Injection Lasers, J. C. Marinace, *Journal of the Electrochemical Society* 110, No. 11, 1153-1159 (November, 1963).

To date, only diffused junctions have been useful in injection lasers, and these tend to be non-flat. Non-flatness is of two kinds: "polygonal" and "amorphous." Besides the easily attributable causes such as surface damage, non-uniform Co, doping inhomogeneity in the substrate, there are other causes which remain undetermined. Generally, the easily attributable causes can be related to the "polygonal" non-flatness, and the undetermined causes to the "amorphous." "Amorphous" non-flatness seems to occur to a greater degree in GaAs crystals with some O_2 in them.

Digital Computer Techniques for Determining Circuit Behavior in a Pulsed Nuclear Environment, W. E. Craig and H. W. Mathers, *IEEE Transactions on Nuclear Science* NS-10, No. 5, 168-176 (November, 1963).

Two digital computer circuit analysis programs which predict circuit response in a pulsed nuclear radiation environment are presented. One program requires that linear direct current equations be written manually and then programmed for computer solution. The other program generates the equations from topological circuit information and then automatically solves the equations during the radiation burst. Predictions generated by the automated program on four different circuits are verified experimentally.

Dilute Solution Properties of a Neutral Polysaccharide*, J. A. Barry and G. D. Halsey, Jr., *Journal of Physical Chemistry* 67, 2821-2826 (December, 1963).

Dilute solution properties of the neutral galactomannan, known as locust bean gum (LBG), have been investigated. Due to formation of random intermolecular hydrogen bonds, large aggregates of the polymer are present in aqueous solution which are broken by elevating the temperature or adding hydrogen bonding agents such as OH^- and urea. The extrapolated molecular weight of a single polysaccharide molecule at infinite urea concentration or zero NaOH concentration is shown to be approximately 2.0×10^7 . The intrinsic viscosity of these aqueous solutions is unaffected by the degree of aggregation but displays temperature dependence as would be expected for a polymer containing OH groups dissolved in a highly polar medium. The viscosity behavior of LBG in NaOH solution has been shown to be the result of conversion of the neutral polysaccharide into a polyelectrolyte by the adsorption of OH^- .

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A Directly Coupled Multiprocessing System, E. C. Smith, Jr., *IBM Systems Journal* 2, 218-229 (September/December, 1963).

Interconnecting processors is one approach to organizing a computer facility to better serve its users. The objective of such system organization is to reduce the elapsed time a job resides in the system (turnaround time) while simultaneously increasing the workload the equipment can handle (throughput). Alternative philosophies of multiprocessing are discussed and, in particular, a concept which enables coupling an IBM 7090 and an IBM 7040 to meet this objective. In this system the smaller machine performs supervisory and input-output functions while the larger machine performs program assembly and computation.

Double Monochromator Systems, R. L. Christensen and R. J. Potter, *Applied Optics* 2, No. 10, 1049-1054 (October, 1963).

A geometrical analysis of image formation in single monochromators is expanded to include the dual monochromator and the tandem monochromator, a system of two single monochromators used in series. The tandem system is useful in measurements of monochromator transmittance and in providing double dispersion. This analysis leads to expressions for the passbands, radiance in the final slit plane, and transmitted flux, as the widths of the intermediate and final slits are varied.

Dynamic Storage Allocation for a Real-Time System, B. I. Witt, *IBM Systems Journal* 2, 230-239 (September/December, 1963).

An algorithm for dynamic storage allocation of variable-size programs and records is described. The algorithm is designed for real-time systems in which core is assigned for data and programs in a completely unscheduled manner as, for example, in reservation systems. The objective is to make efficient re-use of available core with minimal movement of data or programs after entry. The procedure given depends on the frequency distributions of program usage and of data block sizes. However, the distributions need not be specified since the system will adapt to these distributions and, equally important, to any changes in them that may occur. The algorithm has yet to be simulated or tested within an operating system.

Effect of Cation-Exchange Property of Wyoming Bentonite on Its Electro-Optical Birefringence, M. J. Shah and D. C. Thompson*, *Soil Science* 96, 347-352 (November, 1963).

An investigation of the effect of replacement of cations on the surface of bentonite particles with hydrogen on its electro-optical birefringence measurements is presented. The bentonite particles ranged in size from 4000 to 6000 Å, and were suspended in water. Cations were replaced by means of an ion-exchange resin. It was found that the replacement of Ca, Mg, and Na ions present on the bentonite particle surface increases its permanent dipole. Furthermore, when these suspensions are allowed to stand for a few days after ion exchange, the bentonite particle surface appears to regain these cations, probably from the inner clay structure, and the dipole moment is subsequently reduced. Results indicate a definite relationship between the ion-exchange property of bentonite and its permanent dipole moment.

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Effect of Growth Atmosphere on Impurity Precipitation in Alkali Halide Crystals, R. W. Dreyfus, *Applied Physics Letters* 3, 175-178 (November, 1963).

The ionic conductivity and dielectric polarization of doped alkali halide crystals was studied as a function of growth atmosphere. Both measurements indicate that precipitation of divalent metallic impurities is greatly accelerated by the presence of air during the growing process. Furthermore, it was ascertained that annealing the samples in water vapor also facilitated precipitation of metallic doping agents, e.g., SmCl_2 and VCl_2 . Microscopic examination of these crystals showed the presence of a second phase. The geometric shape of these particles depends upon which metallic impurity is present; hence one deduces that the metallic impurity must be one component of this second phase. The general conclusion is that in order to show the usual precipitation-type behavior, a contaminant from the atmosphere, as well as divalent metallic impurities, must be present in alkali halide crystals.

Effect of Short-Range Spin Correlation on the Electrical Resistivity of Dilute Magnetic Alloys, S. H. Liu, *The Physical Review* 132, No. 2, 589-594 (October, 1963).

The s - d exchange-interaction model has been widely used to explain many properties of magnetic metals and alloys. In particular, it has been suggested that the short-range order of the spins in a dilute magnetic alloy may give rise to the resistivity minimum effect. This paper gives a general discussion of the effect of spin correlation on the resistivity. The short-range correlation of the spins is investigated by the cluster expansion method. For dilute manganese-copper alloys where the Mn spins are believed to be coupled by the indirect exchange mechanism, the predicted variation in resistivity around the temperature where the minimum occurs is about 2 orders of magnitude smaller than the observed value. Hence, this model does not seem to explain the resistivity minimum phenomenon.

The Elastic Tensor of Given Symmetry Nearest to an Anisotropic Elastic Tensor, D. C. Gazis, I. Tadjbakhsh, and R. A. Toupin, *Acta Crystallographica* 16, 917-922 (September, 1963).

Given an arbitrary tensor in an n -dimensional Euclidean space, it is required to find its "nearest" tensor of some preassigned symmetry, i.e., the tensor of this symmetry which has the minimum invariant "distance" from the given tensor. General theorems are given concerning the construction and properties of these nearest tensors. The theorems are applied, in the case of elastic tensors, for the construction of the nearest isotropic and cubic tensors to a given anisotropic elastic tensor, and the nearest hexagonal polar tensor to a cubic elastic tensor.

Electric Birefringence of Bentonite. II. An Extension of Saturation Birefringence Theory, M. J. Shah, *Journal of Physical Chemistry* 67, 2215-2219 (October, 1963).

A theoretical analysis is presented for birefringence of a disk-shaped particle which is suspended in a medium and oriented in strong electric fields under a permanent dipole torque along the particle symmetry axis and under an induced dipole torque along the semi-major axis. Results show that, for certain values of the ratio of permanent dipole to the excess polarizability of the particle, the bire-

fringe of the suspension undergoes a minimum and, furthermore, exhibits a reversal in the sign of birefringence with increasing field strength. Theoretical results are compared with the experimental birefringence measurements of bentonite. Values of electrical anisotropy factors for three bentonite particle sizes are obtained from this comparison.

Electric Polarizability of Some Diatomic Molecules, H. J. Kolker* and M. Karplus,† *The Journal of Chemical Physics* **39**, No. 8, 2011-2016 (October 15, 1963).

A variation-perturbation method is employed for the calculation of the electric polarizability tensor of a series of diatomic molecules (H_2 , Li_2 , N_2 , LiH , HF , LiF , CO). The SCF-LCAO-MO functions of Ransil are used as unperturbed solutions, and appropriately orthogonalized perturbation functions are introduced to account for the effect of the electric field. For the three molecules (H_2 , N_2 , CO) for which experimental data are available, reasonable agreement between the theoretical and the measured values is obtained. However, the calculations appear to somewhat overestimate the electric polarizability, particularly so for the parallel component of the tensor; possible theoretical refinements to reduce this error are discussed.

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Electroluminescence and Photoluminescence of GaAs at 77°K, Gerald Burns, M. I. Nathan, S. E. Blum and J. C. Marinace, *The Physical Review* **132**, No. 4, 1482-1485 (November 15, 1963).

The electroluminescence from forward biased GaAs p - n junctions is compared with the photoluminescence of bulk homogeneously doped samples of GaAs. It is found that in the region of the absorption edge at ≈ 1.48 eV, the electroluminescence is similar to the p -type photoluminescence, while at lower photon energy the electroluminescence is similar to the n -type photoluminescence. The results show that centers responsible for the low energy electroluminescence are present in the substrate and are not introduced during the diffusion.

Evaluation and Compensation of Digital Switching Circuits Against Transient Radiation Effects, S. R. Sedore, *IEEE Transactions on Nuclear Science* **NS-10**, No. 5, 159-167 (November, 1963).

This paper deals with the most important considerations that govern digital switching circuits when they are subjected to transient radiation bursts. Emphasis is placed upon the ability of the circuit to maintain a desired state rather than on the switching process itself. A circuit designer's viewpoint has been taken as opposed to the very different one maintained by most solid state physicists.

Beginning with the general switching equations, a criterion is developed that will enable the circuit designer to rate the ability of a circuit to operate within system ground rules when certain transistor parameters are changed due to the radiation environment. These changes may be permanent or temporary. This criterion is applied to two contemporary digital circuits and reproductions of actual test results are present in support.

Evaporation Mechanism and Vapor Composition, D. W. Jepsen and G. A. Somorjai, *The Journal of Chemical Physics* **39**, No. 7, 1665-1670 (October, 1963).

A number of substances are known to evaporate simultaneously into monomers, dimers, and higher polymeric species in the gas phase. For many of these systems the evaporation is expected to be limited by a surface reaction which precedes desorption. A method is given for determining from experiments whether the various species are evaporated independently. The experiments which will define the evaporation mechanism measure the variation of the evaporation rates with the size of the orifice of the evaporation chamber.

The Evaporation Rate of Filament Material from Alternating Current Heated Filaments, A. D. Wilson, *Applied Optics* **2**, No. 10, 1055-1059 (October, 1963).

The operation of an incandescent filament on alternating current of the form, $i = i_0 \sin \omega t$, is reviewed. A model for the ac evaporation rate, in a vacuum of a uniformly heated straight wire, is presented in terms of (1) the known temperature fluctuations, and (2) the evaporation rate evaluated at the dc and the ac mean filament temperatures. It is shown that the ac evaporation rate can be significantly greater than the dc evaporation rate. A method of evaluating the ac evaporation rate in terms of the spectral modulation is developed.

Ferromagnetism and Spin Waves in the Band Theory, Daniel C. Mattis, *The Physical Review* **132**, 2521-2528 (December, 1963).

Intra-atomic exchange (Hund's rule mechanism) and Heisenberg nearest-neighbor exchange are examined for their role in the ferromagnetism of metals with degenerate bands. We examine the ground state, and find there is ferromagnetism once the largest eigenvalue j_{00} of the exchange matrix exceeds $\frac{1}{2} \times$ no. of atoms / density of states at the Fermi surface. We then find several spin wave spectra, of which one "acoustic" and at least one "optical" spectrum have infinite lifetime in the random phase approximation. The initial parabolic behavior of the acoustic spectrum yields Bloch's $T^{3/2}$ law at low temperature. There is a maximum wave vector beyond which no spin wave solutions exist, corresponding to a minimum wavelength of at least several atomic distances. Formulas are given, and the copious numerical results calculated by W. Doherty on the IBM 7094 Computer are summarized in graphs and tables. The ferromagnetic ground state is stable vs antiferromagnetic states only so long as *umklapp* is neglected. Because *umklapp* is most important in half-filled bands, we find qualitative agreement with previous calculations that antiferromagnetism can result in this case, in qualitative agreement with the known antiferromagnetic structure of Mn and Fe in the face centered cubic phase.

The Fiber Optical Properties of Ulexite, A. J. Weichel-Moore and R. J. Potter, *Nature* **200**, 1164-1165 (December 21, 1963).

A variety of the mineral, ulexite, exhibits fiber optical properties. The numerical aperture and resolving power of the crystal fiber bundle have been measured and the phenomenon explained in terms of crystal optics.

Generation of Input Data for Simulations, S. Yagil, *IBM Systems Journal* **2**, 288-296 (September/December, 1963).

An algorithm is given to generate additional input data for simulations when some, but insufficient, historical data are available. The additional data generated are statistically "similar" to the historical. Motivation and application of the algorithm are demonstrated by means of problems related to the monthly water inflow to Lake Tiberias which had to be resolved in connection with the "Israeli Integrated Water Supply" project now under construction. The algorithm is a variant of a method previously used by Thomas and Fiering in hydrological studies.

Geometrical Model of Electromagnetic Fields, E. S. Lowry, *American Journal of Physics* **31**, No. 11, 871-882 (November, 1963).

The electrostatic field, electromagnetic waves, electromagnetic induction, and the pure magnetic field are illustrated and explained in terms of a single pictorial representation of the general electromagnetic field of a classical charged particle. The field of a charged particle is described by the orientation and density of a family of surfaces radially distributed about the path of the particle in space-time. This description of the Maxwell field requires no reference to any coordinate system or field components.

Giant Oscillatory Attenuation of Helicon and Alfvén Waves, P. B. Miller, *Physical Review Letters* **11**, 537-538 (December 15, 1963).

By the use of a quantum model to calculate the current density, we have found that giant oscillations are present in the attenuation and in the real part of the conductivity. The meaning of giant is that the attenuation coefficient in cm^{-1} (Q_i) varies with magnetic field H so that $(Q_i^{\text{Max}} - Q_i^{\text{Min}}) \gg Q_i^{\text{Min}}$. Such giant oscillations have been found in the magnetoacoustic attenuation by Gurevich et al. We find similar giant oscillations in the attenuation of helicon and Alfvén waves although different selection rules on the Landau quantum number lead to a period which is approximately periodic in H^{-1} but which differs from the usual de Haas-van Alphen period and is a slowly varying function of H .

Influence of Multiple-Choice Answer Form Design on Answer-Marking Performance, Irwin Miller and F. J. Minor, *Journal of Applied Psychology* **47**, No. 6, 374-379 (December, 1963).

An evaluation of eight potential new multiple-choice answer forms was conducted. The purpose of the evaluation was to determine whether the new forms differed significantly from a standard IBM form in facilitating the marking of answers. The new forms and the standard IBM form were administered to 4th graders, 8th graders, and college students by means of a timed answer-marking task. Six of the forms produced significantly lower Total Right and Total Erasures scores than the IBM form. Differences in Total Double Marks were not significant. Females were found to achieve consistently higher mean Total Right scores than males on all answer forms.

Injection-Laser Systems for Communications and Tracking, C. M. Johnson, *Electronics* **36**, 34-39 (December 13, 1963).

The survey article treats the present developmental status and postulates future applications of laser systems. The author points out that after a year of research on materials and fundamental properties of injection lasers, some useful coherent light sources are now being tested in experimental communications links. Other applications are awaiting further device improvements, such as increased output power at room temperature, operation at visible wavelengths, and increased coherence.

An Intrinsically Addressed Processing System, J. E. Griffith, *IBM Systems Journal* **2**, 188-199 (September/December, 1963).

This paper, motivated by the classical work of Bush, discusses the possibilities of designing an information processing system based on intrinsic addressing techniques. The primary design objective is to develop a system with increased capability for non-numerical information processing. Suggestions for the physical and programming system logic are outlined from a macroscopic point of view and some applications of the system are indicated.

Ion-Water Interaction ("Salting Out") in Nitromethane and the Free Energy of Transfer of some Electrolytes to Pure Nitromethane from Nitromethane Saturated with Water,* G. R. Haugen† and H. L. Friedman, *Journal of Physical Chemistry* **67**, 1757 (1963).

The solubilities of the perchlorates of Na, K, Rb, and Cs and the perchlorates of K and Rb in nitromethane at 25° have been measured as functions of the concentration of added water. The data have been employed to calculate the free energy of transfer of each of the electrolytes to pure nitromethane from nitromethane saturated with water (1.30 molal water). The dependence of solubility on water concentration is analogous to the nonelectrolyte-electrolyte interaction in water commonly described as "salting out," but is of the opposite sign and also is much larger in magnitude. The electrolyte-water interaction in nitromethane calculated on the basis of a simple ion-dipole model with reasonable parameters is much smaller than observed. This is derived as an application of a general cluster theory expression for the interaction.

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Kinetics of the Thermal Isomerization of Bicyclo [2.1.1] hexane, R. Srinivasan and A. A. Levi, *Journal of American Chemical Society* **85**, 3363-3365 (1963).

The thermal isomerization of bicyclo [2.1.1] hexane in the gas phase in the pressure range from 0.1 to 20 mm and temperature range from 330 to 360°C was found to be a homogeneous, unimolecular reaction. The only product that was observed was 1,5-hexadiene. The kinetics of the reaction fitted the equation $1.49 \times 10^{15} \exp (-55000/RT) \text{ sec}^{-1}$.

Liquid Helium Transfer Tube, M. W. Dowley and R. D. Knight, *Review of Scientific Instruments* **34**, (December, 1963).

A liquid helium transfer tube is described which is a significant improvement on previous designs. Its principal advantages are: the elimination of all but four solder joints, simplicity of construction, light weight, ruggedness and high efficiency.

A Low-temperature Emission Band from Dilute Solutions of Pure Chlorophyll *a*, Seymour Steven Brody and S. B. Broyde, *Nature* **199**, 1097-8 (September 14, 1963).

Chromatographically pure Chlorophyll *a* exhibits two fluorescence maxima, at about 671 and 725 m μ , at room temperature and at 77°K. However, it has been found that further purification results in the appearance of an additional emission maximum at 698 m μ , at 77°K. The purification involves exhaustively washing the chlorophyll, adsorbed on diatomaceous earth, with petroleum ether. The new emission is quenched by the addition of small amounts of the concentrated petroleum ether washings, as well as by nitrobenzene and *p*-phenylenediamine.

Low-Temperature Properties of Evaporated Lead Films, H. L. Caswell, J. R. Priest,* and Y. Budo, *Journal of Applied Physics* **34**, 3261-3266 (November, 1963).

Lead films have been deposited onto room-temperature substrates having low thermal expansion coefficients, and the residual mechanical stresses present in these films have been determined as a function of film thickness and film purity. At room temperature no measurable stress ($<5 \times 10^7$ dyn/cm²) was present in any film. At 78° and 4.2°K the stress σ was given by $\sigma = \alpha + \beta/d$, where α is a constant dependent on temperature, and d is the film thickness. A model involving surface pinning of dislocations predicts an equation of this form, but the experimental values for the stress were found to be appreciably larger than values calculated on the basis of bulk data. The experimental values were substantiated by superconducting critical temperature measurements on films of various thicknesses. Localized crystalline growth was observed in lead films after cooling to 4°K. The film material around these micron-size crystals exhibiting five- and sixfold rotational symmetry was thinned to the point that physical holes were evident in the thinner films. In addition, with repeated temperature cycling, extensive cross slip was observed.

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Luminescence of GaAs Grown in Oxygen, W. J. Turner, G. D. Pettit, and N. G. Ainslie, *Journal of Applied Physics* **34**, No. 11, 3274-3276 (November, 1963).

A 0.65-eV luminescence peak has been observed in GaAs crystals grown in oxygen. The strength of the peak increases with increasing oxygen pressure during crystal growth. The 0.93-eV peak previously reported from electroluminescence measurements on GaAs diodes is observed in photoluminescence to decrease with increasing oxygen pressure and is absent in samples grown under high oxygen pressure. The 0.65-eV emission is not found in GaAs crystals pulled from AlN crucibles or in crystals grown in quartz without added oxygen. These two luminescence emissions appear to be related to the levels observed in optical absorption and photoconductivity measurements on *n*-type GaAs.

A Machine Stored Citation Index to Patent Literature—Experimentation and Planning, P. Reisner, *Automation and Scientific Communication* (Short papers contributed to the 26th Annual Meeting of the American Documentation Institute), Part I, pp. 71-72 (1963).

An experiment now in progress to test the utility of a citation index to patents is described and some properties of the data base given. Experimental processing and display equipment to be used for the machine stored and queried citation index are discussed briefly, and use of the index to monitor a classification system is suggested.

Magnetic Moment of Negative Muons,* D. P. Hutchinson,† Jack Menes,‡ G. Shapiro,§ and A. M. Patlach, *The Physical Review* **131**, 1362-1367 (August 1, 1963).

The magnetic moment of negative muons bound in atoms of carbon, oxygen (in water), magnesium (metallic and in MgH₂), silicon, and sulfur has been measured with a precision ranging from 3×10^{-5} in carbon to 1.6×10^{-4} in sulphur. The measured moment is corrected for relativistic effects, diamagnetism, and nuclear polarization before being compared to the moment of the positive muon. The two moments are found to be equal to 3×10^{-4} , where the major uncertainty is due to Knight shift. The relativistic, diamagnetic, nuclear and solid-state shifts are large enough compared to the statistical and systematic errors to make this technique usable for the investigation of these effects.

* Work supported in part by the U. S. Office of Naval Research.

† University of Pennsylvania, Philadelphia, Pennsylvania.

‡ Brookhaven National Laboratory, Upton, New York.

§ Lawrence Radiation Laboratory, Berkeley, California.

Magnetic Moment of the Positive Muon,* David P. Hutchinson,† Jack Menes,‡ G. Shapiro,§ and A. M. Patlach, *The Physical Review* **131**, 1315-1362 (August 1, 1963).

The magnetic moment of the positive muon has been re-determined in terms of proton moments using a precession technique. The sensitivity achieved yields an error of 13 parts per million. The muons are stopped in various targets in homogeneous magnetic field. The anisotropic distribution of the decay electrons relative to the muon spin direction permits the measurement of the spin precession frequency. The proton spin resonance is measured in the same field yielding $f_{\mu}/f_p = 3.18338 \pm 0.00004$. This result may be combined with that of other experiments, the muon *g* factor, and the ratio of electron cyclotron frequency to proton resonance, f_e/f_p , to obtain a more precise evaluation of the muon mass in terms of electron masses m_{μ}/m_e equals 206.765 ± 0.005 .

* Work supported in part by the U. S. Office of Naval Research.

† University of Pennsylvania.

‡ Brookhaven National Laboratory, Upton, New York.

§ Lawrence Radiation Laboratory, Berkeley, California.

Metastable Alloys of Cu-Co and Cu-Ag Thin Films Deposited in Vacuum, S. Mader, H. Widmer, F. M. d'Heurle, and A. S. Nowick, *Applied Physics Letters* **3**, 201-203 (December, 1963).

By the use of simultaneous vacuum evaporation of two metals onto a cold substrate, it has been possible to produce metastable alloy phases. In the case of Cu-Co a complete set of metastable solid solutions was produced. It was also possible to obtain a single crystal of the metastable solid

solution by evaporation onto MoS₂ substrates. In the case of Cu-Ag near the 50-50 composition, amorphous solutions were formed which decompose upon heating, first (near 100°C) into the metastable solid solution and finally (near 200°C) into the two-phase structure. In both cases the degree of metastability obtained by the present "vapor quenching" method is distinctly greater than that obtained by extremely rapid quenching of liquid droplets.

Molecular Weight Distribution of Linear Polymers from Stress Relaxation in Polymer Melts, W. L. Peticolas, *Journal of Chemical Physics* **39**, (December 15, 1963).

The method of Menefee and Peticolas for obtaining the molecular weight distribution of linear polymers from stress relaxation after steady-state flow has been applied to data on melt samples: a linear polyethylene and polystyrene sample. The results offer considerable promise for a rapid estimation of the high molecular portion of the distribution curve.

The method is based on a rather straightforward extension of the theory of Rouse to bulk molten polymers. A discussion of the validity of this process is given in the light of recent developments.

Nuclear Magnetic Relaxation in LiF at High Temperatures, Maurice Eisenstadt,* *The Physical Review* **132**, 630-635 (October 15, 1963).

Measurements of T_1 and T_2 , the spin-lattice and spin-spin relaxation times are reported for Li⁷ and F¹⁹ nuclei in a single crystal of LiF. T_1 (Li) has been measured from room temperature to the melting point (1120°K) and the other quantities from 830°K to the melting point. Above 620°K, relaxation is caused exclusively by the diffusion of Li and F ions. T_1 (Li), T_2 (Li), and T_1 (F) are mainly determined by ν_{Li} , the jump frequency of Li ions, and T_2 (F) mainly by ν_F . Using a theory of relaxation developed elsewhere, ν_{Li} and ν_F are obtained for the region of intrinsic diffusion as $\nu_{Li} = 1.7 \times 10^{16} \exp(-1.81 \text{ eV}/kT)$ and $\nu_F = 4.5 \times 10^{17} \exp(-2.2 \text{ eV}/kT)$. For the extrinsic region, the motional activation energy of Li ions is obtained as 0.71 eV. The values of ν_{Li} are in good agreement with those obtained from conductivity measurements; to our knowledge, ν_F has never been measured by other methods. Below 620°K quadrupolar relaxation due to lattice vibrations and relaxation by paramagnetic impurities become important, and rough values are obtained for these contributions to T_1 (Li). Large angular variations of T_1 and T_2 are observed in the region of relaxation due to atomic diffusion. T_2 (Li) and T_1 (Li) vary by a factor of 2 and 1.5, respectively, as a function of crystal orientation, in good agreement with theoretical prediction. A crude measurement of T_1 (Li) in molten LiF is discussed.

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Numerical Methods for the Synthesis of Linear Control Systems, Maurice E. Fowler, *Automatica* **1**, 207-225 (1963).

The techniques described in this paper permit a universal approach to the synthesis of continuous and sampled-data systems. Numerical methods are presented for the computation of root locus plots, transient responses, and z-transforms from the block diagrams of transfer functions. These methods are for use with high-speed, general purpose digital computers such as the IBM 7090 data processing system. The methods require little or no algebraic manipulation of

system equations, even for complex multiloop systems containing both continuous and sampled-data transfer functions. Examples are given showing the use of these methods and the results obtained. Programming details, which might be of value to persons desiring to develop similar programs, are briefly covered; future planned work and possible activities are described.

On the Asymptotic Behavior of the Number of Trials Necessary to Complete a Set with Random Selection,* R. K. Brayton, *Journal of Mathematical Analysis and Application* **7**, No. 1, 31-61 (August, 1963).

The problem of collecting m copies of a set of n objects by random selection is studied. Previous efforts on this problem have assumed that the probability of selecting a particular object of the set at any trial is $1/n$. In this paper it is assumed that the probability of selecting the i^{th} object at any trial is given by

$$p_i = \int_{(i-1)/n}^{i/n} f(u) du.$$

The mean and the variance of the number of trials necessary to complete the collection are computed along with their asymptotic behavior as $n \rightarrow \infty$.

* This paper is based on the author's doctoral dissertation, submitted to the Mathematics Department at the Massachusetts Institute of Technology, and was carried out under the direction of Professor Norman Levinson.

On the Computation of a Certain Type of Incomplete Beta Function, I. C. Tang, *Communications of the ACM* **6**, No. 11, 689 (November, 1963).

A straightforward evaluation of the incomplete beta function for certain ranges of parameters leads to a serious loss of accuracy. A technique for evaluating the incomplete beta function suitable for use on a digital computer without loss of accuracy is described.

Optimization Techniques, I. P. V. Carter, *Nordisk Tidsskrift för Informations Behandling (BIT)* **3**, No. 2, 69-92 (1963).

Mathematical techniques concerned with the optimal control of industrial and other processes, and in particular with their possible applications in computer-based control systems, are reviewed. Emphasis has been laid on comparisons rather than on individual descriptions, with a view to indicating factors influencing the choice of the best technique for a given application; with this aim in view, a brief description of the computer activity necessary to implement control by these methods has been given. A technique of constraint, which has not been described elsewhere, is presented in detail in the Appendix.

An Optimized Single Configuration Wave Function for the Ground State of Lithium Fluoride, A. D. McLean, *Journal of Chemical Physics* **39**, 2653-2665 (November 15, 1963).

A simple configuration self-consistent field molecular orbital wave function for the ¹Σ ground state of lithium fluoride from which a total molecular energy of -106.9885 a. u. at an internuclear separation of 2.8877 a. u. can be calculated is reported. It is shown on the basis of correlation energy arguments that this energy is within 0.007 a. u. of the

Hartree-Fock energy for the ground state of this molecule. Results computed with wave functions of slightly lower accuracy (-106.9769 a. u. at the minimum in the computed potential energy curve) are reported over a range of internuclear separations from 1.6 a. u. to 4.85 a. u. The systematic approach used in obtaining the best wave function is described since it appears to be a reasonable approach from the point of view of minimizing the amount of calculation involved, and for molecular wave functions this is a crucial consideration. A comprehensive table of expectation values including the dipole moment, kinetic energy, T , potential energy, V ,

$$\sum_i r_{Li,i}^2, \sum_i 1/r_{Li,i}, \sum_i 1/r_{F,i}, \sum_{i<j} 1/r_{ij},$$

and

$$\sum_i (3z_{Li,i}^2 - r_{Li,i}^2)$$

computed with wave functions of varying degrees of approximation is given.

Overhauser Effect in Metallic Lithium and Sodium,* Richard Hecht† and Alfred G. Redfield, *The Physical Review* **132**, 972-977 (November 1, 1963).

The Overhauser polarization of nuclear spins in Li and Na metal has been precisely measured at 1.5°K and 10.4 G. The electron spin resonance was saturated for a time long compared to the nuclear spin relaxation time, and the resulting Overhauser polarization was then measured by adiabatically applying a high field and sweeping through nuclear resonance in a time short compared to the nuclear relaxation time. The degree of electron saturation was determined with precision by comparison with the change in electron spin magnetization longitudinally measured under the same experimental conditions. For Na the polarization ratio is $100 \pm 3\%$ of its high-field theoretical value γ_e/γ_n ; for Li, $84 \pm 3\%$. At 10.4 G correction must be made for polarization leakage via the nuclear spin-spin energy; the predicted ratios are 98.5% for Na and 90% for Li, of the high-field values. The remaining discrepancy in Li is presumably a result of conduction electron orbital contribution to the relaxation which is important because of the predominantly p character of the lithium conduction electron wave functions. The orbital relaxation rate is estimated theoretically for Li, and the result agrees with the experiment.

* Part of this work was submitted by R. Hecht in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Columbia University.

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Paramagnetic Susceptibility of Metallic Lithium and Sodium by Electron Spin Resonance Saturation,* Richard Hecht,† *The Physical Review* **132**, 966-972 (November 1, 1963).

The total conduction electron spin moment of lithium and sodium dispersions has been measured in polarizing fields of about 10 G. The steady-state change in sample polarization at electron spin resonance was detected and then extrapolated to the limit of full saturation. Surprisingly, it was found that because the rf fields were linearly polarized and comparable to the polarizing field, the saturation level did not increase monotonically with rf field strength. The data were in good fit with saturation curves derived by means of numerical integration of the modified Bloch equation. The conduction electron spin susceptibility χ_s for lithium at 300°K was $(1.96 \pm 0.10) \times 10^{-6}$ cgs volume

units. The relative values of χ_s in lithium were the same at 300, 77, and 1.5°K, within an estimated uncertainty of 3%, and the relative values of χ_s in sodium were the same at 77 and 1.5°K, within an estimated uncertainty of 5%.

* Based on a thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Columbia University.
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A Pattern Identification System Using Linear Decision Functions, J. S. Griffin, Jr., J. H. King, Jr., and C. J. Tunis, *IBM Systems Journal* **2**, 248-267 (September/December, 1963).

This paper is concerned with application of linear decision functions to the pattern identification problem and describes an experimental pattern recognition system for the magnetic ink character font now used in the banking industry.

The system is based on a linear decision function determined by means of a variant of an "adaptive training" technique due to Rosenblatt. The system has been partially implemented (in part, through simulation with aid of a digital computer and, in part, by hardware) and experimental results in using the system are reported.

Pessimistic Circuit Design, N. A. Fruci, *Electro-Technology* **72**, No. 4, 74-78 (October, 1963).

Reliable design of transistor switching circuits requires some estimate of how long the circuit components will perform correctly. Variations in initial component values and in changes in value during the circuit lifetime must be considered.

Piezo-Galvanomagnetische Effekte in Wismut (Piezo-galvanomagnetic Effects in Bismuth), R. Jaggi and A. L. Jain, *Helvetica Physica Acta* **36**, No. 6, 807-808 (1963).

The electrical resistivity and Hall coefficient of single crystals of bismuth have been measured by means of a sensitive ac compensation method as a function of hydrostatic pressure and as a function of uniaxial stress along the trigonal axis at 4.2°K, 77°K and 295°K. The first data presented here have been analyzed in terms of a model consisting of a conduction band overlapping a valence band. The strain dependence of the overlap energy has been evaluated.

Pressure Dependence of the Galvanomagnetic Effects in Bismuth, R. Jaggi, A. L. Jain and H. Weibel, *Physics Letters* **7**, No. 3, 181-182 (November 15, 1963).

The effect of hydrostatic pressure (up to 120 kg/cm²) on the band structure of bismuth has been investigated by measuring resistance, magnetoresistance and Hall effect in pure single crystals. Absolute values and the pressure derivatives of resistivity and Hall coefficient at 4.2°K, 77°K and 295°K are listed. Using an overlap energy of $E_o = 0.034$ eV, a rate of change $\delta E_o/\delta p = -1.8 \times 10^{-6}$ eV/kg/cm² is calculated.

Probability Maps, Richard B. Hurley, *IEEE Transactions on Reliability* **R-12**, 39-44 (September, 1963).

A map method, similar to Boolean algebra-type truth maps is presented for solving probability combinatorial problems. This map technique is shown to be of universal application and simplicity, being equally useful for both series-parallel and nonseries-parallel types of probability combinations. Moreover, it is extendable, in two dimensions, to any finite number of variables.

Programming Systems and Scientific Computing, W. P. Heising, *Data Processing for Science/Engineering* 1, 11-14 (November/December, 1963).

This article is a series of reflections on the author's experience in applying computer technology to scientific applications. It attempts to interpret and define the scientific systems programmer's significance, the major developments which have affected him in the past and those that will affect him, and to place the two in a reasonable perspective.

Project Evaluation and Selection, B. Dimsdale and H. P. Flatt, *IBM Systems Journal* 2, 200-217 (September/December, 1963).

A criterion is formulated which will permit project selection corresponding to management's statement of objectives and their relative importance. An algorithm is developed to implement the criterion. The accompanying programming problem is examined and experience gained in executing the algorithm is described. Application of the algorithm is demonstrated by detailing the solution of a problem.

Properties of HF-H₂O₂ Treated Germanium Surfaces, P. Balk and E. L. Peterson, *Journal of the Electrochemical Society* 110, No. 12, 1245-1252 (December, 1963).

Results are given of the measurements of field effect and surface recombination velocity on HF-H₂O₂ treated germanium samples in air, nitrogen, and vacuum. It is found that the quiescent potential, state density, and surface recombination velocity depend on the amplitude of the field voltage at a given frequency. Although it is generally possible to explain the data for the region near the middle of the gap by assuming one discrete set of recombination centers and one discrete set of inactive states, both near the center of the forbidden gap, a continuous distribution cannot be ruled out. Apparently *n*- and *p*-type samples have different state structures. In addition to the maximum at the center of the gap, which is common to all samples studies, the recombination velocity on *n*-type samples increases again at more negative surface potentials. For *p*-type samples indications of a second peak at positive potential are found.

Pulsed Radiation Effects on Thyatron Tubes, F. C. Tietze, *IEEE Transactions on Nuclear Science* NS-10, No. 5, 139-148 (November, 1963).

Thyatron tubes may be fired by intense pulses of nuclear radiation. The results of early experiments to characterize this phenomenon are re-evaluated in the light of recent results obtained in flash x-ray irradiations. In particular, the recent experiments revealed a significant time delay between the radiation stimulus and the firing of the tube. The duration of this delay depends primarily on the plate voltage. The plate voltage also influences the grid bias necessary to prevent a tube from firing in a given radiation field. From these and other experimental evidences described in the paper, it is concluded that the tubes are fired by radiation-induced ionization of the filling gas; previously the firing was generally attributed to radiation-induced grid voltage transients.

A Punched Card Retrieval System for Automobile Accident Cases, J. L. Garland, *Modern Uses of Logic in Law* (MULL), 130-134 (September, 1963).

The increasing volume of litigation involving motor vehicles is largely responsible for the backlog of civil suits in many jurisdictions. This study describes a technique for helping lawyers and pre-trial referees to prepare automobile accident cases for trial more quickly. It presents an approach to case description which combines coded points of law and fact on punched cards, for high-speed searches on a wide range of electronic processing equipment.

Real-time Digital Computer Acquisition and Computation of Gravity Data at Sea, R. Bernstein and C. O. Bowin,* *IEEE Transactions on Geoscience Electronics* GE-1, No. 1, 2-10 (December, 1963).

A system for the automatic acquisition and computation of gravity data at sea has been tested and is now operational aboard the Research Vessel CHAIN of the Woods Hole Oceanographic Institution. This is the first recorded instance of on-line acquisition and processing of gravity data by the use of a digital computing system. Sampling and computation are performed in a one-minute computation cycle, making knowledge of gravity value, gravity anomalies, and dead-reckoning positions available in real-time.

The system consists of a LaCoste-Romberg Sea Gravity Meter, data conversion units for computer compatibility with the gravity meter, ship's gyro-compass and ship's speed log, an IBM 1710 Mod I Control System (a combination of a 1620 computer and a 1711 Data Converter for A to D conversion), and a typewriter and paper tape input-output units.

* Woods Hole Oceanographic Institution.

Recognition Characteristics of Logic Symbol Types, W. G. Spruth, *Elektronische Rechenanlagen* 5, No. 6, 270-271 (1963).

Presently used logic symbols fall into either one of two categories. The function of form symbols is defined by their shape. Block symbols use a character within the symbol to define their function. This paper studies recognition characteristics of the form and block symbols used in the ASA Standard. Experimental results are discussed. Block symbols exhibit superior performance; their relative error frequency is only 1/3 the value of form symbols. This is assumed to be important for maintenance of digital machines.

Redundancy and Complexity of Logical Elements, S. Winograd, *Information and Control* 5, 177-194 (1963).

This paper deals with the problem of increasing the reliability of gate-type logical circuits through the use of redundancy. We will derive a lower bound on the amount of redundancy necessary to achieve a certain error correcting ability and show how this bound varies with the complexity of the elements used in the design of the redundant circuit, measured by the number of inputs. The complexity of encoders of block codes for transmission of information is defined. A bound similar to the one mentioned above on the error correcting ability of codes is derived which depends on the codes' rate of transmission and on the complexity of their encoders. Finally, we establish a connection between the bound on the error correcting ability of a redundant circuit and the bound on the error correcting ability of a block code.

Remarks on Myhill's Remarks on Coordinate Languages, H. G. Bohnert, *Philosophy of Science* 30, No. 4, 307-308 (October, 1963).

J. Myhill proposed a certain formalized language to overcome alleged difficulties in Carnap's coordinate languages. The difficulties are shown to be illusory.

Requirements Generation, Explosions, and Bills of Material, F. L. Church, *IBM Systems Journal* 2, 268-287 (September/December, 1963).

This paper introduces the principal data processing procedures now applied within many manufacturing industries to the "requirements generation" problem. The procedures discussed take into consideration certain related problems in production planning and inventory control. The nature of the various problems is illustrated and flow charts for the principal procedures are included.

Retention as a Function of Length of Retention Interval, Intelligence, and Training Time,* Millicent Alter, *Journal of Programed Instruction* 2, 7-17 (Summer, 1963).

A program in modern mathematics was administered to 236 subjects ranging in grade from seven to eleven. Subjects were tested immediately after training and again after a retention interval ranging from two to thirty weeks. Initial proficiency was established as the best predictor of delayed proficiency. Findings indicated that this relationship was reasonably constant over time. A distinction was made between delayed proficiency (correlated with initial proficiency) and retention (independent of initial proficiency). There was a significant decrement in retention over time. Intelligence bore a significant, positive, though small, relation to retention. Training time was not significantly related to retention. There were no significant differences in the contours of the retention curves of high, middle, and low IQ groups or fast, intermediate, and slow workers.

* Work performed at The Center for Programed Instruction, Inc.

Secrecy in Industrial Research, A. P. Speiser, *New Scientist* 20, 391-393 (November, 1963).

The science that will ultimately have commercial applications depends, like academic science, upon free exchange of information between its practitioners, regardless of their industrial affiliation. Secrecy makes sense only in the period in which an idea from basic research is being developed into a product.

Slow Surface Relaxation of Germanium, M. H. Pilkuhn, *Journal of Applied Physics* 34, 3302 (November, 1963).

The influence of temperature, ambient atmosphere, and light on the slow surface conductance relaxation of germanium was investigated. The effect of water was found to be very significant and was studied in detail. The experimental results are discussed in terms of a model that uses ion migration in the oxide layer as the cause for slow surface phenomena.

Specific Heat of EuS, V. L. Moruzzi and D. T. Teaney, *Solid State Communications* 1, 127-131 (November, 1963).

Specific heat measurements of EuS between 10°K and 35°K show a sharp peak at 16.2°K. The measurements are analyzed using the constant coupling approximation, and it is shown that the dominant exchange interaction is between nearest neighbor Eu⁺⁺ ions.

Structural Effects of Ionizing Radiation in Ferroelectric Rochelle Salt,* Henri Boutin,† B. C. Frazer,‡ and Franco Jona, *Journal of Physics and Chemistry of Solids* 24, 1341-49 (1963).

Neutron diffraction measurements of the intensity variation of certain sensitive Bragg reflections with radiation dosage, establish that the ferroelectric crystal structure of Rochelle salt is seriously affected by exposure to x-rays and γ -rays. Previously, the remarkable changes in the ferroelectric properties of this crystal had been ascribed almost entirely to macrostructural changes, leading to hindered domain mobility. Also, optical studies have thrown new light on the differences in radiation effects in crystals irradiated within and outside the ferroelectric temperature range. In the first case, crystals irradiated to the point where hysteresis loops are no longer observable not only continue to show domain patterns in polarized light within the normally ferroelectric region, as had already been reported, but also show domains at temperatures well outside of that range. On the other hand, crystals subjected to equivalent dosage at temperatures below the lower Curie point show no domains at all—even in the middle of the normal ferroelectric temperature range. It is suggested that there are two basic types of damage which must be considered. One of these involves local damage centers, distributed more or less uniformly throughout the volume of the crystal, and producing structural effects at the unit cell level similar to those produced by introduction of impurity ions in the lattice. In the other case, previously existing imperfections (such as dislocations, but perhaps also including domain walls) become greatly reinforced by collection of diffusing damage products. The latter type introduces macroscopic clamping effects which hinder domain mobility and tend to stabilize the crystallographic phase existing during irradiation.

* Work performed under the auspices of the U. S. Atomic Energy Commission.

† Brookhaven National Laboratory, Upton, New York.

‡ Guest Scientist from Picatinny Arsenal, Dover, New Jersey.

§ Brookhaven National Laboratory, Upton, New York.

At present a Guest Physicist at the Puerto Rico Nuclear Center, Mayaguez, P. R.

Sublattice Magnetizations in Rare-Earth Iron Garnets, E. L. Boyd, V. L. Moruzzi, and J. S. Smart, *Journal of Applied Physics* 34, 3049-3054 (October, 1963).

The individual iron sublattice magnetizations in yttrium iron garnet and gadolinium iron garnet have been measured by NMR techniques as a function of temperature. The observed resonance frequencies are slightly higher for gadolinium iron garnet in both cases, the differences at low temperatures being about 0.67% for the octahedral sites and 0.70% for the tetrahedral sites. These differences are tentatively interpreted as due to the volume dependence of the hyperfine coupling constant A . The difference for the octahedral sites decreases slightly with increasing temperature, while that for the tetrahedral sites increases appreciably.

A molecular field calculation shows that this behavior can be explained by assuming that the Gd^{3+} ions interact much more strongly with tetrahedral sites than with octahedral sites.

Supplier Delivery-Quality Conformance Rating System, R. A. Hafer, R. T. Mee, and D. A. Shirkey, *Purchasing* **55**, No. 12, 63-65, (December 16, 1963).

Delivery and quality are two factors of prime importance when purchasing items from a supplier. This paper describes the procedure recently instituted at the IBM Space Guidance Center to rate, on a single report, suppliers for conformance to delivery schedules and quality requirements. Data processing equipment is used to compute the ratings and prepare the reports on a monthly basis. Copies of the reports are distributed to responsible supplier and IBM personnel to inform them of the results and assist them in their operations. The joint objective of the rating system is on-time delivery of acceptable products.

Susceptibilities and Critical Fields of Superconducting Films, W. Liniger and F. Odeh, *The Physical Review* **132**, No. 5, 1934 (1963).

The present paper concerns the calculation of field distributions, susceptibilities, and critical fields of a superconducting film using the nonlocal and nonlinear (Ginzburg-Landau) theories with diffuse scattering boundary conditions. Both the Pippard and the BCS kernels are considered. The main tool in obtaining these results is a numerical calculation of the vector potential, but an analytical treatment is possible in the very thin film and bulk limits. A comparison between the results obtained with the two different kernels is made for field distributions and susceptibilities. The present susceptibilities are compared with those for diffuse scattering calculated by Rogers and Schrieffer and with Toxen's results for specular reflection. Maximum fields are obtained from a nonlinear-nonlocal generalization of the Ginzburg-Landau equations due to Bardeen. These equations are solved by a mixture of perturbation and numerical methods using the Pippard kernel. The dependence of these maximum fields on the coherence length is studied, and the present results are compared with Toxen's critical fields for specular reflection. In the thin film limit, the present calculation establishes on a rigorous basis the proportionality of the critical field to the negative three-halves power of thickness. It is shown that there exist two types of transition and a critical thickness in the nonlocal-nonlinear case, just as in the Ginzburg-Landau theory. The type of transition changes, for fixed thickness, from first to second order when the coherence length is raised beyond a certain value.

Techniques for Sputtering Single and Multilayer Films of Uniform Resistivity, L. I. Maissel and J. H. Vaughn, *Vacuum* **13**, No. 10, 421-23 (October, 1963).

The need for increasingly more complex equipment in experiments involving the sputtering of multiple films has led to the development of a multiple cathode sputtering system in which the substrates are fixed and the cathode assembly rotates, instead of vice versa. Some applications of this system to resistive films are described.

Temperature and Pressure Dependence of the Co^{59} Nuclear Resonance Chemical Shift,* G. B. Benedek,† R. Englman,‡ and J. A. Armstrong, *Journal of Chemical Physics* **39**, 3349-3363 (December, 1963).

We have measured with precision the temperature and pressure dependence of the Co^{59} nuclear resonance chemical shift (σ) in the octahedral cobalt complexes $Co(NH_3)_6^{3+}$, $Co(CN)_6^{3-}$, and $Co(NO_2)_6^{3-}$ in aqueous solution. The pressure and temperature range was 1 to 10000 kg/cm² and 3° to 80°C, respectively. From the pressure dependence of σ and a theoretical determination of the compressibility of the complexes we have deduced the dependence of the crystal-field splitting on the cobalt-ligand distance. A theory for the explicit temperature dependence of the chemical shift is presented. The fundamental parameters which enter the theory are the 15 normal mode frequencies when the cobalt electrons are in the ground state and when they are in the excited state. While the former quantities are known from the vibrational spectra of these complexes, the latter are unknown. By fitting the theory to the experimental data, one concludes that on the average the vibration frequencies in the $^3T_{1g}$ excited electronic state must be smaller than those in the ground state by about 30% for the cyanide and nitrate complexes and by about 20% for the ammonia complex. A nonlinear dependence of σ on the temperature is predicted by the theory and observed experimentally.

* Work performed at Harvard University.

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Testable Conditions for Triads of Paired Comparison Choices, H. William Morrison, *Psychometrika* **28**, 369-390 (December, 1963).

Forty-two choice models, each representing stimuli by one-dimensional probability distributions, are obtained by relaxing the assumptions of Thurstone's Case V Law of Comparative Judgment. The models which imply or fail to imply each of nine testable probabilistic conditions are determined. Stochastic transitivity is vulnerable in most of these models. The results suggest discarding weak stochastic transitivity, and in its place using the conjunction of weak stochastic transitivity and the triangular condition. However, unless it is possible to predict which stimuli will produce violations of the conditions, none of the conditions can be rejected on the basis of too frequent intransitive triads of choices.

Thermal Evaporation Techniques, H. L. Caswell, *Semiconductor Products* **6**, No. 12, 23-28 (December, 1963).

The thermal evaporation process is described and data presented on the evaporation rate of various materials. Techniques for heating evaporant sources are discussed and information given on the deposition characteristics of different sources. Methods for monitoring and controlling pertinent deposition parameters are also presented.

A Time Coding Analog-to-Digital Converter, B. T. Cronhjort, *Proceedings of the IEEE* **51**, No. 11, 1541-48 (November, 1963).

A time-coding analog-to-digital converter using an exponential voltage sweep is presented. The technique inherently offers the possibility of convenient automatic recalibration in order to compensate for long-term drift. Thus, the converter is particularly well suited for on-line use in auto-

matic digital data reduction systems. Attention is paid to the calibration and use of the converter. A design procedure is suggested and the obtainable accuracy evaluated in terms of the design parameters. Some comments are made concerning the merits of the scheme as compared with the most common existing systems.

Time-Dependent Variation-Perturbation Method for Many-Electron Systems, M. Karplus* and H. J. Kolker,† *Journal of Chemical Physics* **39**, 2997-3000 (December 1, 1963).

The variation-perturbation method for time-dependent problems is applied to many-electron systems. Specific formulas are developed for the steady-state dipolar interaction between an oscillating electric field and an atom or molecule whose wavefunction is approximated by a Hartree-Fock determinant. The method is illustrated by a number of calculations for the helium atom. Theoretical expressions for the dynamic polarizability, refractive index, and Verdet constant (Faraday effect) are obtained. Comparison with the available measurements shows good agreement between the experimental and the theoretical values.

* Alfred P. Sloan Foundation Fellow.

† National Science Foundation Post-doctoral Fellow.

Toward a Study of Bidding Processes, Part III: Some Special Models,* J. H. Griesmer and Martin Shubik,† *Naval Research Logistics Quarterly* **10**, 199-217 (September, 1963).

This is the third paper in a series on the theory of bidding. It investigates the effect of the costs of preparing a bid and penalties for refusing to accept awards. Several other special models of bidding procedures are presented, together with their interpretations.

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† Now at Yale University.

Transistor Amplifiers with Pulse Risetimes of Less than 5 ns, G. Kohn, *NTZ-Communications Journal* **2**, No. 5, 234-239 (1963).

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

Ultraviolet Absorption in Epidermoid Cancer Cells, L. A. Kametsky, H. Derman,* and M. R. Melamed† *Science* **142**, 1580-1583 (December 20, 1963).

The "excessive functional activity" of some cancer cells first found by Caspersson has been observed in fixed, stained smears from four cases of cervical epidermoid carcinoma studied thus far. On the basis of preliminary results it is suggested that there may be a characteristic difference between the absorption profiles of some epidermoid cancer

cells and other cells found in cytological smears. It is our belief that with an appropriate electronic scanning system such cells can be detected by measurements of their absorptions at two different wavelengths. However, the effect on the absorptions of cells with abnormalities other than cancer and whether every epidermoid carcinoma will contain such cells must yet be determined.

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Uniqueness Theorems for the Helmholtz Equation in Domains with Infinite Boundaries,* F. Odeh, *Journal of Mathematics and Mechanics* **12**, No. 6, 857-867 (November, 1963).

Three uniqueness theorems are given for the reduced wave equation defined in some special domains with infinite boundaries. It is shown first that the radiation condition, with two different wave numbers, ensures the uniqueness of the solution to Sommerfeld's flat earth problem. Secondly, uniqueness of the solution to the Dirichlet problem for an exterior domain which opens up at infinity is proved. Lastly, impedance-type boundary conditions on an imperfectly conducting plane are considered.

* This paper is based on a part of the author's dissertation, submitted to the Department of Mathematics, University of California, Berkeley, and was partly supported by the Office of Naval Research. During the period this paper was being written, Dr. Odeh served as a temporary member of the Courant Institute of Mathematical Sciences.

Variable Field-Length Data Manipulation in a Fixed Word-Length Memory, M. J. Flynn, D. S. Henderson, *IEEE Transactions on Electronic Computers* **EC-12**, No. 5, 512-516 (October, 1963).

Many medium-scale electronic computers currently are being designed to cater to scientific and business data-processing problems. Efficiency of floating point computation for scientific problems usually favors a fixed-word format and a word-oriented memory, so that a complete floating-point operand may be read out of or stored in memory in parallel. The logical processing of strings of characters not starting or ending on a word boundary, or the arithmetic processing of variable field-length fixed-point operands, are penalized. The penalty is the result of time-consuming combinations of masking and/or shifting which must be programmed before results can be stored. The purpose of this report is to describe several representative memory-access systems that avoid the housekeeping necessary for processing variable-length operands in a fixed word-length machine and to evaluate their relative efficiencies.

A Variation-Perturbation Approach to the Interaction of Radiation with Atoms and Molecules, M. Karplus* and H. J. Kolker,† *Journal of Chemical Physics* **39**, No. 6, 1493-1506 (September 15, 1963).

A variation-perturbation formulation for time-dependent interactions is presented and applied to the interaction between atoms or molecules and a semiclassical radiation field. Details of the treatment through second order are given for the steady-state problem and are compared with the standard perturbation-theory results. It is demonstrated that the usual expression for the time-dependent perturbation solution, which consists of a sum over an infinite set of excited states (including any continuum), can be replaced by a small number of frequency-dependent functions that satisfy certain time-independent differential equations. Since an

exact solution to these equations is very difficult for all but the simplest cases, an equivalent variational formulation of more general utility is introduced.

The induced time-dependent electric and magnetic moments of atoms and molecules in an oscillating electromagnetic field are evaluated in terms of the frequency-dependent functions. With the usual continuum medium assumptions, the macroscopic polarizations are determined from these moments, and simple formulas for the index of refraction and optical rotatory power are obtained. The method is illustrated by a simple application to the dynamic polarizability of the harmonic oscillator and by a more detailed examination of the dynamic polarizability and index of refraction of the nonrelativistic hydrogen atom. A comparison is made between an exact solution and a variational approximation for this problem. The excellent agreement between the two methods provides an indication of the power of the variational formulation. An indication of its utility for more general applications is given.

* Alfred P. Sloan Foundation Fellow.

† National Science Foundation Postdoctoral Fellow.

Wide-Band Pulse Transformers for Matching Low Impedance Loads, S. Tansal and H. Sobol,* *The Review of Scientific Instruments* **34**, No. 10, 1075-1081 (October, 1963).

Pulse transformers capable of matching the low impedance load characteristics of integrated circuits are discussed. Experimental models constructed by winding transmission lines on cores were found to pass pulses with rise times between 1 and 2 ns and with little droop for pulses of 300-ns width. A transformer in liquid helium transmitted a 1- μ s pulse with less than 10% droop.

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Work Hardening and Dislocation Arrangement of fcc Single Crystals I. Plastic Deformation and Slip Line Studies of Nickel Single Crystals,* S. Mader, A. Seeger,† and C. Leitz,† *Journal of Applied Physics*, **34**, 3368-3375 (November, 1963).

The work hardening of nickel single crystals and its temperature dependence are investigated. The results are discussed in terms of the long-range stress theory of work hardening. From an analysis of the temperature dependence of the stress τ_{III} at the onset of stage III, we deduce the stacking fault energy of nickel and the magnitude of the stress concentrations in the deformed crystals. Particular attention is given to the question of which of the hardening parameters are structure sensitive and which are insensitive to the differences in the microstructure of the crystals. Simultaneous determinations of the length and height of individual slip lines are carried out. They check with the information on the stress concentrations and agree well with the predictions of the work-hardening theory.

* Work performed at the Max-Planck Institut, Stuttgart, Germany.
† Max-Planck Institut.

Work Hardening and Dislocation Arrangement of fcc Single Crystals II. Electron Microscope Transmission Studies of Ni-Co Single Crystals and Relation to Work-Hardening Theory,* S. Mader, A. Seeger,† and H. M. Thieringer,† *Journal of Applied Physics* **34**, 3376-3386 (November, 1963).

The dislocation arrangement in the primary glide plane of deformed Ni-Co crystals of different compositions and

stacking fault energies was investigated by the transmission electron microscope technique. The thin foils were found to contain mainly dislocations of the primary glide system close to the edge orientation. Very few screw dislocations were observed; they were presumably lost during the preparation. Straight dislocations in $\langle 110 \rangle$ directions, presumably Lomer-Cottrell dislocations, were found in particular at intermediate and low stacking fault energies. The dislocation density shows local variations so that "dislocation braids" can be discerned from the background. For Ni + 40% Co, the dislocation densities and arrangements are compared with slip line results obtained from the same crystals. These results are found to be compatible with the so-called glide-zone model and the geometrical interpretation of the slip-line pattern based on it. The final section deals with the dynamic aspect of plastic deformation and with the theory of work hardening by long-range stresses. It is shown that the experimental observations fit this theory. Some objections that have been raised against the theory are discussed and met.

* Work performed at the Max-Planck Institut, Stuttgart, Germany.
† Max-Planck Institut.

Letters to the Editor

Chemical Shifts in Xenon Fluorides, D. Lazdins, C. W. Kern, and M. Karplus, *Journal of Chemical Physics* **39**, No. 16, 1611-1612 (September 15, 1963).

Comment on Proposed Barriers in Thin Film TiO₂ Diodes, P. J. Magill, *Solid-State Electronics* **6**, 531-532 (October, 1963).

Covariance Matrix Approximation, Leo B. Schlegel, *AIAA Journal* **1**, 2672 (November, 1963).

Epitaxial Growth of Germanium Using Water Vapor, R. F. Lever and F. Jona, *Journal of Applied Physics* **34**, No. 10, 3139-3140 (October, 1963).

How to Measure Thermal Resistance of Transistors, E. L. Vollheim, *Electronic Equipment Engineering* **11**, No. 12, 71-73 (December, 1963).

A Simple Synthesis of Bicyclo [1.1.0] butane and its Relation to the Internal Conversion of Electronic Energy in 1, 3-Butadiene (L), R. Srinivasan, *Journal of American Chemical Society* **85**, 4045 (1963).

Spatial and Time Frequency Relationship in the Direction of Motion of Linear Scanners, E. J. Smura, *Proceedings of the IEEE* **51**, No. 11, 1666-1667 (November, 1963).

Vicinal Proton Coupling in Nuclear Magnetic Resonance, M. Karplus, *Journal of the American Chemical Society* **85**, No. 18, 2870-2871 (September 20, 1963).