IBM Technical Papers Published Recently in Other Journals

Alloy Concentration Limitations for Ideal Superconductivity Transitions, C. Chiou, R. A. Connell, and D. P. Seraphim, *The Physical Review* **129,** 1070-1076 (February 1, 1963).

For mean free paths less than 440 ± 100 A, the dc resistance, magnetic susceptibility, and low-frequency surface impedance data on a series of In-base alloys (Bi, Pb, Sn, Cd, Tl, Hg) indicate negative interfacial energies between superconducting and normal material. The experiments demonstrate the presence of an intermediate state, normal and superconducting at magnetic fields much less than H_c, as well as the usual filamentary superconductivity at high magnetic fields. Thus, quantitatively, the mean-free-path effect and, qualitatively, the intermediate state effect at low fields are in agreement with the theory of Abrikosov and Gorkov. Data on severely cold-worked high-purity tantalum and on a cold-worked In alloy are compared to the effect of alloying alone. Cold work has only a minor effect in increasing the filamentary critical magnetic field in comparison to the mean-free-path effects in indium alloys. The implications for high-field superconductivity are discussed.

Analysis of a Magneto-Optic Readout System, G. Fan, E. Donath, E. S. Barrekette, and A. Wirgin,* *IEEE Transactions on Electronic Computers* **EC-12,** 3-9 (February, 1963).

The signal and the signal-to-noise ratio in a typical magneto-optic readout scheme intended for use in a high-capacity high-speed memory were analyzed. It was found that such a system does not yield higher signal levels and signal-to-noise ratios than are available with conventional magnetic head readout in such a peripheral memory. Calculations show that for 10^{-8}-inch diameter bits recorded on an iron film in a system using an Osram XBO 150 high-pressure xenon lamp, the signal-to-noise ratio at a megacycle transfer rate is in the neighborhood of 1. The maximum signal has about 300 photoelectrons per bit at the photocathode. It was concluded that although a magneto-optic system is impractical for such application, it may still be used in some display devices or in a medium-speed, medium-density, fast access memory.

* Now attending the Institute of Optics, Paris, France.

Applications and Limitations of the New Magnetic Recording Model,* C. D. Mee, *IRE Transactions on Audio* **AU-10,** 161-164 (November-December, 1962).

The simple magnetic recording model which describes the basic phenomena in terms of the growth and decay of a cylindrical magnetization volume from one side of the tape coating is reviewed. The relevance of practical tape hysteresis loops is considered and a model hysteresis loop developed and applied to the description of the recording process. Areas of applicability for the recording model are described, including distortion in ac-bias recording.

* Work performed at CBS Laboratories, Stamford, Conn.

Applications of Topology to Analysis, W. L. Miranker, *Applied Mechanics Reviews* **16,** 1-4 (January, 1963).

In this paper a number of examples of the applications of topology to analysis is discussed. The notions of compactness and connectedness, some fixed-point theorems, the method of continuity, and Betti numbers are introduced. Then some standard problems in analysis are solved by making use of these topological ideas.

Calculating with Jets, A. E. Mitchell, *New Scientist* **329,** 510-514 (March 7, 1963).

The logical operations required for digital computing can be carried out using one jet of air or water to deflect or alter another. Small, reliable devices carrying out such operations in about a millisecond may find application in accounting machines and in the control of industrial processes.

Charge Transfer Controlled Surface Interactions Between Oxygen and CdSe Films, G. A. Somorjai, *Journal of Physics and Chemistry of Solids* (Pergamon Press) **24,** 175-186 (1963).

The interaction of oxygen with CdSe surfaces has been studied with thin films of CdSe evaporated in ultra high vacuum in the temperature range 0 to 360°C and pressure range 10^{-4} to 10 mm Hg. The effect was monitored via conductivity measurements carried out *in situ*. When oxygen is introduced, the initially "clean" film undergoes an instantaneous irreversible chemisorption followed by a slow uptake which is also irreversible in the studied temperature range. This interaction brings out a 3- to 5-order of magnitude decrease in the conductivity of the *n*-type film, i.e. oxygen exhibits acceptor-like properties. The rate of the slow irreversible oxygen uptake can be expressed as $dN/dt = Kp_{O_2}^{1/4} \exp(-bN)$ and the activation energy for the process has been measured. Donor-type weakly adsorbed oxygen was also found to be present on CdSe films which could be reversibly removed from the surface; this reaction was also accompanied by charge transfer and was strongly pressure dependent. The heat of reaction for this process is 12 kcal/

mole. The boundary layer theory was evoked to explain the kinetics of the slow uptake of the acceptor-like oxygen. Attempts have been made to explain the mechanism of the different surface reactions.

Cluster Expansion Methods for Systems of Polar Molecules: Some Solvents and Dielectric Properties, Donald W. Jepsen and H. L. Friedman,* *The Journal of Chemical Physics* **38,** No. 4, 846-864, (February, 1963).

General methods are developed for evaluating Mayer cluster diagrams for systems of molecules with orientation-dependent forces. These methods are particularly useful for obtaining chain and ring contributions. Simplification occurs for ordinary two-body forces in the absence of external fields because of invariance under rotation of the two-body complex as a whole. Using these methods we adapt Mayer's rearrangement procedure to calculate the cluster expansion of the potential of the average force between two ionic or dipolar solute molecules that are immersed and fixed in a gas of dipolar molecules. The comparison of this potential with the corresponding macroscopic quantity leads to a cluster expansion for the dielectric constant of the dipolar gas.

* One-year resident consultant with Philips Laboratories, Eindhoven, The Netherlands.

Codes for Providing Protection Against Errors in Data Transmission, F. Corr and E. Gorog, *L'Onde Électrique* **431,** 117-127 (February, 1963).

The use in data transmission of a switching network (or eventually of any other circuit) makes necessary, on the one hand, very exact information about the possible errors which can arise during transmission, and on the other hand, the development of control devices for efficiency countering these errors.

These two aspects of the problem for reliability of transmission are closely linked and their examination requires the application of practical ideas as well as theory. Included is a statistical description of typical errors obtained in a series of tests on real lines, the theoretical development of the best codes suitable for detecting or correcting these representative errors and a practical study of their operational efficiency.

Computer Construction of Minimal Project Networks, B. Dimsdale, *IBM Systems Journal* **2,** 24-36 (March, 1963).

Computer techniques employed by management in the planning, scheduling and control of projects generally rely on the formulation of project "networks" as input to the computer programs. A computer procedure is described for improving this input by obtaining networks with certain minimal properties and it is shown how, with this improvement in input, the overall efficiency in using existing programs can be increased.

Constrained Molecular Wavefunctions: HF Molecule,* A. Mukherji** and M. Karplus, *The Journal of Chemical Physics* **38,** 44-48 (January 1, 1963).

A simple approach for supplementing the usual variational energy criterion for molecular wavefunctions is described. With the requirement that integrals of selected operators agree with the known experimental or theoretical values for the corresponding properties, a constrained variation method is formulated. For an appropriate choice of one-electron operators, the resulting charge distribution can be of greater accuracy than that obtained from an unrestricted variation treatment with the same basis set. Since the method is of most interest for simple wavefunctions, it is illustrated in terms of a modification of the best-limited LCAO-MO hydrogen fluoride function of Ransil. A comparison of the two functions shows that the constrained variation treatment leads to improved results for certain one-electron properties. The calculations also demonstrate the sensitivity of the one-electron expectation values to small changes in the orbital coefficients and the total energy.

* Acknowledgment is made to the donors of the Petroleum Research Fund, administered by the American Chemical Society, for partial support of this research.
** Saha Institute of Nuclear Physics, Calcutta, India.

The Control of Multivariable Processes in the Presence of Pure Transport Delays, F. Kurzweil, Jr., *IEEE Transactions on Automatic Control* **AC-8,** 27-34 (January, 1963).

This paper presents a digitally oriented technique for the control of processes in which a primary characteristic of the process is a set of pure transport delays associated with the input/output dynamics of the process.

The paper is divided into two major sections: (1) A section which formulates the continuous control problem into discrete form. Thus the problem becomes amenable to computational solution on a digital computer. (2) A section which provides a theoretical solution to the minimum-finite-settling-time regulating problem. The development of the theory indicates the similarities between control of processes with and without pure transport delays. In this respect, the paper represents an extension of recent ideas presented in the area of multivariable saturating systems.

Correlation of Signals Having a Linear Delay, R. Remley, *The Journal of the Acoustical Society of America* **35,** 65-69 (1963).

The output signal of a cross-correlation detector is calculated for a general signal spectrum and integration time under the assumption of a constant delay rate but otherwise ideal conditions. The delay-rate degradation of the output signal is shown to be equivalent to passing the ideal cross-correlation function through a low-pass filter. The output signal-to-noise is evaluated for the threshold case by introducing straightforward noise statistics. Subsequently, low-pass rectangular signal spectra are assumed, and the output signal-to-noise ratios for various delay rates and time-bandwidth produces are numerically evaluated. For zero delay rates, the output signal-to-noise ratio is a linear function of the time-bandwidth product, but for nonzero delay rates, optimum points exist.

Cycloidal vs Modified Trapezoidal Cams: In Elastic Systems, Which Profile Minimizes Acceleration at the Driven Mass, D. C. Allais, *Machine Design* **35,** 92-96 (January 31, 1963).

A cam follower and load form a dynamic system which may be approximated by a spring driving a mass. These dynamic elements cause the acceleration of the load to differ from that at the cam surface. In general, the peak load acceleration will exceed that predicted from simple

kinematics, sometimes by a factor of two or three. The curves presented relate load acceleration to cam acceleration for the cycloid and modified trapezoid cam profiles. These results and certain limitations on their validity are examined from the viewpoint of the cam designer.

Cyclotron Resonance Studies of the Fermi Surfaces in Bismuth, Yi-Han Kao, *The Physical Review* **129,** 1122-1131 (February 1, 1963).

Experiments on cyclotron resonance of the Azbel'-Kaner type were performed on pure Bi at 34.5 kMc/sec. Angular variation of the cyclotron masses for both the electrons and the holes with the magnetic field in the binary, bisectrix, and trigonal planes were studied. For the electrons in Bi, the tilt angle of the Fermi surface in the crystallographic coordinate system was directly measured. The mass parameters in Cohen's nonellipsoidal-nonparabolic model were determined for the first time. The inverse effective mass tensor components in Shoenberg's ellipsoidal-parabolic model were completely determined by using the tilt angle.

The results indicate that the ellipsoidal-parabolic model is unable to explain quantitatively all the angular variation in the electron cyclotron masses. One particular case of Cohen's model corresponding to electron Fermi surfaces at centers of the six pseudohexagonal faces of the Brillouin zone was shown to be in better agreement with the experimental results. Angular variation of the light-hole cyclotron masses with field in the three crystallographic planes were fitted quite satisfactorily by the one-spheroid model. No resonance of a heavy hole was observed in this experiment.

Data Treatment Using Numerical Transmission Over Long Distances, A. Desblache, *L'Onde Électrique* **431,** 243-250 (February, 1963).

The long-distance transmission of intelligence opens new possibilities in the technique for treating such intelligence and the article examines the designs already available in this field: systems for the simple conveyance of data from one point to another, data collecting systems, systems suitable for direct use and finally message exchangers.

Each piece of equipment is examined in particular in the light of all the various criteria, namely: speed of efficiency, reliability, or number of undetected transmitted errors. The conclusion emphasizes that this technique is still very much in evolution and that important developments can be expected in the years to come.

Die Erschliessung des Feldes Nordlicht-West unter besonderer Berueksichtigung des Abteufens des Wetterschachtes Prosper 9 (Nordlicht) (Exploration of the Northlight-West Mining Field in Particular Regard to the Ventilation Shaft Prosper 9),* F. R. Hertrich and D. H. Buss,** *Glueckauf Bergmannische Zeitschrift* **99,** 105-129 (January 30, 1963).

This paper describes in detail the exploration and planning of a new coal mining field. Also discussed are the mining and construction equipment, the geological investigations, and, in particular, the sinking of a ventilation shaft by a unique freezing method. New results are reported regarding earth pressure measurements and stability of shaft linings.

* Work performed at Rheinstahl Bergbau AG, Essen, Germany.
** Rheinstahl Bergbau AB, Essen, Germany.

Discrimination Reaction Time as a Function of the Number of Stimulus-Response Pairs and the Self-Pacing Adjustment of the Subject, R. Seibel, *Psychological Monographs* **76,** No. 42, Whole No. 561 (1962).

The effects of amount of information on DRT are examined. Experiment involved five-lamp patterns which the operator transcribed to a five-key keyboard. Information was varied from one through approximately five bits. The DRT increases with information transmitted from one to approximately three bits, but shows no further increase from three to five bits. Motor difficulty, i.e., the particular finger pattern, is the most important determiner of DRT. Interaction effects are found between specific pattern difficulty and difficulty of the set of patterns. A model accounting for results is outlined; in it the central variable is the self-pacing adjustment of the subject.

Double Photon Excitation in Organic Crystals, W. L. Peticolas, J. P. Goldsborough, and K. E. Rieckhoff, *Physical Review Letters* **10,** 43-45 (1963).

Crystals of benzpyrene, anthracene and other polycyclic aromatic hydrocarbons were irradiated with intense light of 14,400 cm^{-1} from a ruby laser and the resultant blue-green fluorescence observed. That fluorescence is emitted less than a microsecond after excitation was shown by the absence of measurable time delay between the laser spikes and those of the fluorescence. Intensity of the blue fluorescence varies with the square of the laser intensity which gives further evidence of a two-photon absorption. The fluorescent spectrum light is identical to the usual singlet-singlet fluorescence spectrum of the crystals. The experiments are interpreted in terms of the two-photon absorption theory of M. Goeppert-Mayer.

A Dynamical Theory of Elastic Dielectrics, R. A. Toupin, *International Journal of Engineering Sciences* **1,** 101-126 (1962).

A theory of the electromagnetic field in moving, finitely deformed elastic dielectrics is developed. The equations for a weak field superimposed on a strong field and an arbitrary state of finite deformation are deduced. It is shown how certain electro- and magneto-optical effects and the retardation of a sound wave by a strong magnetic field in a dielectric can be explained and correlated.

Economic Evaluation of Management Information Systems, D. F. Boyd and H. S. Krasnow, *IBM Systems Journal* **2,** 2-23 (March, 1963).

A method of representing the gross characteristics of an information system within a dynamic model of the firm is presented. The performance of the firm and, indirectly, that of the information system is measured in accordance with usual financial accounting practice. The procedure is demonstrated by simulations (programmed using a general purpose simulator) conducted with a specific model of a hypothetical manufacturing firm.

Effects of Ultraviolet Radiation on Fluorescent Lamp Phosphors,* J. H. Singleton** and Lawrence Suchow, *Journal of the Electrochemical Society* **110,** 36-41 (January, 1963).

Irradiation of halophosphate lamp phosphors by a low-pressure mercury arc causes a loss in luminescent efficiency,

changes in the absorption spectra, and thermoluminescence. The 1849 A wavelength is primarily responsible for these changes, which are partially reversed by longer wavelength radiation or by heat. X-radiation produces larger changes in the absorption spectra, which are compared to observations on unactivated halophosphates. The relation between luminescent efficiency and color center formation is discussed.

* Work performed at Westinghouse Electric Corporation, Bloomfield, New Jersey, and Pittsburgh, Pennsylvania.
** Research Laboratories, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania.

Electrolyte Solutions that Unmix to Form Two Liquid Phases. Solutions in Benzene and in Diethyl Ether, H. L. Friedman,* *Journal of Physical Chemistry* **66,** 1595 (1962).

Some simple solutions of electrolytes in solvents of low dielectric constant exhibit a miscibility gap corresponding to the coexistence of two liquid phases. An explanation is given in terms of electrical forces among ion pairs. An approximation to the effect of these forces is based on the interaction of a simple ion pair with an ideal dielectric having the dielectric constant of the solution.

The dielectric constant as a function of composition is measured for NH_4FeCl_4 in $(C_2H_5)_2O$, which unmixes, and is found to be consistent with the theory, as are other less complete dielectric constant data for other unmixing solutions. However, the observed osmotic coefficients of these solutions approach unity much more slowly with increasing dilution than one deduces from the simple theory, a discrepancy which seems to be due to pairwise association of ion pairs in the real solutions.

* One-year resident consultant with Philips Laboratories, Eindhoven, The Netherlands.

Electron Beam Switched *p-n* Junctions, A. V. Brown, *IEEE Transactions on Electron Devices* **ED-10,** No. 1, 8-12 (January, 1963).

A high-speed, high-power switching device is analyzed and experimental results presented. The device consists of a back-biased *p-n* junction switched by an electron beam. A single position tube for use as a magnetic core driver has been tested. The device operated at a beam voltage of 19 kv and can give a 150-v, 1.5-a output pulse with a rise time of less than 4 nsec and a maximum device power dissipation of 14 w.

Designs for a multiposition device and also a high-power amplifier, similar in operation to the single position device, are discussed.

An Evaporated Film 135-Cryotron Memory Plane,* C. J. Kraus, *Electronics Reliability & Microminiaturization (International Journal)* **1,** 245-249 (3rd Quarter, 1962).

This paper describes the design, operation, and fabrication of a computer memory plane made entirely of evaporated thin films. Applying the principles of superconductivity to the design, and also to the operation of this memory plane, reductions of physical size, space, and power requirements have been accomplished.

* Paper was originally presented at the AGARD Conference on Microminiaturization, Oslo, Norway, July 1961.

Extended Basis-Set LCSTO-MO-SCF Calculations on the Ground State of Carbon Dioxide,* A. D. McLean, *Journal of Chemical Physics* **38,** 1347-1355 (March 15, 1963).

Extended basis set SCF-STO-MO wave functions for the ground state of CO_2 are reported. In particular, the effect of doubling the number of $2p\sigma$ basis functions and the effect of changing their orbital exponents has been investigated, together with the effect of addition of $3d\sigma_C$ basis functions. The effect of expanding the π basis set by addition of extra $2p\pi_C$ basis functions and $3d\pi_{O_1,\ O_2}$ basis functions is also shown. A wave function using the best σ basis set together with the best π basis set used in these calculations would give molecular energy approximately 9 ev below that obtained from a "best atom" minimal basis set calculation. This is to be compared with the estimated Hartree-Fock molecular energy which is approximately 24 ev below the "best atom" minimal basis set value. This highlights the importance of the choice of basis functions and minimization of total energy with respect to orbital exponents in the case that the number of basis functions out of which MO's can be constructed is limited. The quadrupole moment of CO_2 is computed from two of the wave functions reported.

* Work performed at Laboratory of Molecular Structure and Spectra, University of Chicago, and at University of Western Australia, Nedlands, Western Australia. Work assisted by grant from National Science Foundation and Wright Air Development Center under contract with University of Chicago.

Extensional Waves in Cubic Crystal Plates, D. C. Gazis and R. F. Wallis,* *Proceedings of 4th U. S. National Congress of Applied Mechanics,* pp. 161-168 (1962).

A theoretical discussion is given of extensional waves in a cubic crystal plate bounded by two principal planes. The investigation was carried out using the linear theory of anisotropic elasticity and also using a discrete particle model. Particular emphasis was placed on the investigation of the transition from plate-extensional waves to essentially surface waves as the ratio of plate thickness to wavelength increases from zero to infinity. An essential difference was observed in this asymptotic transition between materials which propagate Rayleigh-type surface waves and those which propagate generalized Rayleigh surface waves.

* U. S. Naval Research Laboratory, Washington, D. C.

Film Circuit Panel for Space Guidance Computers,* A. E. Lessor, J. W. Skerritt, R. E. Thun, and D. S. Weed, *Electronics Reliability & Microminiaturization (International Journal)* **1,** 333-338 (4th Quarter, 1962).

By use of evaporated film resistors, insulators, and connectors, and compact multielement semiconductor blocks, an extremely high component density has been realized in a two-sided 2½′ × 3½″ modular panel for a space guidance computer. The arithmetic section of the computer employs diode-AND-diode-OR-transistor-INVERTER logic. Circuit and logic diagrams of both panel sides are discussed in detail.

* Paper was originally presented at the Electronic Components Conference, Washington, D. C., May, 1962.

Fluid Logic Devices and Circuits, A. E. Mitchell, H. H. Glaettli, and H. R. Müller, *Transactions of the Society of Instrument Technology* 1-16 (February, 1963).

A review of fluid logic devices is given. The devices are

classified into two main groups depending on whether or not they utilize movable or deformable mechanical parts. Some general comparisons and a discussion of the governing and limiting parameters are made in the text. Several examples of circuits are given to illustrate the techniques used in their design and fabrication. Fabrication methods and applications are discussed in the concluding sections of the paper.

Formulas for Integrals of Products of Associated Legendre or Laguerre Functions, James Miller, *Mathematics of Computation* **17,** No. 81, 84-87 (January, 1963).

A very simple technique has been used to obtain formulas for the integrals of products of Legendre functions

$$\int_{-1}^{1} P_{n_1}^{m_1}(x) P_{n_2}^{m_2}(x) \cdots P_{n_r}^{m_r}(x)\, dx,$$

where n_i and m_i are integers and $\Sigma_{i=1}^{r} m_i$ is even, and of Laguerre functions,

$$\int_{0}^{\infty} e^{-\alpha x} x^{\beta} L_{n_1}^{m_1}(\lambda_1 x) L_{n_2}^{m_2}(\lambda_2 x) \cdots L_{n_r}^{m_r}(\lambda_r x)\, dx,$$

where n_i, m_i and β are non-negative integers and $\alpha > 0$. Recurrence relations between necessary coefficients are given to facilitate programming.

FORTRAN, W. P. Heising, *ACM Communications* **6,** No. 3, 85-86 (March, 1963).

A brief summary is given of the nature and history of FORTRAN for IBM machines, with particular emphasis on maintenance, improvement, documentation and manuals.

Graphs des réseaux logiques séquentiels, E. Gorog, *Chiffres* **4,** 209-222 (December, 1962).

Graph theory is used to study simple sequential logical networks. The proposed problem is to determine the initial state of the network which will generate the maximum number of different possible sequential states. Notions of matrix calculus defined for different logical operations are introduced and used to solve this problem.

In the particular case where only the EXCLUSIVE OR function is concerned it is well known that, for this type of problem, irreducible primitive polynomials are of great interest. An attempt is made to generate families of some irreducible polynomials with characteristic 2.

High-Density Magnetic Head Design for Noncontact Recording, L. F. Shew, *IRE Transactions on Electronic Computers* **EC-11,** 764-773 (December, 1962).

The information storage density in digital magnetic recording is dependent on both the pulse resolution and the track definition. This paper is concerned with these two factors in the design of magnetic heads for noncontact recording (head-to-medium separation of 100 microinches or larger). A concept of changed pole-tip geometry which led to a significant improvement of pulse resolution is introduced. A general expression based on "single-pulse" superposition is derived for various bit densities and data codes. In addition, several recording methods are discussed for achieving near-maximum track density under various head-repositioning error conditions.

High-Speed Servo Positioner Bonds Mesa Transistors, Robert L. Moore, *Electronics* **36,** 58-61 (February 8, 1963).

Assembling mesa transistors requires attaching a gold lead to an extremely small metalized contact assembly. This can present a serious problem in mass production. An optically controlled servo positioner and associated logic is used to control automatic thermo-compression bonding.

How to Balance High-Speed Mechanisms with Minimum Inertia, F. R. Hertrich, *Machine Design* **35,** 160-164 (March 14, 1963).

A study was made to determine what could be done to reduce the inertia of counterweights in high-speed rotational mechanisms. Formulas for calculating counterweight dimensions for both accessible and inaccessible centers were derived by applying variational calculus. Results indicate that a counterweight with a minimum of inertia has a cylindrical outside contour, the cylinder being parallel and tangent to the center of rotation. The counterweight should be as long as possible, and be made of heavy material.

IBM Puts Spare Copier to Work, M. J. Shirhall, *Reproduction Methods for Business and Industry* **3,** 29 (January, 1963).

Recent erection of a 144,000 sq. ft. development laboratory building at the IBM plant site in San Jose, California, spurred the engineering reproductions department to design a facility to accommodate accelerated activity, with a minimal addition of new equipment. To give improved service to a larger number of people, the reproductions facility mated an existing Verifax copier with a new process which uses low-cost Ektalith paper masters.

Information-controlled Printing Unit. Development of a Parallel Printer, W. Rehwald, *Feinwerktechnik* **67,** h.1, 20-24 (1963).

The introduction of this report summarizes the requirements made on a printer for data processing machines; it then gives the typical characteristics of a parallel printer and describes design and general production problems by means of an example.

The In-Line Cryotron, A. E. Brennemann, *Proceedings of the IEEE* **51,** 442-451 (March, 1963).

A planar thin-film cryotron, namely an in-line cryotron, is described and its characteristics compared with those of a crossed-film cryotron. The in-line cryotron has its gate and control elements superimposed and parallel, or in-line, whereas the crossed-film device has its gate and control at right angles.

The gain curve for the in-line cryotron has a region where incremental gains of 1 to 10 may be obtained without a change in the gate to control width ratio, W_g/W_c, whereas large gains are not possible for the crossed-film cryotron without altering the width ratio. Larger gate resistances are possible with the in-line cryotron and calculations are given to show it is feasible to properly terminate low impedance strip transmission lines with characteristic impedances of 0.1 to 1.0 ohms. Other advantages and the disadvantages of the in-line cryotron are discussed.

Internal Conversion in the Photochemical System 1, 3-Cyclohexadiene: 1, 3, 5-Hexatriene, R. Srinivasan, *Journal of Chemical Physics* **38,** 1039-1045 (March, 1963).

It has been shown that a classification of the reactions in this system, as those that are common to both photochemistry and thermochemistry, and those that occur only in photochemistry, parallels the behavior with pressure. It is argued that the first class occurs from a vibrationally excited ground state molecule which originates from the initially formed excited singlet state by internal conversion. The trends observed with an increase in temperature support this general picture.

Investment-Cast Prototypes from Low Cost Handmade Patterns, C. R. Yungkurth, *Machine Design* **35,** No. 5, 133, (February 28, 1963).

The advantages of the investment casting process are usually associated with the production of small, intricate castings with high dimensional accuracy. In this report it is shown that investment casting is applicable to the situation where only one or two parts are required for testing or prototype purposes. By use of a machined or cemented-up one-shot plastic pattern, a metal part in any desired metal can be produced with significant savings in machine time and labor costs. The handmade plastic pattern is sent to the investment foundry and an exact duplicate (except for shrinkage) of the pattern is returned in metal. The plastic pattern is destroyed in the casting process.

Kinetics of Vapor-Solvent Growth in the System ZnS: HCl, F. Jona, *Journal of Physical Chemistry of Solids* **23,** 1719-1728 (December, 1962).

The method of growing ZnS crystals in a closed tube containing HCl as a vapor solvent and located in a temperature gradient around 1000°C is investigated. Experiments show that net flux of solid is directly proportional to the cross sectional area of the container and practically unaffected by surface reaction rates. The flux of solid increases with the square root of the pressure up to about 2 atm and is thereafter almost independent of pressure, showing only a slight monotonic decrease with increasing pressure up to 15 atm. In the latter range, the process is essentially diffusion controlled and the pressure dependence can be explained by the concomitant action of two chemical equilibria; viz. $ZnS + 2HCl \rightleftharpoons ZnCl_2 + H_2S$, and the dissociation of hydrogen sulfide, $H_2S \rightleftharpoons H_2 + \frac{1}{2} S_2$.

Experiments carried out with mixtures of HCl and Ar, and of HCl and H_2S reveal effects on the transport rate. One arises from the change of diffusion coefficients in the case of HCl and Ar. In addition, there is the change of chemical equilibrium in the case of HCl and H_2S.

Light-Collecting Properties of a Perfect Circular Optical Fiber,* R. J. Potter, E. Donath, and R. Tynan, *Journal of the Optical Society of America* **53,** 256-260 (February, 1963).

The meaning and the limitations of the numerical aperture of a perfect circular, cylindrical fiber are discussed. The light-collecting properties of the fiber due to skew rays collected beyond the meridional or nominal numerical aperture are shown. An effective numerical aperture which completely describes the light collection capacity of the fiber can be defined. It is shown that appreciably more light can be accepted by a fiber when all skew rays are considered than would be expected in a meridional approximation. The angular distribution of the emitted light has also been calculated for a typical case, and the effects of Fresnel reflection at the faces of the fiber are considered.

* Presented in part at the October 18-20, 1961, meeting of the Optical Society of America in Los Angeles, California.

Luminescence in ZnS, Se:Cu, Cl, F. Morehead, *Journal of Physics And Chemistry of Solids* **24,** 37-44 (January, 1963).

A series of ZnS, Se phosphor alloys activated with 1.5×10^{-3} Cu and 10^{-3} Cl was investigated for the wavelength dependence of the excitation and quenching of photoluminescence and the photoluminescence emission. Glow curves and the temperature dependence of the photoluminescence were also studied. The objective of this work is to show the position of the trapping and recombination levels that exist in these materials as a function of the varying base lattice composition and band edge. A modified Schön-Klasens model is shown to accomodate the data satisfactorily.

Magnestisches Moment und Quadrupolmoment des 8.42 keV-Zustandes von Tm^{169} aus der Hyperfeinstrukturaufspaltung in Tm-Metall (Magnetic moment and quadrupole moment of the 8.42 kev level of Tm^{169} from the hyperfine splitting in Tm metal), M. Kalvius,* P. Kienle,* H. Eicher,* W. Wiedemann,* and C. Schüler, *Zeitschrift für Physik* **172,** 231-238 (1963).

The hyperfine transition from the 8.42 kev level to the groundstate of Tm^{169} was investigated using the Mössbauer effect in Tm-metal in the temperature range between 5° and 60°K. Well resolved hyperfine spectra were found between 5° and 25°K indicating an internal magnetic field of about 7×10^6 oe and a large electric field gradient. The ratio of the magnetic moments of the 8.42 kev rotational state to the ground state $\mu_a/\mu_g = -2.33 \pm 0.04$ was deduced from these measurements. The magnetic moment of the groundstate and the quadrupole moment of the 8.42 kev level were deduced from calculated internal fields. These data were analyzed in terms of the "unified nuclear model" and the results compared with other known magnetic moments and M-1-transition probabilities in the $K = \frac{1}{2}$ rotational band of Tm^{169}. The complicated hyperfine spectra obtained above 25°K reveal the influence of complex magnetic ordering on the internal fields in Tm-metal.

* Laboratorium für Technische Physik der Technischen Hochschule München und der Kommission für Tieftemperaturforschung der Bayerischen Akademie der Wissenschaften.

Many-Particle Theory of Impurity States in Polar Crystals, Stephen J. Nettel, *The Physical Review* **128,** No. 6, 2573-2579 (December 15, 1962).

An attempt is made to generalize to polar semiconductors Kohn's many-particle approach to the theory of shallow impurity states in nonpolar crystals. Nuclear coordinates are included as dynamic variables. The impurity state is described as a linear combination of exact many-particle eigenfunctions that correspond to the motion of a polaron through the impurity-free crystal. The resulting effective dielectric constant is likewise identified as the usual static constant, by considering the interaction between an electron bound by an infinitesimal impurity charge and a small

classical charge fixed at a large displacement from the impurity. Corrections to the resulting hydrogenic equation arise from the need to include real phonon states. These corrections are estimated for substances with weak electron-lattice coupling only. The corrections are found small for most III-V semiconductors. They are rather more serious for substances such as $CdAs_2$ and CdS that have somewhat stronger coupling, suggesting a limitation to the applicability of the theory. In an Appendix an interpretation of the new formal contribution to the effective dielectric constant is given in terms of the motion of the ion cores.

Mechanical Processing of Change Orders, R. W. Edwards, *Graphic Science* **5,** 1, 22-25 (January, 1963).

A system to speed production and distribution of Engineering Change documents was devised utilizing microfilm and xerographic printing techniques. This paper describes the drafting standards established to insure document compatibility with the film system, and illustrates the organization and production of the final Engineering Change document. Details of the process are given, and the advantages of the mechanized system are listed.

Modulus and Damping of Copper after Plastic Deformation at 4.2°K, L. J. Bruner* and B. M. Mecs, *The Physical Review* **129,** No. 4, 1525-1532 (February 15, 1963).

An investigation of the Bordoni dislocation relaxation peaks in copper has been carried out under experimental conditions which permit plastic deformation of speciments at 4.2°K, with measurement of their Young's modulus and internal friction upon subsequent warmup. Isochronal annealing at progressively higher temperatures in the interval from 100° to 360°K, taking data from 4.2°K after each anneal, shows (a) a pronounced reduction in height of both the major peak at 62°K and the minor peak at 28°K for annealing temperatures to 200°K, (b) a slow regrowth and shift to higher temperature of the major peak with annealing above 200°K, accompanied by continued diminution of the minor peak, and (c) a monotonic increase, through the full range of annealing temperatures, of the Young's modulus as measured at 4.2°K. A qualitative discussion of these results indicates that the interaction between point defects and dislocations is an essential feature of the dislocation relaxation process.

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

New Approach to Thin Films,* A. E. Lessor, *CEC/RECORDINGS* (a publication of Consolidated Electrodynamics Corporation) **17,** No. 1, 4-7 (1st Quarter, 1963).

Film circuits, in particular resistive-capacitive networks, have reached a state of development where their large-scale application has become feasible. One of the first semi-automated systems scaled for mass production has been built by IBM's Components Division. Developed for the Naval Avionics Facility at Indianapolis, the prototype combines deposition equipment, controls, and monitors into an integrated system.

* This work was performed in part under support from the United States Army Signal Research and Development Laboratory and the United States Naval Avionics Facility, Indianapolis, Indiana. The effort was essentially sponsored by the Bureau of Weapons as an industrial preparedness measure.

Noise Figure and Sensitivity of a Superregenerative Parametric Amplifier,* C. P. Wang and G. Wade,** *IRE Transactions on Circuit Theory* **CT-9,** 320-328 (December, 1962).

The characteristics of superregeneration in a low-noise cavity-type parametric amplifier are examined both theoretically and experimentally.

The superregenerative parametric amplifier is a device performing the functions of both sampling and amplification. Incorporated with a detector, this device can be used for video-modulated signal reception. Because of the internal sampling operation, the frequency of the modulation on the input signal must be less than half the sampling frequency in order for the information to be recovered without distortion. However, input noise and circuit noise may have a bandwidth much wider than half the sampling frequency and therefore produce a folded spectrum at the output of the amplifier. This fact complicates the use of noise figure in determining the sensitivity of such an amplifier. For many applications, sensitivity is a more meaningful figure of merit than noise figure.

This paper discusses sensitivity and noise figure and derives expressions for the noise figure. The derivations take into proper account the noise spectrum folding associated with the sampling operation. Experimental data on sensitivity and noise figure are presented.

* Work performed at Stanford University, Stanford, California.
** Research Division, Raytheon Company, Burlington, Mass.

The Non-Detonative Synthesis of Cadmium Selenide and Other II-VI Compounds From the Elements, A. Reisman and M. Berkenblit, *Journal of Physical Chemistry* **67,** 22 (1963).

The cause of detonations in the direct synthesis of CdSe and other II-VI compounds from the elements has been shown to be due to the formation of insoluble passivating layers around the reactants. These passivating layers do not rupture until they attain temperatures high enough to achieve appreciable solubility of the desired compound in melts rich in the elemental constituents. It is demonstrated that single-stage, nondetonative, low temperature synthesis of each of the compounds can be effected, via use of reactant powders whose particle sizes apparently are less than twice the thickness of the passivating layer which tends to form, such that the reactants are completely consumed during the passivating layer formation. The method appears to be general for binary compounds which melt appreciably higher than either of the elemental constituents.

Non-linear Programming—A Survey, W. S. Dorn, *Management Science* **9,** No. 2, 171-208 (January, 1963).

Some of the more recent theoretical and computational developments in non-linear programming are surveyed. The notions of Lagrange multipliers and duality are discussed together with applications of these ideas to scientific and business problems. Moreover, several algorithms for solving quadratic programming problems are reviewed. Explicit rules are given for two of these algorithms, and a simple example is solved by both methods. A large-step gradient method for the solution of convex programs is given and one of Gomory's algorithms for integer programming is described. Simple examples are solved using both of these techniques. Linear fractional programming is also discussed briefly.

Nuclear Magnetic Resonance in Solid Helium-3,* Haskell A. Reich, *The Physical Review* **129,** 630-643, January 15, 1963).

Nuclear magnetic resonance experiments have been performed in solid He^3 at constant molar volumes in the α and β phases at various magnetic fields and temperatures by the spin echo method. The self diffusion coefficient D, as well as the relaxation times T_1 and T_2 have been determined. D is observed to obey the Arrhenius equation as the temperature is lowered in the α phase, but at a low enough temperature it becomes temperature independent and depends only on the density. The activation energy for diffusion correlates well with that determined from specific head measurements. At high magnetic fields T_1 and T_2 are observed to obey the BPP relationships characteristic of relaxation caused by diffusion. At low magnetic fields, T_1 becomes temperature independent as the temperature is lowered, and is observed to depend on magnetic field as exp (H^2/H_0^2), implying that the relaxation is from Zeeman to exchange systems. Values of the exchange integral J are deduced from temperature-independent diffusion, field-dependent relaxation, and rigid-lattice values of T_2, and show fair agreement internally. No agreement can be obtained with values of J deduced from observations of departures from Curie's law, the values here reported being much smaller.

* Portions of this work have been previously reported in *Proceedings of the Second Ohio State University Symposium on Helium-3,* 1960.

Nuclear Magnetic Resonance Saturation in Lithium, A. G. Redfield and R. J. Blume, *The Physical Review* **129,** No. 4, 1545-1548 (February 15, 1963).

The real part χ' of the rf nuclear magnetic susceptibility was measured absolutely for applied rf fields between 0.001 and 5 G, at 77°K and 10.7 Mc/sec. Above the saturation level of 0.02 G the discrepancy between theory and experiment is less than 20%.

The Observation by Electron Diffraction of a "Superlattice" in Annealed Nickel Single Crystal Films, E. I. Alessandrini and J. F. Freedman, *Acta Crystallographica* **16,** 54-57 (January, 1963).

The appearance of a "superlattice" formation and other structural changes during annealing have been studied in single crystal films of Ni using transmission electron diffraction techniques. The single crystal films were epitaxially grown by vapor deposition on heated, freshly cleaved (100) faces of rock salt. Annealing experiments were carried out after the films had been floated off the NaCl and mounted on 200 mesh Ni grids. Heating was done in the instrument at the rate of 1°C per minute, and patterns were obtained at temperature and after cooling to room temperature. The diffraction patterns indicate that both Ni and NiO are present in the as-grown films with their (100) planes parallel to those of the substrate. Twinning is also observed on (111) planes. Forbidden reflections, as well as splitting of the basic Ni spots, are observed at annealing temperatures in excess of 400°C, and this structure is stable up to 600°C. The formation of the extra reflections is accompanied by the disappearance of NiO. Heating above 650°C results in the disappearance of all extra reflections. This transformation is not reversible, and reannealing the films in the lower temperature range does not cause the "superlattice" reflections to reappear. The "superstructure" is interpreted to be dependent upon the presence of oxide in the films, and occurs by a disassociation of the oxide and diffusion of the oxygen into preferred sides of the nickel lattice.

Observation of Domain Wall Resonances in Ferrimagnetic Oxides, E. L. Boyd, J. I. Budnick,* L. J. Bruner,† and R. J. Blume, *Journal of Applied Physics* **33,** No. 8, 2484-2485 (August, 1962).

The observation of domain wall resonances by swept frequency spectrometer techniques is reported. These resonances appear as groups of very strong lines approximately 200 kc apart in the frequency range 80 to 20 Mc.

* Present address: Fordham University, New York, New York.
† Present address: University of California at Riverside, California.

The Occurrence of Limit Cycles in the Equations of a Tunnel Diode Circuit. W. L. Miranker, *IRE Transactions on Circuit Theory* **CT9,** No. 4, 316-320 (December, 1962).

In this paper the author considers the operation of a tunnel diode circuit in which the parameters permit self-sustained oscillations to occur. A set of response relations are derived which characterize the number, frequency, and amplitude of these oscillations. These response relations are analyzed graphically. Using these graphs, a method for operating the tunnel diode as a bistable memory device in the present case when oscillations can occur is explained. The stable modes of operation are a stable oscillation and a stable steady state. These stable operating modes are separated by an unstable oscillation.

On a Problem of C. Berge, Chong-Yun Chao, *Proceedings of American Mathematics Society* **14,** No. 1, 80 (February, 1963).

The paper gives a negative answer to the unsolved problem number 4 in Berge's book, *Theorie des Graphes et ses Applications,* Dunod, Paris, 1958.

On the Choice of Binary Codes and Thresholds, C. V. Freiman, *Proceedings of the IEEE* **51,** No. 3, 478 (March, 1963).

A memoryless binary channel subject to additive Gaussian noise is considered. Optimum threshold settings are found for codes which were designed for use in channels with completely asymmetric error properties. The performance of these code-threshold combinations is then compared to the performance of an optimum code designed for the binary symmetric channel used with a symmetric threshold setting. The asymmetric codes are shown to yield significantly lower error rates in the cases presented even though maximum channel capacity is achieved through use of symmetric threshold settings.

On the Origin of the Dipole Moment of Tetrazoles, John B. Lounsbury,* *Journal of Physical Chemistry* **67,** No. 3, 721-723 (March, 1963).

A theoretical examination of the dipole moment of tetrazole was undertaken. Two possible structures were considered because the location of one hydrogen atom is uncertain. The molecule was assumed to be planar. Pi electron distributors, x and y components of the $C^+ - H^-$ moment, the net lone pair moment, and the $N^+ - H^-$ moment, are tabu-

lated. The total dipole moments for the two structures were calculated at $\mu = 5.22$ Debye and $\mu = 1.63$ Debye. The experimental dipole moment of tetrazole is 5.11 Debye.

• Department of Chemistry, Illinois Institute of Technology (IBM Predoctoral at IIT).

On the Possibility of Observing a Bose-Einstein Condensation of Excitons in CdS and CdSe, R. C. Casella, *Journal of Physics and Chemistry of Solids* **24,** 19-26 (January, 1963).

It is shown that ideally a Bose-Einstein condensation of excitons ought to be observable in CdSe as a narrowing of the fundamental emission line with increasing concentration above a critical concentration, $\sim 10^{16}/cm^3$, using available pulsed light sources. It is concluded (with less justification) that the effect ought also to be observable in CdS. Deviations from ideality and their expected effects on conditions required for observation of the condensation and on its existence are discussed.

Optical Faraday Rotation Studies of Paramagnetic Resonance in Neodymium Ethylsulfate, K. E. Rieckhoff and D. J. Griffiths,* *Canadian Journal of Physics* **41,** 33 (January, 1963).

The magneto-optical Faraday-effect was used to measure the saturation of the spin levels in concentrated neodymium ethylsulfate in both steady state and pulsed microwave resonance experiments at liquid helium temperatures. The steady state experiments yielded the paramagnetic resonance spectrum consisting of a main triplet and an extensive hyperfine structure. The line-positions are explained in terms of the known spin Hamiltonian of the diluted salt and spin-spin interaction between nearest neighbors. An asymmetry of the line-shape was observed for sufficiently low temperatures in qualitative agreement with existing theories. Measurements of saturation s versus microwave power P at constant field and temperature were made and yielded the relationship $s(P) = \alpha P^{1/2}/(1 + \alpha P^{1/2})$ for $s > 10$ percent. The steady state experiments also revealed the existence of a spatial gradient in the saturation across the sample.

The pulsed experiments gave the spin lattice relaxation time τ as a function of magnetic field H at various temperatures. At 4.2°K, τ was found to be independent of H and of the order of 11 msec for fields from 800 to 2600 ϕ, while at temperatures below 2°K, τ was found to be strongly field dependent, indicating the importance of cross-relaxation effects at temperature $\leq$ 2°K.

• Department of Physics, University of British Columbia, Vancouver, British Columbia.

Optimum Response Analysis, C. F. Kossack, *IBM Systems Journal* **2,** 49-56 (March, 1963).

As the first in a series of papers dealing with statistical techniques that can be conveniently applied with the use of a digital computer to practical problems, the present paper discusses a technique, developed by G. E. P. Box and K. B. Wilson, which permits solution of the problem of finding an optimum (or minimum) value without first finding the underlying mathematical model. Applications of the method and the accompanying programming problem are also considered.

Overdetermined Systems of Linear Equations, T. J. Rivlin, *SIAM Review* **5,** No. 1, 52-66 (January, 1963).

This paper contains a simple and unified presentation, depending only on convexity considerations, of the theory of Čebyšev solutions of overdetermined systems of linear equations. Some new results in the case of constrained solutions are presented.

Paramagnetisches Verhalten dünner ferromagnetischer Schichten oberhalb des Curie-Punktes (Paramagnetic behavior of thin ferromagnetic films above the Curie point), H. Thomas, *Zeitschrift für angewandte Physik* **XV,** No. 3, 201-204 (March, 1963).

The paramagnetic susceptibility of thin ferromagnetic films above the Curie point is calculated as a function of film thickness, using the renormalised spin wave theory of Brout and Englert (F. Englert, *Phys. Rev. Letters* **5,** 102 (1960), R. Brout, *Physica* **26,** 215 (1960)). A pronounced thickness dependence is found only in the region of very small thickness, where also the spontaneous magnetization at low temperatures decreases with decreasing thickness (W. Döring, *Zs. Naturforschung* **16a,** 1146 (1961)). Included is a discussion of difficulties of arriving at an exact definition of the Curie temperature for a sample of finite thickness.

Perfectly Elastic Materials with Couple-Stresses, R. A. Toupin, *Archives of Rational Mechanics and Analysis* **11,** No. 5, 385-414 (1962).

A generalization of classical elasticity theory which allows that the elastic energy density might depend upon the strain gradient as well as the strain is proposed. Certain novel effects overlooked by the classical theory are discussed.

Phasing Inverting Modulator/Demodulator for the Transmission of Data on Telephonic Circuits, J. M. Pierret, *L'Onde Électrique* **431,** 177-185 (February, 1963.)

The high transmission speed made necessary by the development of devices for dealing with the treatment of incoming information justifies the development of methods different from those which have been applicable at telegraphic speeds. Among these possibilities, that using inversion modulation seems to be the most satisfactory for the transmission of binary data. The present article is concerned with the description of a modulator/demodulator developed for examination of data transmission on telephone circuits using this kind of modulation.

Piezoresistance in Degenerate *n*-Type Germanium, Maurice J. Katz,* *Helvetica Physica Acta* **XXXV,** 511-516 (1962).

Heavily doped *n*-type Ge samples are subjected to high strains so that all carriers are in one valley. The scattering anisotropy is measured by three different techniques. Results compare favorably with the theory for ionized impurity scattering. Conjectures on the shape of the band edge are made.

* Columbia University, William Bayard Cutting Traveling Fellow, 1961-1962.

Polynomials of Best Uniform Approximation to Certain Rational Functions, T. J. Rivlin, *Numerische Mathematik* **4,** 345-349 (1962).

The polynomials of best uniform approximation to a certain class of rational functions on $-1 \leq x \leq 1$ are obtained explicitly.

A Procedure for the Determination of all Irredundant Normal Forms of a Truth Function, V. Kudielka, *Elektronische Rechenanlagen* **5,** h.1, 11-21 (December, 1962).

For an introduction the known definitions and theorems for the minimization of normal forms are presented. The proofs, however, are given in a new formal way. The procedure itself is based on the fact that all irredundant normal forms are represented by the core prime implicants of the presence function. A program in ALGOL 60 is given which, due to the representation of truth functions chosen, mainly consists of two subroutines, each generally used three times. Functions with don't-care conditions may be handled as well.

Programming Considerations for the 7750, N. Sternad, *IBM Systems Journal* **2,** 57-75 (March, 1963).

The design of real-time commercial data processing systems includes special computers serving as communications control devices. This paper considers the new concepts involved in programming a particular stored-program data exchange computer so that it can be used in conjunction with standard data processors to achieve simplification of the system's programs as well as an increase in overall system efficiency.

The Propagation of a Pulse Along a Cylinder,* Martin C. Gutzwiller, *Proceedings of the Fourth U. S. National Congress of Applied Mechanics,* pp. 189-194 (January, 1963).

The propagation of a pulse is investigated for a body of circular cross section which stretches to infinity in one direction. Its cylindrical surface is stress free, whereas the end-face starts moving suddenly with uniform speed. The particle acceleration at the surface is obtained during a time interval which begins with the first arrival and extends over several reflected arrivals. Calculations in the special case of a "fluid cylinder" give a qualitatively different result compared to the "fluid slab." The method which consists in adding up all vibrational modes in their high frequency approximation is sketched for the cylindrical solid.

* Work performed at Shell Development Company, Exploration and Production Research Division, Houston, Texas.

The Punched Card as Information Carrier and as Technical Problem, K. Lindner, *Feinwerktechnik* **67,** h.2, 55-61 (1963).

The characteristics, the historical development and the significance of the punched card are discussed. Then the phenomenological causes are deduced for the fact that the punched card, while being transported through the machine by means of feed rolls, does not exactly cover the way which would result from the geometric relations from the roll diameter.

Recovery for Computer Switchover in a Real-Time System, H. Nagler, *IBM Systems Journal* **2,** 76-83 (March, 1963).

A programming technique is described which permits switching from central to stand-by computer in case of failure. Switchover is accomplished automatically and without loss of data or interruption in service. It is concluded that the technique is applicable to a large class of commercial real-time systems which must function in an uninterrupted manner and that during normal periods, when both computers are operable, the programming system permits the second computer to be utilized independently for other data processing.

Sequential Data Processing Design, V. P. Turnburke, Jr., *IBM Systems Journal* **2,** 37-48 (March, 1963).

A systematic method is outlined for design of a data processing tape system utilizing currently available types of equipment. The primary effort was devoted to obtaining a procedure which would approach an "optimal" system design. The method presented is an iterative procedure which tends to focus special attention on the critical system functions and the critical relations between functions.

A Short Review of Read-Only Memories, D. M. Taub, *Proceedings of the IEEE* **110,** No. 1, 157-165 (January, 1963).

The history of read-only memories in telephone and digital-computer systems is briefly surveyed and their similarity to logic circuits demonstrated by reference to the diode matrix. A description is given of the principles of operation and important characteristics of the following types of read-only memory: capacitor matrix, mutual-inductance matrix, transformer (Dimond ring) type, square-loop ferrite-core matrix, permanent-magnet twistor matrix, flying-spot store, and electroluminescent matrix. These memories are briefly compared.

Should We Computerize Complex Refineries? R. A. Mugele, *Petro/Chem Engineer* **35,** 46-48 (March, 1963).

Consideration is given to the relative merits of different modes for automation of a complex, integrated refinery. Each of the modes involves at least one stored-program computer.

In Mode I, the computer produces an optimal schedule, which is implemented by the operators in charge of the refinery units. In Mode II, key units of the refinery are under closed-loop control, again subject to the optimal schedule.

In Mode III, all operations are synchronized to the control of a central computer. The method of analysis centers on a comparison of profitability of these modes of operation, thus aiding selection of the most suitable control system for a particular refinery.

Similarity Rules for Isothermal Bubble Growth, W. E. Langlois, *Journal of Fluid Mechanics* **15,** Part I, 111-118 (1963).

A normalized formulation of the problem of isothermal bubble growth, dominated by viscosity and diffusion, reveals that in its full generality the problem involves eight dimensionless parameters. Limiting cases for extreme values of each of these parameters are investigated.

Simulation Tests of Lot Size Programming, B. P. Dzielinski, C. T. Baker and A. S. Manne,* *Management Science* **9,** No. 2, 229-258 (January, 1963).

This paper presents the results of some digital computer simulation tests of a procedure for the economic planning of lot sizes, work force, and inventories. A dynamic, deterministic, linear programming model was used to obtain approximate solutions to the actual problem which is both dynamic and stochastic. The tests were made with data taken from an actual factory. An alternate procedure, based upon single-item inventory control, was also tested; its results were compared with those obtained from the linear programming model. On the basis of these tests, this linear programming method appears to offer a promising method for the practical economic planning of production activities.

* IBM Consultant, 1959. Stanford University, Stanford, California.

Spectral Characteristics of Exploding Wires for Optical Maser Excitation,* M. J. Stevenson,** W. Reuter, N. Braslau, P. P. Sorokin, and A. J. Landon, *Journal of Applied Physics* **34,** 500-509 (March, 1963).

As pulsed light sources, exploding wires can be used to provide intense, narrow spectral lines as well as the characteristic continuum of very high temperature black bodies. The surface brightness depends on the wire material and conditions under which the wire is exploded. Optimum conditions for the 100 to 500 μsec light pulses from wires exploded in air have been found for tungsten, tantalum, and molybdenum wires 0.005 to 0.010 inches in diameter for energy inputs of 3000 *J* or more. Wires exploded in small diameter vacuum tubes radiate as blackbodies, but narrow line spectra are produced in vacuum enclosures of larger dimensions. The spectral radiance of air-exploded wires is three orders of magnitude greater than that of conventional flash lamps. Vacuum-exploded wires have spectral radiance greater by another factor of eight. Excitation of various optical masers with exploding wires is discussed.

* This research was supported jointly by International Business Machines Corporation and the United States Army Research Office, Durham, North Carolina.
** Now with Samson Associates, 680 Fifth Avenue, New York, N. Y.

Spin Hamiltonian Parameter D versus Axial Crystal Field for *S*-State Ions, W. J. Nicholson and Gerald Burns, *Physical Review* **129,** No. 6, 2490-2495 (March 15, 1963).

Measurements have been made, in a Mossbauer absorption experiment, of the nuclear quadrupole splitting of the $^6S_{5/2}$ state in Fe^{3+} substituted in several compounds. The compounds chosen were those for which electron spin resonance measurements had previously been made of the quantity *D* in the electron spin resonance Hamiltonian. The measured quadrupole coupling eqQ/h is directly proportional to the axial crystal field, V_{ax}. Hence, it is possible to compare the results of the dependence of *D* on the axial crystal field with theoretical predictions of Watanabe and Pryce. It is found that considerable scatter of data points occurs about any smooth curve one might draw. This scatter is possibly the result of covalent bonding or the distortion of the iron wave functions by the surrounding ions. Moreover, a functional dependence of any smooth curve through the experimental points disagrees with the theoretical calculations. If the data are to be even crudely fit by a smooth curve, the sign of the coefficient of V_{ax}^2 should be positive and not negative as theory indicates. Finally, there is serious disagreement between theory and experiment on the dependence of the *D* vs V_{ax} curve on the particular paramagnetic ion (i.e., on whether the substituted ion is Fe^{3+} or Mn^{2+}).

Spinordnungsffekte im elektrischen Widerstand dünner Gadolinium, Dysprosium und Terbium Filme (Spin-ordering effects in the electrical resistance of thin gadolinium, dysprosium and terbium films), C. Schüler, *Zeitschrift für angewandte Physik* **XV,** No. 3, 218-220 (March, 1963).

Thin films of Dy and Tb were deposited in ultrahigh vacuum, and the resistance measured between 50° and 400°K, covering the ferro-, antiferro-, and paramagnetic range. The scattering of conduction electrons at disordered spins produces an additional resistivity term, which can be found by analysis of the $\rho(T)$ curves. As in bulk material, this additional term decreases with increasing temperature. (R. V. Colvin, S. Legvold, F. H. Spedding, *Phys. Rev.* **120,** 141, 1960). Quantitative results are compared to the quoted measurements on bulk material.

Static Grounds for Inequalities in Finite Strain of Elastic Materials, C. Truesdell* and R. Toupin, *Archives for Rational Mechanics and Analysis* **12,** No. 1, 1-33 (1963).

The strain energy function of an isotropic material in the classical linear theory of elasticity is positive definite if and only if the shear modulus μ and the bulk modulus $\lambda + 2/3$ (μ) are positive. The problem of finding corresponding restrictions on the energy function and stress-strain relations in the theory of finite elastic deformations is the subject of this paper.

* Johns Hopkins University, Baltimore, Md.

Stress Anisotropy in Silicon Oxide Films, J. Priest,* H. L. Caswell, and Y. Budo, *Journal of Applied Physics* **34,** 347-351 (February, 1963).

The residual stress in films formed by vacuum sublimation of bulk silicon monoxide has been studied as a function of the angle of incidence of the evaporant. Using a source temperature of 1350° to 1400°C and a system total pressure of $\sim 2 \times 10^{-6}$ Torr, a pronounced dependence of stress on angle of incidence and a distinct stress anisotropy was observed. The stress in the *x* direction (i.e., perpendicular to the direction of the evaporant irrespective of substrate orientation) increases from 4×10^8 dyn/cm² for normal incidence to 14×10^8 dyn/cm² for an incident angle of $\sim 50°$ and then decreases to 4×10^8 dyn/cm² for an incident angle of 80°. The stress in the *y* direction (i.e., perpendicular to the *x* direction) is peaked at $\sim 30°$ at a value of 13×10^8 dyn/cm² and then decreases to $\sim 0.5 \times 10^8$ dyn/cm² at 80°. Films formed at normal incidence are quite stable and not susceptible to the effects of water vapor. However, films formed by depositing at grazing incident angles ($>30°$) are very unstable and invariably buckle and rupture when exposed to atmospheres of water vapor. Substrate temperature, film thickness, and inert residual gases were found to have little effect on the stress and stability of films deposited at an angle of incidence of 45°. When a lower source temperature ($<1200°C$) is used and a high partial pressure (10^{-4} Torr) of water vapor is present during deposition, the resulting highly oxidized films show a compressive stress ($\sim 2 \times 10^8$ cyn/cm²) and very little dependence on the angle of incidence. These films are

stable when exposed to higher partial pressures of water vapor.

* Present address: Physics Department, Miami University, Oxford, Ohio.

Strong Resonances of Rectangular AT-Cut Quartz Plates, R. D. Mindlin* and D. C. Gazis, *Proceedings of the 4th U. S. National Congress of Applied Mechanics,* pp. 305-310 (1962).

Vibrations of rectangular AT-cut quartz plates are investigated using two-dimensional equations of motion of crystal plates which take into account the coupling of flexural, extensional, and face-shear deformations with each other and with the lowest thickness-orders of thickness shear and thickness twist deformations. Appropriate solutions of these equations are obtained and the results of computations of the resonant frequencies are compared with experimental results obtained by Koga and Fukuyo.**

* Columbia University, New York, N. Y.
** I. Koga, and H. Fukuyo, *J. Inst. Elec. Comm. Engrs. of Japan,* **36,** 59 (1953).

Susceptibilities and Critical Fields of Superconducting Films, W. Liniger and F. Odeh, *Physical Review Letters* **10,** 2, 47-48 (January, 1963).

The letter is concerned with the calculation of 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 is made of the susceptibilities obtained with the two different kernels. 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.

Systematize Your Design Steps. D. H. Rutherford, *Electronic Design* (in two parts) Part 1: **11,** No. 5 62-68; Part 2: **11,** No. 6 66-74 March 1 and 15, 1963).

Digital systems, because of their inherent logical characteristics, lend themselves to a logical design approach. Part 1 of this paper describes the specification and organization steps of the design process. A flow chart—using a diamond-shape for a cause symbol (IF), and a block shape for an effect symbol (THEN) which states the action for the "yes" or "no" answers—is included which charts the sequential synthesis of a digital system. This chart helps the designer represent the desired system specifications in a clear, complete manner. It also enables arranging and representing the major system components, and shows their interrelationships and intended system purposes. Part 2—dealing with system specifications and organization—describes a system configuration design process which is detailed to the point where transformations to algebraic representations are possible. These transformations enable producing a set of defining equations detailed enough to allow construction of the system. Numerous factors in system design are discussed including system data flow, pseudo-signals, time-sharing of system memory elements, flip-flop equations, logical building blocks, et cetera.

The Temperature Dependence of NMR of Fe^{57} in Magnetite, E. L. Boyd, *The Physical Review* **129,** No. 5, 1961-1964 (March, 1963).

A report is made of an attempt to fit the temperature dependence of the observed (NMR) frequencies for the two sublattices in magnetite to the measured temperature dependence of the magnetization. It is shown that when the microwave g_{eff} values as reported in the literature are used in this calculation, no fit between the NMR experiment and the moment measurement is obtained. If a $g_{eff} = 2$ is assumed, however, the data may be brought into good agreement.

Temperature Stabilization of Transistors, G. J. Sprokel, *Semiconductor Products* **6,** 1, 24-28 (January, 1963).

A transistor amplifier stage can be stabilized against temperature changes by temperature dependent dc feedback from collector to base. The network contains a Zener diode with a positive temperature coefficient and a resistive voltage divider. The condition necessary to make I_B independent of T is that the ratio of the temperature coefficients be equal to the ratio of the resistors in the divider.

Theoretical Calculation of Vapor Transport of Solid in the ZnS : HCl System, F. Jona and G. Mandel, *Journal of Chemical Physics* **38,** 346-349 (January, 1963).

A theory has been previously developed which allows calculation of the rate of diffusion-limited vapor transport of solids in a multicomponent multireaction system which is driven by a small temperature gradient. This theory is applied to the case of $ZnS_{(s)}$ being transported by reaction with $HCl_{(g)}$. All the required parameters, i.e., gaseous diffusion coefficients, thermodynamic data, etc, are either known or independently estimated. The calculated results are found to be in quantitative agreement with the experimental results within the estimated uncertainties in the thermodynamic and diffusion coefficient data over a wide range of initial HCl pressures. Below an initial HCl pressure of 1 atm, it is seen that the experimental rate of transport drops sharply in comparison to the theoretical prediction. This has previously been attributed to kinetic limitations.

It is shown that the assumption of a single binary diffusion coefficient, applying to all pairs of component species, may lead to results in approximate agreement with the more "exact" theoretically predicted results.

Theory of Magnetothermomechanics, D. C. Mattis and T. D. Schultz, *The Physical Review* **129,** 175-181 (January, 1963).

We show that in both ferromagnetic and antiferromagnetic

systems with weak magnetostrictive coupling the coefficient of thermal expansion gives a useful measure of the magnetic specific heat. We also analyze the strong coupling situation by means of our simplified but soluble model, and find it possible to introduce an effective temperature T^* and an effective magnetic susceptibility. The exact pressure dependence of the thermodynamic functions can be found, and the pressure dependence of the Curie temperature is given explicitly. In strong coupling, a novel first-order thermodynamic phase transformation can occur which is manifested by a discontinuity in T^* as a function of T. An equal area rule for determining the transition is derived, which is reminiscent of the laws of condensation of nonideal gases. It is also shown that in its simple version the theory is not directly applicable to a one-dimensional chain, which is separately analyzed in an Appendix.

The Thermoelectric Properties of Mixed Crystals of $Mg_2Ge_xSi_{1-x}$*, Richard J. La Botz**, Donald R. Mason***, and Daniel F. O'Kane, *Journal of the Electrochemical Society* **110,** 127-134 (February, 1963).

The purpose of this work was to determine the thermoelectric properties of the pseudobinary system Mg_2Si-Mg_2Ge. The compositions investigated were Mg_2Si, $Mg_2Ge_{0.2}Si_{0.8}$, $Mg_2Ge_{0.4}Si_{0.6}$, $Mg_2Ge_{0.8}Si_{0.2}$, and Mg_2Ge. X-ray diffraction lattice parameter measurements and differential thermal analysis measurements established the existence of complete solid solubility between Mg_2Si and Mg_2Ge.

Electric resistivity and Hall effect measurements indicated that at 300°K the electron Hall mobility in the mixed crystals is essentially the same as that of the pure compounds. The forbidden energy gap appeared to vary monotonically from about 0.78 ev for Mg_2Si to about 0.70 ev for Mg_2Ge. Thermal conductivity measurements on the pseudobinary system showed that the lattice thermal conductivity of the solid solutions is substantially lower than that of either of the pure compounds at 300°K.

*Work performed at the College of Engineering, The University of Michigan, Ann Arbor, Michigan.
** Present address: Advanced Development Section, Liquid Rocket Plant, Aerojet-General Corporation, Sacramento, California.
*** Department of Chemical and Metallurgical Engineering, University of Michigan, Ann Arbor, Michigan.

A Toroidal Nondestructive Read Memory Element, M. Teig and J. R. Kiseda, *Communication and Electronics* **64,** 523-526 (January, 1963).

The operation of a 1-core-per-bit magnetic nondestructive read (NDR) element using a bias restoration technique is discussed. Nondestructive read time of 100 nsec was easily achieved. Peak signal/noise ratios ranged from 5:1 to 15:1. Writing was done by using simple 2D wiring. The main advantages over other NDR elements are larger signal/noise ratios with larger signal levels and simple writing and wiring.

Two-dimensional Transonic Gas Jets, R. E. Norwood, *Proceedings of the 4th U. S. National Congress of Applied Mechanics,* pp. 1359-1367 (March, 1963).

This paper describes a method of finding the flow pattern of a two-dimensional isentropic gas jet issuing from a vessel having straight walls. The method is applicable for both subsonic and supersonic jet velocities. A numerical solution is obtained in the hodograph plane where the boundaries of the flow are easily determined and that solution is then transferred into the physical plane. Calculations to determine the contraction coefficient and velocity distribution were carried out on an IBM 709 Data Processing System for the physical configuration of an infinite slit with an upstream wall perpendicular to the plane of symmetry of the slit. The results agree with the sonic calculation of Chaplygin and Frankl's maximum flux case.

Uniqueness and Existence of the Solution to the Static London-Maxwell Equations in Two Dimensions, F. Odeh, *Journal of Mathematical Physics* **4,** 1, 141-146 (January, 1963).

A theorem is given for the existence and uniqueness of the time-independent solution of the exterior-interior problem associated with determining the distribution of superconducting current, according to the London model, in simply- or doubly-connected two-dimensional regions. The proof of the corresponding theorem in three dimensions is outlined. A discussion is also given of the relationship between two "different" solutions which already exist for rectangular regions.

Vanadium Films Evaporated onto Liquid Helium Cooled Substrates in Ultra-High Vacuum, J. C. Suits, 1962 *Transactions of the Ninth National Vacuum Symposium of the American Vacuum Society,* pp. 74-80.

Vanadium films were evaporated onto substrates cooled to liquid helium temperature. The vacuum during evaporation was 6×10^{-12} Torr. An indicated vacuum of 6×10^{-14} Torr, as measured on a cold cathode magnetron gauge, could be attained prior to film deposition. The magnetron gauge was calibrated against a Bayard-Alpert gauge and was found to be linear down to at least 10^{-11} Torr. Resistance measurements were made during and following film evaporation. Resistance measurements indicated that 1) a structure change occurred in the film during evaporation, 2) the thicker films were superconducting with a transition temperature near the bulk value, and 3) anomalous resistance changes occurred at 160° and 200°K.

Xerography—A New Non-Mechanical Printing Method, Max Preisinger, *Elektronik* **12,** h. 2, 33-36 (February, 1963).

Very often the speed of data processing equipment can not be fully utilized since input and output still are executed mechanically so that a "bottleneck" with regard to time results, through which all information has to pass. In the meantime attempts are made to eliminate these bottlenecks. In the future, the xerographical process will be important to the output of data; a summarizing review offers quick information on this subject.

X-Ray Irradiation Effects on Potassium Iodide, C. H. Ma and J. Makris, *Journal of Applied Physics* **34,** No. 2, 441-443 (February, 1963).

X-ray irradiation effects on alkali halides are: change of surface hardness, creation of color centers, change of lattice constants, and inducement of crystalline growth. Electron micrographs reveal marked surface differences between x-ray irradiated and non-irradiated potassium iodide crystals, giving rise to the belief that x-rays can produce hardness changes and bombardment dislocations in alkali halides.

The Clock Paradox, E. S. Lowry, *American Journal of Physics* **31,** No. 1, 59 (January, 1963).

Compound Barriers in Thin Film TiO_2 Diodes, P. J. Magill, *Proceedings of IEEE* **51,** No. 1, 223 (January, 1963).

Constitutional Supercooling and Facet Formation of GaAs, Charlotte Z. LeMay, *Journal of Applied Physics* **34,** 439 (1963).

Demonstration of Nuclear Magnetic Resonance in Cobalt with a 'Grid Dip' Meter, R. J. Blume, *American Journal of Physics* **31,** 58 (January, 1963).

Direct Determination of the Scattering Time in Bismuth and Antimony-Bismuth Crystals at Low Temperature, L. Esaki and J. Heer, *Journal of Applied Physics* **34,** 234 (January, 1963).

Discussion on the paper "Reattachment of a Two-Dimensional Compressible Jet to an Adjacent Flat Wall" by R. E. Olson, A. E. Mitchell, *Proceedings of the Symposium on Fluid Jet Control Devices* (ASME Winter Meeting, New York City, November 25-30) p. 31 (1962).

Effect of Correlation on the Ferromagnetism of Transition Metals, Martin C. Gutzwiller, *Physical Review Letters* **10,** No. 5, 159-162 (March 1, 1963).

An Error Analysis in the Digital Computation of the Autocorrelation Function, Henry L. Crowson, *AIAA Journal* **1,** No. 2, 488-489 (February, 1963).

Ferro-acoustic Resonance in Yttrium Iron Garnet, B. Lüthi, *Physics Letters,* **3,** No. 6, 285-287 (February 1, 1963).

Helix-Coil Transition and Electron Conductivity of the Amylose-Iodine Complex, W. L. Peticolas, *Nature* **197,** 898-9 (1963).

Mercury Photosensitized Isomerization of 1, 5-Cyclo octadiene to Tricyclo [3.3.0.$0^{2,6}$] Octane, R. Srinivasan, *Journal of the American Chemical Society* **85,** 819-820 (March, 1963).

Metal Transfer and the Wedge Forming Mechanism, M. Antler, *Journal of Applied Physics* **34,** No. 2, 438-439 (February, 1963).

Multi-center Pi-electron Integrals for the Benzene Molecule, M. Karplus and I. Shavitt*, *Journal of Chemical Physics* **38,** #5, 1256-1257 (March 1, 1963).

* Now at Technion-Israel Institute of Technology.

Optimizing the Digital Magnetic Recording Process, D. W. Chapman, *Proceedings of the IEEE* **51,** 247-248 (January, 1963).

Radial Shearing Interferometer, E. Donath and W. Carlough, *Journal of the Optical Society of America* **53,** No. 3, 395 (March, 1963).

Suggested Mechanism for Formation of Hopper Crystals in Flux Systems, R. A. Lefever* and E. A. Giess, *Journal of the American Ceramic Society* **46,** 153-4 (March, 1963).

* General Telephone & Electronics Laboratories, Incorporated, Palo Alto, California.

Theoretical Limit on Digital Magnetic Recording Density, D. W. Chapman, *Proceedings of the IEEE* **51,** 394-395 (February, 1963).

Thermal Stresses in an Elastic Half-Space With a Moving Boundary, I. G. Tadjbakhsh, *Journal of the American Institute of Aeronautics and Astronautics* **1,** No. 1, 214-215 (January, 1963).

Ultraschallabsorption in Ferrodielektrika (Theory of sound absorption in ferrodielectrics), Paul Erdös, *Helvetica Physica Acta,* **XXXV,** 516-517 (1962).