

IBM Technical Papers Published in Other Journals

Additional Spin Resonance Spectrum in Antimony-Doped Germanium, R. W. Keyes and P. J. Price, *Physical Review Letters*, **5**, 473-474 (November 15, 1960). It is shown that the anomalous spin resonance spectrum observed in antimony-doped germanium by Pontinen and Sanders may be explained by the strain fields ordinarily present in germanium crystals.

All-Purpose Computer Circuits, R. J. Domenico and R. A. Henle, *Electronics*, **33**, No. 34, 56-58 (August 19, 1960).*

A new approach to transistor logic design which permits complete flexibility in transistor circuit interconnections is described. Through the use of a photoconductor matrix with light patterns determining the interconnections, logical circuits can be rewired in milliseconds to achieve different system organization. Logical circuit speeds are determined only by the transistor circuitry, and can be in the fractional microsecond range. This flexibility can be used to achieve the capability of "self-repair" in a computer logical network. The computer can in effect "rewire" itself in order to remove malfunctioning components.

*For period July 1 through September 30, 1960.

Analysis of a Magnetic Resonance Spectrometer, J. P. Goldsborough and M. Mandel,* *The Review of Scientific Instruments*, **31**, No. 10, 1044-1046 (October, 1960).

This paper analyzes an electron paramagnetic resonance microwave bridge spectrometer, and expressions are given for the relation between the signal and the imaginary part of the magnetic susceptibility. From these the conditions for maximum signal are obtained. The analysis is also applicable to many other types of magnetic resonance spectrometers.

*Department of Physics, Stanford University.

The Analysis of Molecular Wave Functions by Nuclear Magnetic Resonance Spectroscopy,* M. Karplus, *Journal of Physical Chemistry*, **64**, 1793-1798 (December, 1960).

A valence-bond formulation is presented for the relationship between molecular wave functions and the electron-coupled nuclear spin interactions observed by nuclear magnetic resonance spectroscopy. For non-bonded atoms, the magnitude of the coupling is shown to depend on the deviations from perfect pairing in the wave function. This result makes it possible to use the measured coupling constants in testing models for hyperconjugation. An application to the second-order hyperconjugation in ethane is given. For directly-bonded atoms, the coupling constant depends on parameters, such as orbital hybridization and bond polarization, in localized electron-pair functions. Use of this dependence is made to determine the bond polarization in several tetrahedral molecules.

*Work done at Noyes Chemical Laboratory, University of Illinois.

Atomic g_j Values for Neon and Argon in Their Metastable 3P_2 States; Evidence for Zero Spin of $^{10}\text{Ne}^{20+}$, A. Lurio,** G. Weinreich,† C. W. Drake,‡ V. W. Hughes,§ and J. A. White,§ *The Physical Review*, **120**, No. 1, 153-157 (October 1, 1960).

The gyromagnetic ratios of neon and argon in their metastable 3P_2 states have been measured by the atomic beam magnetic resonance method. The results are $g_j(\text{Ne}, ^3P_2) = 1.500888 \pm 0.000005$ and $g_j(\text{Ar}, ^3P_2) = 1.500964 \pm 0.000008$, in agreement with the less precise optical spectroscopic measurements. Theoretical values, including radiative and relativistic effects, are $g_j(\text{Ne}, ^3P_2) = 1.50088$ and $g_j(\text{Ar}, ^3P_2) = 1.50095$, in good agreement with the experimental values. In addition, the Zeeman transition frequency for neon has been measured as a function of magnetic field to obtain evidence that the magnetic moment of Ne^{20} is less than 4×10^{-4} nuclear magneton, and hence that the spin of Ne^{20} is probably zero.

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**Yale University and IBM Watson Laboratory.

†Present address: Physics Department, University of Michigan.

‡Yale University.

§Present address: Physics Department, Harvard University.

Data Processing Techniques for Parts Cataloging, P. F. Santarelli and R. F. Cunningham, *STWE Review*, **7**, 4-7 (April, 1960).*

The computer techniques described in this paper are for the preparation and maintenance of an illustrated parts breakdown manual. These procedures are the culmination of a project undertaken at IBM in 1955 which resulted in the preparation of an illustrated parts breakdown manual consisting of more than six thousand pages of listing and fourteen hundred illustrations.

Adapted from a paper presented by the authors at the 1958 Technical Writers' Institute, Rensselaer Polytechnic Institute.

*For period April 1 through June 30, 1960.

A Digital Differential Shaft-Motion Analyzer, R. L. Lyon, *Proceedings of the 1960 National Electronics Conference*, **16**, 829-834 (October 12, 1960).

A system permitting measurement of the angle between two points in a dynamic shaft system using digital and incremental techniques is described. Low inertia incremental shaft transducers and transistorized logic were used to resolve 2-1/2 minutes of angle at shaft speeds up to 1400 rpm. Additional logic was used to compare the movement between these two transducers and sum the difference in a reversible binary counter. The output voltage for a suitable recorder is derived from a digital-to-analogue converter. The output deflection on the recorder is then proportional to the instantaneous angle between the two points in the dynamic shaft system. The

analyzer is able to make 200,000 comparisons of position per second.

Experiments performed to measure the differential angle in shaft systems with speed ratios of other than 1/1 and measure the instantaneous velocity of a shaft with the signals from the same incremental transducers are described.

Dünne Schichten als Rechenmaschinenelemente (Thin Films as Computer Elements), W. E. Proebster, *Elektrotechnische Zeitschrift*, **81A**, No. 25, 913-920 (December, 1960).

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

The Dynamic Mechanical Properties of Plastics Dielectric Materials, T. D. Callinan, *Electro-Technology*, **66**, No. 6, 150-156 (December, 1960).

The electrical characteristics of plastics materials are not the only design parameters in insulation systems. The mechanical properties are equally and increasingly important as environmental and service conditions become progressively more severe. These considerations are analyzed here in terms of basic theory, specific classes of insulation, examples of application in components and systems, and from the standpoint of fabrication variables.

The Electrical Properties of Some Natural Waxes, T. D. Callinan and Ann M. Parks, *Journal of the Electrochemical Society*, **107**, No. 10, 799-803 (October, 1960).

The dielectric constants and dielectric loss factors of carnauba, Ouricuri, and American Montan wax determined over a temperature range of -60° to 90°C and at frequencies of 0.1, 1, 10, and 100 kc, indicate that the component omega-hydroxy acid esters rotate in the solid state in the temperature region 25° - 70° . Furthermore, from dipole measurements, the molecules were found to possess a trans-trans configuration.

The Electrical Properties of Some Solid Organic Esters,* A. M. Parks, *Insulation*, **6**, No. 12, 102 (December, 1960).

The preparation of a series of symmetrical diesters of long-chained aliphatic alcohols and dibasic acids is described and trends in the electrical properties caused by systematic increases in chain length and dipole separation are discussed. The dielectric constants and loss factors were measured from 0.1 to 100 Kcps and from 90°C to -60°C in an Elliott cell. The most probable structural configurations are discussed in terms of the dipole moments at 22°C , and correlation with physical properties is indicated.

*This article is a review of a talk presented at the Conference on Electrical Insulation in Washington, D. C. in October, 1960.

Electronic Image Intensification of X-Ray Diffraction Patterns, R. E. Thun, J. Johnson,* B. H. Krause* and E. A. Meredith,* *Analytical Chemistry*, **32**, No. 8, 939-941 (July, 1960).**

Studies of crystal structure transitions require diffraction equipment yielding a high time resolution. To achieve a sufficiently short exposure time with the x-ray powder technique, the diffracted intensity has to be increased by a factor of more than 10^2 . Such a gain can be obtained by an electronic image converter tube. The required speed has not been reached yet, but it is shown that a further development within the present state of the art should yield the necessary time resolution.

*U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va.

**For period July 1 through September 30, 1960.

Error Recording and Analysis for Data Transmission, C. M. Melas and E. Hopner, *Proceedings of the 1960 National Electronics Conference*, **16**, 54-57 (October 12, 1960).

During data transmission tests made recently over the telephone networks of several European countries, errors were recorded to help in the evaluation of error correction or detection schemes necessary for reliable transmission. The error checking and recording equipment designed for these tests had to be simple enough to be readily transportable and yet record all pertinent data for subsequent compilation by the computer. A repetitive 8-bit combination was used for transmission, and error checking was accomplished without the use of a synchronizing signal at the receiver. The character generator is also able to produce a long pseudo-random sequence, which is duplicated at the receiver for bit-by-bit error detection, providing a closer approximation of actual operating conditions. The data thus acquired is reduced to provide information on the duration and nature of error bursts and interruptions, as well as the length of error-free transmissions.

Die Erzeugung sehr kurzer Nadelimpulse. (The Generation of Extremely Short Pulses), H. P. Louis, *SEV-Bulletin*, **51**, No. 20, 1067-1072 (October 8, 1960).

The generation of extremely short pulses requires high rates of voltage rise. These are achieved by pulse generators delivering a high current to a small load capacity. The characteristics of some generators are discussed and methods of subsequent pulse forming are described. An example is given for the generation of 0.35 μ sec-pulses of 400 mv amplitude.

An Estimation of the Relative Efficiency of Two Internal Sorting Methods, Harry Nagler, *Communications of the ACM*, **3**, No. 11, 618-620 (November, 1960).

Two internal sorting methods, one the conventional two-way merge, the other a machine-specific form of binary search, are compared for efficiency on the IBM 705 Models I and II. Expressions are developed for the expected number of the more time-consuming machine operations, taking into consideration the length of control words; and a table is given showing which method is superior in any given application.

Evaporation Rate Monitor, G. R. Giedd and M. H. Perkins, *Review of Scientific Instruments*, **31**, No. 7, 773-775 (July, 1960).*

A method for controlling the deposition rate of vacuum-deposited films is described. This paper presents details of the rate-sensing device and furnace-control system. The control system utilizes a saturable-core reactor driven by the output of the rate monitor. This controls the furnace current, thus completing the system. Operation and calibration of the control system is described, and experimental results are tabulated.

*For period July 1 through September 30, 1960.

Ferroelectric Properties of $\text{BaLi}_{2x}\text{Al}_{2-2x}\text{F}_{4x}\text{O}_{4-4x}$, T. G. Dunne and N. R. Stemple, *The Physical Review*, **120**, No. 6, 1949-1950 (December 15, 1960).

Single crystals of $\text{BaLi}_{2x}\text{Al}_{2-2x}\text{F}_{4x}\text{O}_{4-4x}$, where $x=0.15$ to 0.30 , have been found to be ferroelectric with a Curie temperature in the range $127-153^\circ\text{C}$ and a room-temperature spontaneous polarization along the hexagonal c axis of approximately $0.1 \mu\text{coul}/\text{cm}^2$. The structure of these mixed crystals is unrelated to that of any previously known ferroelectric, but appears to be very similar to that of BaAl_2O_4 .

Ferromagnetic-Antiferromagnetic Interaction in Fe-FeS, J. H. Greiner, I. M. Croll and M. Sulich, *Journal of Applied Physics*, **31**, p. 2316 (December, 1960).

A previously unreported ferromagnetic-antiferromagnetic interaction in the Fe-FeS system is described. Exchange anisotropy effects previously have been observed for compacts of fine, sulfide-coated iron particles. In the work reported here a $\sin \theta$ variation of the torque and a rotational hysteresis were found for samples cooled in a magnetic field from the Néel temperature of FeS (613°K). Samples cooled in a demagnetized state displayed no measurable change of torque with angle.

A Four-Terminal P-N-P-N Switching Device, M. Klein, *IRE Transactions On Electron Devices*, **ED-7**, No. 4, 214-217 (October, 1960).

A four-terminal germanium P-N-P-N switching transistor is described. In an appropriate circuit the device has useful switching gain for both the turn-on and turn-off operations. Expressions are derived for switching gain, and requirements on device parameters are obtained. Device structure is described and switching performance data are given for what the author refers to as a fast switch for moderate current loads.

Freie Energie von 180° -Wänden und Oberflächen im kubisch raumzentrierten Dipol-Gitter (The Free Energy of 180° -Domain Walls and Surfaces in a Body-Centered-Cubic Dipol Lattice), R. Sommerhalder, *Helvetica Physica Acta*, **XXXIII**, Fasc. 6/7, 617-626 (October 1, 1960).

The free energy of 180° -domain walls and surfaces in ferroelectrics is estimated, assuming a simple model of dipole-interaction in a body-centered-cubic lattice. The wall and the surface layer are found to be about one lattice constant thick except for temperatures very close to the Curie temperature. Spontaneous polarization in the surface layer is found to have lower values than in the undisturbed crystal for all temperatures.

Freie und Erzwungene Schwingungen der Magnetisierung in Dünnen Permalloy-Schichten, (Free and Forced Oscillations of the Magnetization in Thin Permalloy Films), P. Wolf, *Zeitschrift für Physik*, **160**, 310-319 (October 20, 1960).

Free oscillations of the magnetization ranging from 500 to 1100 mc/sec have been excited in thin permalloy films by a pulse field with a risetime less than 0.45 nsec , and observed with a sampling oscilloscope. The eigenfrequencies and the damping constants of these free oscillations are compared with the resonance frequencies and the damping constants of forced oscillations obtained in ferromagnetic resonance experiments. Perpendicular and parallel orientation of the magnetization with respect to the easy direction of the induced

uniaxial anisotropy of the film are considered. The results show reasonable agreement with theoretical values gained from the Landau-Lifshitz equation.

How a Communications Group Can Help You, J. W. Hunton and R. W. Slade, *Product Engineering*, **31**, No. 48, 90-92 (November 21, 1960).

The purpose of a communications group, what it means to the engineer, and how to organize for effective communication are explained in terms of a personal messenger service. This article goes into detail on handling the variety of notes, reports, magazine articles, and conference papers resulting from effective communications.

Improvements to Current Switching, F. K. Buelow, *IRE Transactions on Electronic Computers*, **EC-9**, No. 4, 415-418 (December, 1960).

Diode switching circuits have been used in conjunction with emitter followers and current switching circuits to evolve a new set of system building blocks. These blocks exhibit typical delays under 5 nanoseconds. Diodes cost less and are physically smaller than transistors; therefore, this new system is cheaper and faster than an all-current switching system and permits at least a fivefold increase in packaging density.

Instrumental Quality Control for Color, T. G. O'Brien, *Industrial Quality Control*, **17**, No. 4, 4-7 (October, 1960).

This paper discusses the problems inherent in visual inspection of color, matching problems with multiple sources for the same part and preparation of color standards. The instrumental color control system used at IBM Kingston is described. The use of the Gardner Color Difference Meter in conjunction with the system is explained.

Integrated Accounting Through Data Processing, T. Bloomer, *The Federal Accountant*, **10**, 87-95 (December, 1960).

Two possible approaches may be used to achieve integration of data processing. One is through utilizing a central processing unit to encompass all applications. If this approach is used, the computer must initially have all the basic components that will be required in the ultimate system. Perhaps the greatest disadvantages of this type of integration are lack of flexibility and unused capacity. The second approach involves the use of several computers which are tied together with a communications system. Integration is achieved by use of a common random-access file, and all records that are affected by a particular type of transaction, regardless of their functional location, are updated by one input of the data through the system.

An Integrated Analysis and Planning System, W. O. Reuther, *The Federal Accountant*, **10**, 96-108 (December, 1960).

The use of electronic equipment for handling large volumes of data in the recording and reporting function is well established. The use of computers, however, in some of the broader management functions, particularly in planning through simulation and model making, is still relatively undeveloped. If management is to develop into its full potential, the total administrative function must be integrated into a single autonomous system. Computers provide a means for accomplishing this. An integrated data processing system can

remove duplication, permit any desired correlation of data, and test alternatives through the use of models.

Irreversible Processes in Isolated Systems, E. N. Adams, *The Physical Review*, **120**, No. 3, 675-681 (November 1, 1960).

The point of view is taken that the irreversibility paradox of Loschmitt and Zermelo arises because there are two valid transport equations, one causal, the other anticausal, each consistent with the fundamental equations of mechanics. From this point of view the problem of irreversibility is to characterize a given nonequilibrium distribution as to which transport equation it will obey. Using the transport theories of Kohn and Luttinger and of Van Hove, we obtain a statistical criterion capable of so characterizing distribution functions of both stationary and time-varying types. We discuss the question of how experimental procedures consistently bring about a situation to which the causal transport equation applies; we answer the question for a very simple kind of experimental situation.

Isobaric Dissociation Studies of Alkali Metal Carbonate Hydrates Using Simultaneous Differential Thermal Analysis-Thermogravimetric Analysis, A. Reisman, *Analytical Chemistry*, **32**, 1566-1574 (November, 1960).

Superficial similarities between the differential thermal analysis and thermogravimetric analysis graphs of copper sulfate pentahydrate and those given by carbonate hydrates are attributable to phenomena other than solid-vapor dissociative processes. Based on thermal and x-ray results, the carbonate hydrates were assigned formula weights of $2\text{Cs}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$, $4\text{Rb}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$, and $5\text{K}_2\text{CO}_3 \cdot 8\text{H}_2\text{O}$, the latter being in disagreement with the commonly accepted value of $2\text{K}_2\text{CO}_3 \cdot 3\text{H}_2\text{O}$. Equipment is described which enables the simultaneous study of the mass and thermal characteristics of a single sample at constant pressure. In addition, a high gain differential thermal analysis unit capable of operation between -190° and 400°C under controlled or equilibrium pressures is discussed.

Kinetics of Magnetic Annealing in Cobalt-Substituted Magnetite, W. Palmer, *The Physical Review*, **120**, No. 2, 342-352 (October 15, 1960).

The time dependence of the magnetic annealing effect in single crystals of magnetite containing various amounts of substituted cobalt has been investigated by a technique which permits observation of the effect at the annealing temperature. The annealing kinetics in a particular crystallographic direction are determined by measuring the decay of the torque in the (001) plane following a preparatory anneal in a direction 45° removed. The annealing kinetics observed in the [100] and [110] directions are different, and the nature of torque decay in both directions depends upon the cobalt concentration of the sample. The torque decay in the [100] direction is attributed to the redistribution of single cobalt ions and certain pairs of adjacent cobalt ions over the octahedral cation sites, whereas the decay in the [110] direction is attributed to the redistribution of cobalt ion pairs only. The results of a theoretical analysis of the annealing kinetics that would result from such ionic redistribution are in good agreement with the experimental observations. Comparison of the annealing behavior of samples in different states of oxidation indicates that ionic redistribution occurs by a vacancy diffusion mechanism, and the activation energy observed for this process is 1.05 ± 0.03 ev.

Low-Temperature Transport in "Split p-Germanium," S. H. Koenig and J. J. Hall, *Physical Review Letters*, **5**, 550-553 (December 15, 1960).

By measuring conductivity and Hall mobility of p-Ge at low temperature under large strains ($>10^{-3}$), we have been able to determine the sign, the ratio, and the approximate magnitude of the two deformation potentials that describe the change, under shear, of the valence band.

Lumped-Model Analysis of Space-Charge Widening, J. F. Gibbons* and D. A. Linden, *Proceedings of the IRE*, **43**, No. 11, 1920 (November, 1960).

Lumped models of transistors and diodes have been shown to contribute considerable insight and analytical simplification in the solution of a wide range of problems occurring in the applications of these devices. The lumped-model approach is extended to include the effects of space-charge layer widening.

*Stanford Electronics Labs., Stanford University.

Magnetic Resonance Determination of the Nuclear Moment of Tantalum-181 in KTaO_3 ,* L. H. Bennett† and J. I. Budnick, *The Physical Review*, **120**, No. 5, 1812-1815 (December 1, 1960).

The nuclear magnetic moment of Ta^{181} is found from the nuclear magnetic resonance of Ta^{181} in KTaO_3 . The uncorrected value of the moment is 2.340 ± 0.001 nm. Consideration of diamagnetic shielding effects and a possible second order paramagnetic correction leads to the estimated value of $\mu = 2.35 \pm 0.001$ nm.

*Supported in part by the Department of Defense.

†National Bureau of Standards, Washington, D. C.

Martingales in a σ -Finite Measure Space Indexed by Directed Sets, Y. S. Chow, *Transactions of the American Mathematical Society*, **97**, 254-285 (November, 1960).

Let (Ω, B, μ) be a σ -finite measure space and (x_h, B_h, H) a martingale where H is a directed set and B_h is a σ -algebra of measurable sets such that B_h, CB_h for $h^1 < h$ and x_h is B_h -measurable. If for every set $A \in B_h$ of finite measure, $\sup \int_A \lim |x_h| d\mu < \infty$, $h \in H$, then $\lim x_h$ exists a.e. and $\int_A \lim |x_h| d\mu < \infty$, provided that a certain Vitali-type condition is satisfied. Krickeberg (*Trans. Amer. Math. Soc.*, **83**, 337 (1956)) has obtained a similar result under the condition that there exists a countable cofinal subset of H . An application of this theorem is a new proof of the Lebesgue differentiation theorem of an interval function of bounded variation (Saks, *Theory of the Integral*, p. 115). By using a semi-martingale analogue of a lemma in Saks (ibid, p. 135), a convergence theorem is obtained: Let $(x_n, B_n, n \geq v)$ be a semi-martingale where B_n is generated by disjoint atoms I_i^j , $i=1, 2, \dots$ of finite positive measure and $\inf [\mu(I_{n+1}^j)/\mu(I_n^j)] > 0$, where $i, j, n \geq 1$ and $I_j^{n+1} \subset I_i^n$. Then $\lim x_n$ exists and is finite a.e. where $\lim \sup x_n < \infty$.

Maximum Density Interconnections for Microminiaturized Circuitry, R. G. Counihan, *Proceedings of the 1960 National Electronics Conference*, **16**, 199-205 (October 12, 1960).

Some of the problems and approaches in fabricating extremely dense interconnection networks are discussed. These include techniques for the multilayer vacuum deposition of

conducting paths between miniaturized elements. The advantages of these techniques are that first level interconnections between circuits can be made with films as thin as one micron insulated by non-conducting films of the same order of thickness. Multiple levels of conducting paths are possible, all of which, with their associated insulators, can be deposited in a single pump-down of a vacuum system. In addition, this technique is directly compatible with the vacuum deposition of components. Key problem areas noted are vacuum technology, mask precision and registration, integrity of the insulating film, and topological considerations.

A Measure of Man-Machine Coupling, E. T. Klemmer, *IRE Transactions on Human Factors in Electronics*, **HFE-1**, 72-73 (September, 1960).*

In order to predict human operator performance in a new situation, we need some knowledge of the general factors which affect operator performance. These factors must be identifiable and measurable in many situations so that rules relating them to operator performance (and to each other) can be specified. Four such general factors are proposed: Time, Information, Compatibility, Coordinability or logon content. The last factor, which relates to the complexity of the input and output and the number of dimensions used in the coding, deserves more attention from psychologists and human engineers.

*For period July 1 through September 30, 1960.

Measurements of the Dielectric Constant of BaTiO₃ Single Crystals in the Paraelectric Region at X Band, A. Lurio and E. Stern, *Journal of Applied Physics*, **31**, No. 10, 1805-1809 (October, 1960).

The dielectric constant and loss tangent of single crystals of BaTiO₃ were measured as a function of temperature in the frequency range of 8.2 to 12.4 kMc. The technique consisted of looking for transmission resonances through the crystal whenever its thickness became $\lambda/2$ (where λ is the wavelength in the material). From the Curie-Weiss behavior of the dielectric constant in the paraelectric region, the A constant was determined to be $3.77 \times 10^{-5} \text{ } ^\circ\text{C}^{-1}$.

The Mechanical Design of a Mobile Electronic Data Processing System, W. M. Young and G. O. Boehm, *Electrical Design News*, **5**, No. 10, S-18 and S-19 (October, 1960).

In the mechanical design of an electronic data processing system using pulse magnetic circuitry for mobile use, many challenging problems are encountered. The major requirements are: ruggedness, light weight, wide temperature extremes, high humidity, and modularity of design. A few of the problem areas were: high density packaging, temperature control within circuit and component limits, and designing equipments so that servicing and maintenance can be accomplished from the front of the machine.

A Method for Computing Maximum Flows Through a Communication Net, R. T. Chien, *IRE Transactions of The Sixth National Communications Symposium*, pp. 282-285 (October, 1960).

This paper considers the computation of maximum flows of information through a communication net. A new procedure is outlined which gives the amount of maximum flow between every pair of terminals of the network.

Some graph-theoretic results are obtained concerning the

cut-sets of the graph. As a result of this, the computational labor involved is reduced by fifty percent. These results, along with the max-flow min-cut theorem, makes this simple procedure effective and feasible.

It is also shown that this method is particularly suited to the use of digital computers.

A Method for Overlapping and Erasure of Lists, G. E. Collins, *Communications of the ACM*, **3**, 655-657 (December, 1960).

An important property of the Newell-Shaw-Simon scheme for computer storage of lists is that data having multiple occurrences need not be stored at more than one place in the computer. That is, lists may be "overlapped." Unfortunately, overlapping poses a problem for subsequent erasure. Given a list that is no longer needed, it is desired to erase just those parts that do not overlap other lists. In LISP, McCarthy employs an elegant but inefficient solution to the problem. The present paper describes a general method which enables efficient erasure. The method employs interspersed reference counts to describe the extent of the overlapping.

Microminiaturization Utilizing Thin Film Technology, W. N. Carroll and F. F. Jenny, *Proceedings of Northeast Electronics Research and Engineering Meeting*, Boston, Massachusetts, pp. 12-13 (November 15-17, 1960).

This paper describes the progress made in "microminiaturizing" electronic functions by the use of evaporated thin films in a three-dimensional or multi-layered structure. Performance data of operating circuits, together with an outline of fabrication techniques are discussed.

Nomogram for Voltage Dividers, M. E. Arthur, *Electrical Design News*, **5**, No. 11, p. 72 (November, 1960).

This nomogram solves the equation $E_{out} = \frac{E_1 R_2 + E_2 R_1}{R_1 + R_2}$

when E_1 , E_2 , R_1 , and R_2 are known. Additional usefulness is shown.

Nuclear Magnetic Resonance in Tantalum Metal,* J. I. Budnick† and L. H. Bennett,‡ *Journal of Physics and Chemistry of Solids*, **16**, 37-38 (November, 1960).

The nuclear magnetic resonance of Ta¹⁸¹ has been observed in tantalum metal. The sample was a stack of high purity foil which was degassed and annealed. No resonance was observed in tantalum metal powder.

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†Now at Watson Research Laboratory.

‡National Bureau of Standards, Washington, D. C.

Operation and Analysis of Planar Cryotrons and Simple Cryotron Circuits, G. B. Rosenberger, *Proceedings—Symposium on Superconductive Techniques for Computing Systems*, pp. 374-395 (May 17-19, 1960).*

Simple cryogenic loops containing two drive cryotrons and a number of sensing cryotrons have been constructed. It is possible with such loops to study both the operating characteristics of the individual cryotrons as well as the static and dynamic switching characteristics of the loop. Some of the characteristics of the individual cryotrons and the reproducibility of cryotrons with these characteristics are discussed. The speed with which current can be transferred from one branch of the loop to another has been both measured ex-

perimentally and calculated theoretically from the dimensions and various measured parameters of the loop and its cryotrons. There is found to be good agreement between theory and experiment. The loops have been run dynamically in an effort to detect thermal effects associated with heat dissipation in the resistive cryotron elements. The upper limit to the dynamic operation is currently set by the viewing equipment, and, to date, no adverse heating effects have been observed.

*For period April 1 through June 30, 1960.

Origin of Magnetoelastic Effects in Cobalt-Iron Ferrite, J. C. Slonczewski, *Journal of Physics and Chemistry of Solids*, **15**, 335-353 (October, 1960).

The dependence of magnetostrictive strain and elastic coefficients on temperature and orientation of spontaneous magnetization is calculated for the special case of a cubic crystal containing an orbitally degenerate transition ion in a trigonal crystal field. The functional dependence of strain on orientation has a special form which cannot be expressed by means of standard phenomenological formulas. The strain is an order of magnitude larger than that which Tsuya calculated for certain ferrites not involving orbital degeneracy. The temperature dependence of strain agrees partially with measurements in cobalt-iron ferrite. By fitting theory to experiment a trigonal-field splitting of about 1600 cm^{-1} for the ground state of the cobalt ion is inferred.

An orbitally degenerate transition ion should have a large electrical polarizability because its first excited state is separated from the ground state by only spin-orbit energy. This polarizability is shown to give rise to elastic energy which depends on orientation of magnetization. This energy should be appreciable in cobalt-iron ferrite.

Post-Stimulus Cuing in Immediate Memory, N. S. Anderson, *Journal of Experimental Psychology*, **60**, 216-221 (October, 1960).

The post-stimulus cuing technique for sampling perception has been used effectively for separating perceptual and response processes. The present study extends this method to a short-term memory task to develop some interesting suggestions about short-time human information storage.

Probabilistic Model of System Operation with a Varying Degree of Spares and Service Facilities, K. G. Ashar, *Journal of the Operations Research Society of America*, **8**, No. 5, 707-718 (October, 1960).

The techniques for evaluating the probabilistic properties of systems having identical operational and spare units with different facilities for repairs are discussed in this paper. The important properties studied are:

- a) Reliability and transient behavior of systems.
- b) The expected values of times to failures and the measure of variations from the distributions of system failures.
- c) Asymptotic or steady state probability of such a system being in unavailable state.

The general expressions are obtained for many cases, while the methods are illustrated by a simple practical example.

Prompt Critical Assembly Gamma Ray Sources, C. S. Shapiro, *Nuclear Science and Engineering*, **8**, No. 6, 515-517 (December, 1960).

The method of obtaining the gamma dose rate during a prompt critical burst from the "Godiva" reactor is presented.

In this measurement, the fission product gamma ray contribution to the total gamma ray dose must be determined. The determination of this quality is described along with the results. Conclusions are drawn as to the relative contributions to the total dose from prompt, capture, and inelastic collision gamma ray sources.

Proton Spin Coupling by Pi Electrons,* M. Karplus, *Journal of Chemical Physics*, **33**, 1842-1849 (December, 1960).

A theoretical formulation is developed for the pi-electron contribution, $A_{HH'}(\pi)$, to the spin coupling between pairs of protons in hydrocarbon molecules. By means of the correspondence between the $\sigma-\pi$ interaction in unsaturated molecules and related free radicals, the proton spin coupling is expressed in terms of hyperfine constants and triplet state energies. With known values for these quantities, $A_{HH'}(\pi)$ is found to be in agreement with experimental measurements available for molecules in which the pi-electrons are expected to dominate the coupling. Of particular interest are the large couplings (1.3-8 cps) calculated for certain systems with protons separated by three or four carbon atoms. Also, absolute signs are predicted by the theory, with $A_{HH'}(\pi)$ equal to -6.7 cps for allene and $+7.8$ cps for butatriene.

*Work done at Noyes Chemical Laboratory, University of Illinois.

Die Quasi-Logarithmischen Eigenschaften des Restklassensystems (The Quasi-Logarithmic Properties of the System of Residual Classes), W. Hoffmann and H. E. Müller, *Zeitschrift für Angewandte Mathematik und Mechanik (ZAMM)*, **40**, Special Issue GAMM — Meeting, Freiberg/Sa. Germany, T61-T64 (November, 1960).

In the computers constructed today, the numbers to be computed are presented exclusively in a polyadic number system (binary or decimal coding). However, because of several notable properties, the proposed number representation in the System of Residual Classes (SRC) by M. Valach and A. Svoboda, Prague, deserves the attention of mathematicians or engineers concerned with computer system design. The System of Residual Classes which per se is known from the number theory, is based on the properties of the linear congruences. The fact of carry-free SRC-arithmetic is derived therefrom. The quasi-log-arithmetic properties of the SRC based on the index calculus renders possible the reduction of higher degree arithmetic operations to simple digital adding operations. By making use of the concept of the indices, the advantages of the logarithmic computations are for the very first time introduced into the field of mechanized digital computing.

Range Safety System of the Atlantic Missile Range, H. Carroll, *Missile Design and Development*, pp. 42, 43, 89-93 (October, 1960).

With missiles being launched almost daily at Cape Canaveral, it is necessary to maintain extreme range safety measures. The latest sensing devices are used to physically track the missiles. An IBM 709 at Cape Canaveral refines tracking data in real time, making it possible to destroy a missile harmlessly, if necessary. The tracking net covers the complete down-range area.

Reducing Item Variety, Parts I and II, J. J. O'Farrell, Jr., *The Magazine of Standards*, Part I, **31**, 304-307 (October, 1960), Part II, **31**, 337-340 (November, 1960).

This paper, published in two parts, presents an argument for a company-wide program of standardization using competi-

tion and the profit motive as the incentives to development and use of company standards.

Some Optical Properties of CdSe Single Crystals, S. P. Keller and G. D. Pettit, *The Physical Review*, **120**, No. 6, 1974-1977 (December 15, 1960).

Optical transmission and reflection measurements were made on a single crystal of CdSe (crystal class C_{6v}) with light polarized parallel and perpendicular to the c axis. The absorption coefficients, $\mu_{\perp}$ and $\mu_{\parallel}$, were determined and are presented as functions of incident photon energy, at room temperature. The selection rule, $\mu_{\perp} > \mu_{\parallel}$, expected for all solids in the crystal classes C_{nv} and $\bar{C}_{nv}$, where $n=3, 4$, or 6 , is very well obeyed in CdSe. The absorption coefficients are not simple functions of the photon energy, but are nearly exponential and almost follow Urbach's rule.

The fluorescence of the single crystal has been measured at 77°K. It is peaked at 920 m μ and it is slightly polarized perpendicular to the c axis. The results are similar to what has been obtained for hexagonal ZnS.

Some Uses of the Distribution of the Largest Root in Multivariate Analysis,* D. L. Heck, *The Annals of Mathematical Statistics*, **31**, No. 3, 625-642 (September, 1960).**

There has been only limited application of the distribution of characteristic roots for testing purposes and construction of confidence intervals in multivariate analysis, largely because a comprehensive set of tables and easy instructions were not available. The present report is a partial attempt to fill this gap.

In this paper, testing procedures for three tests in multivariate analysis are given, and for two of the test situations which require the distribution of the largest characteristic root, numerical examples are worked out. Charts of the upper 1%, 2.5%, and 5% points of this distribution for the degrees of freedom $s=2(1)5$, $m=-\frac{1}{2}$, $0(1)10$, and $5 \leq n \leq 1000$ are included, as well as a procedure for obtaining the points for $n > 1000$. The method used in computing the percentage points is also described. Multivariate confidence bounds which may be set up using these percentage points were not considered in this study.

*This paper was prepared with the support of the United States Air Force through the Air Force Office of Scientific Research of the Air Research and Development Command.

**For period July 1 through September 30, 1960.

Space Technology: Reporting the New Dimension, R. E. Hohmann, *IRE Transactions on Engineering Writing and Speech*, **3**, No. 1, 7-15 (April, 1960).

Certain problems of technical writing have persisted throughout the entire development of science and engineering during the past 150 years. This paper describes the classic approach to effective report writing as used by the early scientists who laid the groundwork for our present space studies. Their techniques are recommended for use in scientific reporting in the space age.

*For period April 1 through June 30, 1960.

Steady Performance Characteristics of Gas-Lubricated Journal Bearings with Slenderness Ratio $L/D=\pi$, W. A. Gross, *Journal of the Aerospace Sciences*, **27**, No. 11, 869-870 (November, 1960).

Elrod and Burgdorfer recently published performance characteristics of infinitely long gas-lubricated journal bearings. These results, together with the approximate side-flow factors given by Ausman, yield fairly good predictions for the behavior of finite gas-lubricated bearings. Load, friction, and attitude angle results are given for gas journal-bearing films which have slenderness ratio (length/diameter) $L/D = \pi$.

Steady-State Distribution Function in Dilute Electron Gases, D. C. Mattis, *The Physical Review*, **120**, No. 1, 52-57 (October 1, 1960).

It is usually assumed that optically-created carriers in a photoconductor rapidly thermalize to a Boltzmann distribution, regardless of the generation and recombination mechanisms. However, it can be shown that this distribution which is characteristic of thermodynamic equilibrium is incompatible with the requirements of steady state. A variational principle is introduced to find the steady-state distribution, which is found to approach the Maxwell-Boltzmann function in the limit of strong thermal scattering. Interband scattering is found to be potentially a strong thermalizing influence, in addition to the intraband scattering usually considered. For a simple model semiconductor, significant deviations from the Boltzmann distribution are found to be possible at temperatures below a few degrees Kelvin. This result is then discussed in connection with certain experiments on germanium.

Stimulated Infrared Emission of Trivalent Uranium, P. P. Sorokin and M. J. Stevenson, *Physical Review Letters*, **5**, 557-559 (December 15, 1960).

A solid state optical maser at 2.5 microns using a new material, trivalent uranium in calcium fluoride, is described in detail. The energy level structure of trivalent uranium permits a much lower pumping threshold for oscillation than in the case of the ruby optical maser.

STRETCH — eine neue Entwicklungsstufe der Datenverarbeitungsmaschinen (STRETCH — A New Stage of Development in Data Processing), A. P. Speiser, *Neue Zürcher Zeitung*, Beilage Technik, Nr. 3584, 3-7 (October 19, 1960).

STRETCH is the largest and most powerful data processing system in operation and has recently been completed. Its speed surpasses that of the previous generation of machines by a factor of almost 100. This has been achieved in part by the use of novel, high-speed transistor circuits, and in part by a high degree of parallelism throughout the system.

Synthesis of Active Networks with One Negative Impedance Converter, R. T. Chien, *Proceedings of the 1960 National Electronics Conference*, **16**, 405-411 (October 12, 1960).

The Linvill configuration is used to synthesize second-order, non-positive-real, driving-point functions. Synthesis is accomplished by the use of a surplus factor. With the arbitrariness of the surplus factor, one is able to control the driving-point function. The existence of the solution in all cases is demonstrated and the minimum number of elements property of the solution is proved. It is shown that only five elements are required besides the NIC. RC networks are used in some cases and RL networks are used in the remaining cases.

The method used is extended to realize all three functions.

Necessary and sufficient conditions are found for three functions to be a realizable set. The synthesis itself is carried out in the same manner as in the previous case.

Synthesizing Minimal Stroke and Dagger Functions, J. Earle, *IRE Transactions on Circuit Theory*, Special Supplement, CT-7, 144-154 (August, 1960).*

The techniques of the functions tables, theorems of Boolean algebra, and Karnaugh maps are extended to provide synthesizing and minimizing methods for the stroke and dagger functions. The transformations among these and more familiar functions are described. These methods are applicable to NOR and all AND-Inverter, OR-Inverter type circuits performing these functions.

*For period July 1 through September 30, 1960.

Thermal Conductivity of Pure Indium,* R. E. Jones and A. M. Toxen, *The Physical Review*, 120, No. 4, 1167-1170 (November 15, 1960).

The thermal conductivity of a pure indium specimen was measured in the normal and superconducting states in the range of temperatures 1.3-4.2°K. In the normal state the specimen showed sizable magnetothermal resistivity effects which were not in agreement with Kohler's rule for thermal conductivity. Near the transition temperature the ratio of conductivities K_s/K_n exhibited the finite slope with temperature characteristic of electronic conduction limited by phonon scattering. The results were compared with a simple model proposed by Kadanoff and Martin and the agreement was found to be good.

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

Toroidal Energy Surfaces in Crystals with Wurtzite Symmetry, R. C. Casella, *Physical Review Letters*, 5, 371-373 (October 15, 1960).

A group-theoretical study of the one-electron energy vs. wave vector dispersion relation demonstrates the possibility of toroidal energy surfaces in crystals having wurtzite symmetry. The consequence of this dispersion relation on the density-of-states, cyclotron frequency, zero-field conductivity tensor, and the Hall effect is derived. It is found that the Hall effect should be highly anisotropic at low temperatures.

Ultra-Precision Magnetic Field Control for High Power Magnets, A. M. Patlach, *Electronics*, 33, 66-69 (November, 1960).

Excitation of 50-kw electromagnet is held constant by double loop, high-gain DC regulator. Absolute field control is provided by using signal derived from proton resonance. A short discussion of proton resonance is included.

Ummagnetisierungsvorgänge in dünnen Ferromagnetischen Ni-Fe-Schichten (Reversal Phenomena in Thin Ferromagnetic Ni-Fe Films), S. Middelhoeck, *Helvetica Physica Acta*, XXXIII, No. 6/7, 519-524 (October 1, 1960).

In contradiction with theory, irreversible magnetization processes in the hard direction occur. It is assumed that the domain walls which appear when the films are reversed in the hard direction are the cause. Some experiments are described which confirm this assumption.

Use of a Digital/Analog Arithmetic Unit within a Digital Computer, Donald Wortzman, *Proceedings of the Eastern Joint Computer Conference*, Sec. 6.2, 269-282 (December 13-15, 1960).

A novel approach to arithmetic operations in digital computers is described which combines digital and analog techniques. This is accomplished by using parallel-serial interconnections of digital/analog converters. The interconnections are under stored program control and are effected by selecting multiplexers which route the analog signals to perform various arithmetic operations. The final analog signal, which is the result of the computation, is converted to digital form by means of an analog/digital converter.

Because of the extreme parallel nature of D/A arithmetic, high computational speeds are attained, although all the circuitry is operating slowly by present digital computer standards. Using present techniques the analog nature of the computation limits the accuracy to four or five significant decimal figures. Therefore, the D/A arithmetic unit could not replace the arithmetic unit presently in digital computers, but could be used to solve problems or parts of problems that do not require extreme accuracy.

Vergleich hydraulischer digitaler Schaltelemente mit elektronischen und elektromechanischen "Äquivalenten" (Comparison Between Hydraulic Logic Elements and Their Electronic and Electromechanical Counterparts) H. H. Glättli and H. R. Müller, *Zeitschrift für angewandte Mathematik und Physik (ZAMP)*, XI, No. 6, 535-536 (November 25, 1960).

Differences in logic behaviour and response time are discussed. A valve stands logically between a transistor and a simple relay. Its response time is of the same order of magnitude as that of relays. Branching prolongs the response time proportional to $\sqrt{n}$, where n is the number of driven elements.

Die Verknüpfungsaufgabe in Einem aus dünnen Magnetschichten Bestehenden Schaltkreis-system (Switching Circuits of Thin Magnetic Films for Logical Operations), H. J. Oguey, *SEV-Bulletin*, 51, Jg. No. 20, 1004-1010 (October 8, 1960).

Thin magnetic films of the permalloy type have two important characteristics which make them attractive for computer applications:

1. A uniaxial anisotropy leading to a bistable element.
2. Fast switching of a whole magnetic domain by coherent rotation of the magnetization.

This article describes a system in which the positive or negative direction of the magnetic flux in a thin film is used as a memory for binary coded information. Information transfer between two or more films is by coupling strip lines. It is shown how logical functions can be performed by shift registers and other circuits. No intermediate amplifiers are needed. In spite of the simplicity of the proposed system, switching frequencies of about 20 Mc/s are expected.

What You Should Know About Systems Engineering, R. E. Merwin, *Product Engineering*, 31, No. 47, 62-65 (November 14, 1960).

A careful, closer look at systems engineering, that specialized new approach to cumbersome problems encountered in large networks of equipment, is presented in this article. It defines a system, the role of the systems engineer, and the new mathematical tools he needs to perform. Systems components and the systems approach to design are covered.