Technical Papers by IBM Authors Published Recently in Other Journals

Alfvén Waves in Bismuth: Charge-Carrier Mass Densities and Relaxation Times, D. S. McLachlan, *Physical Review* **147,** No. 1, 368 (July 8, 1966).

Alfvén waves in bismuth have been studied in the frequency range 300 to 2000 Mc/sec, for propagation along the magnetic field. All the measurements were done on the same single crystal, and it was found that at the higher frequencies the real part of the dielectric constant is greater than the imaginary and that at lower frequencies the reverse is the case. This frequency dependence had a marked effect on the real part of the refractive index of the medium, which allowed one to measure, in addition to the usual charge-carrier mass density, some mean relaxation time of the charge carriers. The mass densities are in reasonable agreement with theory when the effective masses of the holes and electrons for bismuth from some previous experimental results are used, though there are some inconsistencies, which are discussed. A detailed analysis of the relaxation times proved impractical, but the magnitudes of the values agree well with other experimental results. The effect of Shubnikov-de Haas oscillations on the transmission was also studied.

All Digital Simulation of Saturn I, IB and V Boost Vehicle and Guidance and Control Systems, W. D. Carson, R. E. Poupard, T. D. Steele and F. W. Eubank, *Supplement to IEEE Transactions on Aerospace and Electronic Systems* **AES-2,** No. 4, 809-819 (July, 1966).

In Saturn I flights an all-digital simulation was used in preflight verification of the onboard computer's flight program, and in postflight evaluation to investigate any unpredicted inflight behavior. An equivalent simulator is being used for the Uprated Saturn I and V vehicles. Saturn IB and V simulators are more complex and are being applied more extensively to the design and checkout of the onboard computer's flight program.

This paper traces the early development of the Saturn I simulator and subsequent verification of its math models during the SA-6 flight. A description is given of the simulator's construction and the problems presented in the development of such a simulator, with special attention given to the problem of simulating the flight computer.

An Analytical Study of the Impulsive Approximation, H. M. Robbins, *AIAA Journal* **4,** No. 8, 1417-1423 (August, 1966).

Trajectory analyses for space missions are often based on an impulsive approximation, in which finite-thrust powered phases of finite duration are replaced by instantaneous changes of velocity. An analytical investigation of the impulsive trajectory has been carried out, by use of perturbation methods which enable an optimal impulsive trajectory to be compared with corresponding finite-thrust trajectories for the same mission. The analysis is limited to in-space maneuvers (orbit transfers).

An Annotated Descriptor Based Bibliography of the Use of Computers for Non-Numerical Mathematics, J. E. Sammet, *Computing Reviews* **7,** No. 4, B1-B31 (July-August, 1966).

This bibliography contains about 300 items related to the use of computers for non-numerical mathematics. This includes the fields of (1) theorem proving; (2) "pure" mathematics; (3) formula manipulation; and (4) tools for items 1 to 3. Each article has a complete citation, and has been given an annotation and a set of descriptors. Computer listings, sorted by code number, descriptor, author, and date, are included. The introductory section contains a list of system names with a one-sentence description of each.

Anomalous Magnetizations in the Yttrium Gallium Iron Garnet System and the Exchange Constant of Yttrium Iron Garnet, B. Lüthi,* *Physical Review* **148,** No. 2, 519-521 (August 12, 1966).

Magnetization curves for the yttrium gallium iron garnet system $Y_3Ga_xFe_{5-x}O_{12}$ in the region $x = 1.3$ to 1.5 are presented. These show anomalous temperature dependences. They are very similar in character to those anticipated by Néel and found for some spinel ferrites by Gorter. The molecular field theory is applied to these curves using an appropriate set of exchange constants. The best fit is achieved using rather small values for J_{aa} and J_{dd}. This is in good agreement with the most reliable determination of these constants for yttrium iron garnet and with the current belief that these constants should indeed be small.

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The Application of a Few Hyperplane Decision Techniques to Handprinted Character Recognition, D. D. Johnson, C. F. Haugh and K. P. Li, *Proceedings of the National Electronics Conference* **22,** 869-873 (1966).

Because of cost, size, and speed limitations, it is often impractical to use as many as n hyperplanes to separate n distinct classes. The restriction to m hyperplanes ($m \leq n$) influences the design of output codes and training algorithms. This paper reports on the use of ten hyperplanes for the classification of ten handprinted digits, twenty-six handprinted block alphabetics, and thirty-six handprinted alphanumerics. The data gathering system, which obtains no sequential information from the pattern, and a set of loose constraints on character formation are described briefly. Results obtained using various training algorithms, output codes, and recognition techniques are compared and analyzed. All results were obtained by computer simulation. Inferences for future development work are drawn and discussed.

Artificial Satellite Orbit Computations, P. Sconzo, *Proceedings of the International Astronomical Union, Symposium No. 25, The Theory of Orbits in the Solar System and in Stellar Systems,* pp. 363-371 (1966).

In this paper an orbit computation program for artificial satellites is presented. This program is operational and it has already been used to compute the orbits of several satellites. After an introductory discussion on the subject of artificial satellite orbit computations, the features of this program are thoroughly explained. In order to achieve the representation of the orbital elements over short intervals of time a drag-free perturbation theory coupled with a differential correction procedure is used, while the long range behavior is obtained empirically. The empirical treatment of the non-gravitational effects upon the satellite motion seems to be very satisfactory. Numerical analysis procedures supporting this treatment and experience gained in using our program are also objects of discussion.

Automated Facilities Layout Programs, J. M. Seehof, W. O. Evans, J. W. Friederichs and J. J. Quigley, *Proceedings of the ACM 21st National Convention,* pp. 191-199 (1966).

This IBM 7090/1401 commercial plotter computer program optimizes organizational positioning (layout) based on (1) a preference table indicating organizational placement desires, (2) preselected mandatory positioning for areas such as elevators, (3) square footage per organizational unit. The organizational unit is not restricted and may be a department, machining area, chemical lab, person, pieces of equipment, etc. Results are produced in graphical form for the designer. The program can be used for layouts of a manaufacturing floor, for floor plans, office space within a department, school buildings, playgrounds, cities, lunar bases, etc., with the preference table and scoring table set up to reflect a given application.

Cameras Make It Go Purr Instead of Going Thwack, R. H. Peterson, *PMI—Photo Methods For Industry* **9,** No. 9, 38-40 (September, 1966).

Oscilloscopes are teamed with high-speed cameras to locate the sources of noise in document-handling machines. With this technique, the exact time, magnitude, and location of each noise is recorded. Once the locations of noise are pinpointed, standard noise control technology can be applied.

A Closed-Tube Technique for Diffusing Impurities into Silicon, W. J. Armstrong and M. C. Duffy, *Electrochemical Technology* **4,** No. 9-10, 475-478 (September/October, 1966).

A sealed-tube technique for the diffusion of B, P, As, Ga, and Sb into silicon with excellent uniformity and reproducibility is described. The method is usable over wide temperature and concentration ranges and results in clean, glass-free surfaces. A transport mechanism for movement of the impurities from the source to the silicon is proposed.

Complex Spatial Filtering with Binary Masks, B. R. Brown* and A. W. Lohmann, *Applied Optics* **5,** No. 6, 967-969 (June, 1966).

Usually a hologram is produced by means of an interference experiment. Here, however, we let a computer-guided plotter draw the hologram. The plot, which has to be minified and recorded on film, contains no grey, only binary transmittance values. Our binary holograms yield reconstructed images of a quality equal to that of images obtained from usual holograms of comparable dimensions. When a Fourier hologram is inserted into the Fraunhofer plane of a coherent image forming system, it acts as a special type of a spatial filter, a so-called optical matched filter. Our binary matched filter is suitable for optical character recognition, the same as the usual optical matched filter introduced by Vander Lugt.

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Computer-Aided Design of Two Servosystems, D. B. Gasich, *Proceedings of the Western Electronic Show and Convention (WESCON),* pp. 1/3/1-10 (1966).

Servosystems as a subset of control systems is a familiar subject in electrical engineering. The theory derived for linear systems is well understood and could be simulated or mechanized on the digital computer. Control of nonlinear systems on the other hand, has limited theoretical support; consequently, the design must be supported by simulation of the system's dynamics. Aside from the analysis of the system's dynamic characteristics, there are statistical problems, problems of simple but lengthy data digestion, and plotting, all of which can be readily handled on the computer. By using the digital computer, significant time and monetary savings can be realized. This was made apparent in the development of two data files, the single-disk storage for the IBM Model 44 System and the IBM 2321 strip file.

A Computer-Aided Method for Checking and Making Monolithic Integrated Circuit Masks, D. M. Sheppard, W. T. James, M. E. Harris, and A. M. Barone, *Proceedings of the Western Electronic Show and Convention (WESCON),* pp. 1/4/1-7 (1966).

Integrated circuit designers are now confronted with the same type of problems in implementing logic into monolithic chips that card and module designers have had in the past. These problems can be generally categorized as: developing an efficient layout procedure, checking the logic against the layout and converting the layout diagram into master artwork for etching or screening.

This paper presents some techniques that have been developed to aid the chip designer in solving these problems. The underlying basis for all the steps used was to allow the device engineer to do only what he could do best and to replace the tedious, repetitive steps with computer routines. The foundation for this method is the "master slice" concept of device fabrication. In addition to producing the artwork for the master slice, the program checks, widens, and fabricates the "personality" masks required for interconnecting the master slice components into useful circuits and logic blocks. The use of a numerically controlled pattern generator to fabricate the master chip artwork was used in conjunction with some novel computer techniques for creating the input tape from a minimum of designer data. The use of a display console in creating and modifying layouts was analyzed as an alternate input medium.

Computer Control of a Kraft Paper Machine, A. Ekström and G. Sangregorio, *Proceedings of the Paper, Rubber and Plastics Automation Congress,* Antwerp, C8-1-C8-11 (1966).

At the Billerud paper mill at Gruvön, Sweden, an IBM process control computer is used for an integrated system with several functions including closed-loop process control, quality control and production supervising of a large kraft-paper machine. Production planning for the whole paper mill is also included. This paper presents first a summary description of the integrated system and its objectives, and then deals in more detail with the closed-loop control of the paper machine.

Computer Determination of Sidebands in Frequency Modulation with Complex Periodic Modulation Functions, G. N. Miller, J. L. Conley and G. M. Engel, *Supplement to IEEE Transactions on Aerospace and Electronic Systems* **AES-2,** No. 4, 469-481 (July, 1966).

Manual methods are not practical for accurately determining the sideband properties of a frequency-modulated system involving complex modulation functions. A technique, utilizing an IBM 7094 Data Processing System, accomplishes the solution with accuracy to four decimal places for an unmodulated carrier amplitude of one. This technique was programmed in FORTRAN IV language.

Practical applications of the method, in conjunction with PREDICT (an IBM automated transient circuit analysis program), are demonstrated as applied to premodulation filtering techniques in pulse-code modulation systems, utilizing periodic modulation functions of any complexity. These two systems allow the evaluation of premodulation filter designs using the criteria of time-domain and frequency-domain responses. Analysis results of various premodulation filters, along with their measured responses, are presented.

A Computerized Radioisotope-Scan-Data Filter Based on a System Response to a Point Source, D. W. Chaapel, A. C. Sprau, and W. N. Tauxe,* *Mayo Clinic Proceedings* **41,** No. 9, 585-598 (September, 1966).

This article deals with the development of programs that solve the problem of inconsistent resolution in current scintiscanning devices by using a digital computer. Functionally, the process behaves as a mathematical "filter." Scintiscan information is gathered and stored by a multichannel digital tape recorder. This tape is used as direct input to an IBM 7040 computer. In a preliminary clinical series, this filtering process afforded a significant improvement in scintiscans, because each of as many as 20 levels of counting-rate intensity could be clearly separated and represented by a symbol.

* Mayo Clinic.

A Computer-Oriented Method for Analyzing Networks with RLC Elements and Ideal Transformers, K. Lock, *Proceedings of the Western Electronic Show and Convention (WESCON),* pp. 1/1/1-19 (1966).

A method is presented for formulating networks of RLC elements and ideal transformers in terms of properly selected node-pair voltages which minimize round-off errors arising from matrix inversions. Algorithmic methods suitable for implementation into computer programs are given for both complex frequency plane and transient analyses. Using the same approach, methods are developed for analyzing networks by partition, which should prove very valuable in handling networks of extremely large size, many common subnetworks, or localized nonlinear elements.

Constant-Current Offset for A/D Conversion, J. W. McCullough, *Electro-Technology* **78,** No. 3, 96 (September, 1966).

The accuracy of an analog-to-digital converter can be maintained even when the range of the converter is extended. An epitaxial junction transistor circuit, applied as a single constant-current source, provides accurate offset for all A/D converter ranges.

Continuity and Realizability of Sequence Transformations, L. Hellerman, W. L. Duda, and S. Winograd, *IEEE Transactions on Electronic Computers* **EC-15,** No. 4, 560-569 (August, 1966).

In this paper we study some relations between the continuity of sequence transformations and their realizability by logic nets. The main results discussed include: the Curtis-Hedlund-Lyndon theorem which states that, if a sequence transformation is continuous and unitary (commutative with the shift transformation), then it can be realized by a net without feedback, and, the extension of this theorem to the finitary case. We find that unitary transformations are realized by definite automata, and finitary transformations are realized by indefinite automata. The term "automata" is used here in a modification of its usual sense, and we explore the relation between the conventional and modified notions.

Many of the concepts and more significant mathematical results in this report can be found in another context in works by Hedlund and others. What may be new and of interest to computer scientists, we believe, is their application to the theory of sequential circuits.

Control of Diffused Diode Recovery Time Through Gold Doping, J. M. Fairfield and B. V. Gokhale, *Solid-State Electronics* **9,** No. 9, 905-907 (September, 1966).

Gold (and its recombination properties) are very important in the fabrication of silicon transistor structures. Recently a model was developed to describe the recombination properties of gold in silicon and was shown to be applicable to simple alloyed diodes. These diodes were ideal in the sense that built-in electric fields were not present and the gold concentration in the areas of charge storage could be determined from measurements prior to diode fabrication. The question of whether this model can be applied to the switching transients of practical, diffused diodes (gold doped) in a reasonably simple manner remains. The problems of such an application arise from the influence of built-in fields upon the switching characteristics of diffused diodes, and from the uncertainty of the concentration of gold recombination centers in the presence of p^+ or n^+ diffused structures. This note describes an investigation into diode recovery times of gold-doped n^+-p and p^+-n diffused diodes and shows that, with certain assumptions concerning the above problems, the reported recombination model can be applied. The validity of the model itself is assumed.

Diffusion-Limited Adsorption at Spherical Electrodes, S. L. Phillips, *Journal of Electroanalytical Chemistry* **12, No. 4,** 294-299 (October, 1966).

Both the diffusion coefficient and maximum surface concentration of a surfactant may be calculated from potentiostatic current-time curves obtained using spherical electrodes. The theoretically derived relation between the maximum surface concentration, diffusion coefficient, and time at which maximum surface coverage is attained was tested by adding tetrabutylammonium ion to a solution of cadmium (II) in 0.1*M* perchloric acid.

A Discrete Design Method for Digital Control, R. W. Koepcke, *Control Engineering* **13,** No. 6, 83-89 (June, 1966).

When considering discrete systems, control engineers tend to pose a continuous problem, find the continuous solution, and then invoke z-transforms to obtain the discrete solution. Filtering then becomes complicated because folding frequency effects and the sampling theorem assume exaggerated importance. The net result of the procedure is to create the impression that discrete systems are poor imitations of continuous systems. Here is a more direct approach —a discrete design technique for two-mode control.

Effect of Band Tails on Stimulated Emission of Light in Semiconductors, F. Stern, *Physical Review* **148,** No. 1, 186-194 (August 5, 1966).

The dependence of the stimulated emission of radiation in semiconductors on temperature and on impurity concentration has been calculated using a Kane model with a Gaussian band tail for the density of states, and an optical model with a constant matrix element and no selection rule for the radiative transitions. The screening length and the characteristic energies for the widths of the conduction- and valence-band tails are calculated by a self-consistent procedure, and the calculation has no adjustable parameters. Numerical results are obtained using parameters appropriate for GaAs injection lasers. The presence of band tails leads to a more nearly linear dependence of gain on excitation level, in better agreement with experiment, than did the calculation without band tails by Lasher and Stern. Increasing impurity concentration leads to a weaker temperature dependence of the excitation rate required to reach a given gain.

Effects of Modulation Transfer Function Shapes on Preferences among Typewritten Reproductions C. K. Clauer and R. L. Erdmann, *Proceedings of the Conference of Photographic Science and Engineering,* pp. 176-177 (1966).

Comparative preferences of typewritten reproductions were determined for original and third carbon documents with the reproducing modulation transfer function (MTF) shape and spatial frequency scale factor as independent variables by using four different ranking tasks. Rank discrimination was excellent with each of the MTF shapes for scale factor steps of about 10 percent. Considerable variability resulted when all five MTF shapes were compared at equal scale factors. Comparisons between the two extreme MTF shapes reversed as scale factors were increased. The original document scale factor equivalents of the carbon document scale factors were also determined for each MTF shape.

Elastic Constants for a H. C. P. Structure Bound by Central Forces, E. F. Hayes,* *Philosophical Magazine* **14,** No. 128, 415-419 (August, 1966).

General expressions for the elastic constants are derived for a hexagonal lattice bound by central forces. The treatment essentially follows the method developed by Max Born for cubic lattices.

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An Electron Beam System for Unattended Reliable Operation, K. H. Loeffler, *Proceedings of the Sixth International Congress for Electron Microscopy,* Kyoto, pp. 203-204 (1966).

An electron optical system has been designed which delivers an automatically stabilized electron beam without any operator attendance for at least 20 hours or (using automatic daily filament exchange) for two weeks with a subsequent minimum maintenance time. The engineering model being described has been tested with the approximate data of 10^{-8} amp beam current, 12 kV acceleration voltage, 1 μ spot diameter, 0.4 cm^2 scanned area, and 10 cm working distance and can be easily adapted to a variety of other operating conditions.

Electronic Structure of MgF_2:Co^{++}, H. M. Gladney, *Physical Review* **146,** No. 1, 253-261 (June 3, 1966).

The F^{19} superhyperfine structure of the EPR spectra of Co^{++} in MgF_2 is interpreted with simple molecular-orbital theory. A necessary preliminary analysis is made of the g tensor and of the spacing of the six Kramers doublets derived from the $^4T_1$ ground manifold. The ligan-field parameters of the rhombic field, $\Delta \cong 510$ cm^{-1} and $\Gamma \cong -390$ cm^{-1}, and the spin-orbit coupling, $\lambda \cong -157$ cm^{-1}, are significantly different from values derived from less complete data. The reported superhyperfine interactions provide sufficient data to determine, without recourse to much less certain orbital-reduction factors, the s-, sigma-, and pi-bonding fractions: $f_s = (0.61 \pm 0.02)\%$, $f_\sigma = (3.9 \pm 0.3)\%$ and $f_\pi = (0.9 \pm 0.3)\%$ for the two equivalent fluorine ions along [110]. For the other four fluorine ions similar estimates are obtained. These results are at variance with the suggestion, made for octahedral Co^{++}, that sigma and pi bonding are of comparable magnitude.

Eliminating Monotonous Mathematics with FORMAC, R. G. Tobey, *Communications of the ACM* **9,** No. 10, 742-751 (October, 1966).

The FORMAC (FORmula MAnipulation Compiler) programming system is an extension of FORTRAN IV which permits the use of the computer to perform the tedious algebraic computations that arise in many different fields. Among the areas in which it has been successfully used are: dif-

ferentiation of complicated expressions, expansion of truncated power series, solution of simultaneous equations with literal coefficients, nonlinear maximum likelihood estimation, tensor analysis, and generation of the coefficients of equations in Keplerian motion. These types of analysis—which arose in the solution of specific practical problems in physics, engineering, astronomy, statistics and astronautics—are discussed in the paper. In addition to its usage for specific problem solutions, FORMAC can also be used to automate the analysis phase in certain production programming. Several such applications are presented.

Evaluation of Some Display Parameters with Human Performance Measures, C. K. Clauer, A. S. Neal and R. L. Erdmann, *Proceedings of the Seventh National Symposium on Information Display,* pp. 15-23 (1966).

The physical parameters which affect display "quality," such as screen luminance and contrast, are well known and readily measured. However, display system designers need to know how the user of the display, the human observer, will perform as a function of many display parameters. Traditional human factors literature is helpful, but such sources usually treat the human visual process at threshold levels and typically consider only one of the many physical parameters at a time. Therefore, human performance measures are generally necessary to evaluate the effects of specific parameters in the suprathreshold situation of complex real display systems. Subjective judgments, such as preferences for various physical parameters, can also be obtained, but such criteria usually show high variability and are often misleading.

In a study conducted with a rear projection teaching machine, human performance measures were used to evaluate certain display parameters. The physical parameters of screen luminance, ambient illumination and image polarity (positive or negative) were investigated. The human performance measures were the amount of time taken and the number of errors made on a programmed course of instruction. Preference information was also obtained as a function of the physical parameters by allowing the observer freedom in choosing his viewing conditions. The preference information here shows a positive correlation with the performance measures.

In another study, television displays were compared to film displays to determine points of equal "quality." The physical parameters were character size, television bandwidth and original film image size. The human performance measure was legibility, i.e., the percentage of correctly identified letters. Preference information was also obtained which demonstrated how discrepancies can occur between subjective judgments and objective performance measures.

Excited-State Mixing in the Optical Pumping of Alkali-Metal Vapors, F. A. Franz* and J. R. Franz, *Physical Review* **148,** No. 1, 82-89 (August 5, 1966).

The effect of excited-state mixing on the optical pumping of alkali-metal vapors is considered for the case where the energy separation between the $^2P_{1/2}$ and $^2P_{3/2}$ first excited states is relatively large, allowing the isolation of mixing effects within a particular J level. Two models for the mixing process are proposed, one a random reorientation of the total electronic angular momentum J, and the other a reorientation of J subject to the selection rule $\Delta m_J = 0, \pm 2$. The probabilities for mixing transitions among J-state sublevels have been calculated for an alkali atom of nuclear spin 3/2, and can be used to calculate the optical-pumping transition probabilities for a vapor subject to any degree of excited-state mixing. Several possible experiments suggested by these calculations are discussed.

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Extending Image Reproduction System Analysis to Include the Observer, C. K. Clauer, *Proceedings of the Seventh National Symposium on Information Display,* pp. 9-13 (1966).

Image reproduction systems such as photographic projection and television displays produce a visual display which is an analog reproduction of a source pattern. The technique of employing a modulation transfer function (MTF) to characterize image reproduction systems of all kinds has been found very useful for predictive analysis. While such analytical methods are effective for characterizing physical image systems, they have not provided quantitative evaluation of the display from the observer's viewpoint.

Recently, efforts have been made to define a modulation transfer function that characterizes a standard human observer and could be combined with the MTF of the physical image system to evaluate the total display-observer system. This approach can be shown to be invalid, since the human visual system, unlike the physical system, does not respond at all at contrast levels below the contrast threshold and, above this threshold, responds as a *non*linear function of modulation (contrast).

This paper proposes a graphical method for extending image reproduction system analysis to include the observer. A procedure is outlined for plotting the contrast threshold function of a standard observer on the same coordinates as the system modulation transfer function; obtaining difference values which represent the objective physical modulation (or contrast) transfer above threshold; and finally, converting the physical modulation levels above threshold to the Munsell psycho-physical response scale.

For a Crew in Lonely Orbit, Something to Lean on in Space, A. Adelman and J. Cohen, *Electronics* **39,** No. 20, 129-138 (October 3, 1966).

A brief portrait is projected of the kind of computer system that in coming years will help man exploit space in an orbiting laboratory. The system will be the operating center of the orbiting laboratory and the link that joins men and equipment in space to their counterparts on the ground. In addition to providing guidance and navigation aid as do current spacecraft systems, the more flexible and sophisticated future aerospace computer will check out onboard systems and experiment equipment, support the performance of experiments, and manage a large volume of experimental data. To meet these needs, it will be necessary to design a new concept general-purpose computer. The possible configuration of such a computer and how it will interface with related equipment is discussed.

Further Analysis of an Integrated Switching and Multiplexing (ISAM) System, P. Thrasher, *IEEE Transactions on Communications Technology* **COM-14,** No. 4, 373-381 (August, 1966).

This paper extends earlier analysis work relating to a new method to achieve frequency division multiplexing, which may be integrated with time division switching in an effective manner. The band shifting inherent in frequency division multiplexing and demultiplexing is achieved by placing a sampling gate between a baseband and a sideband filter. When this technique is combined with time division switching, the transmission path also includes the cases of transmission via a switch between sideband filters that may or may not cover the same sideband region, and between baseband filters. Resonant transfer is incorporated for all cases. Only the case of resonant transfer between baseband filters has been considered in the past. In general, it may be said that the basic transmission path to be analyzed is one between sideband filters, where the term sideband is used in the sense to include baseband. This is logical since the baseband may be considered to be an upper sideband around zero frequency. Such a basic transmission path is rigorously analyzed on the basis of certain ideal assumptions. The purpose is to provide further insight into the fundamental operation of this new modulation—demodulation scheme.

General Analytical Model for Process Analysis, R. G. Kiwimagi and R. E. Watson, *Proceedings of 30th National Meeting of the Operations Research Society of America,* Vol. 14, Supplement 2, B217 (October, 1966).

The General Analytical Model for Process Analysis was developed to furnish a convenient means of evaluating a change in a process in terms of equipment utilization, manpower and product cost. The program was designed to handle processes which include several parts using the same equipment, many scrap points and recycles, as well as varying cycle times and scrap rates per recycle. The program is able to handle a three-dimensional matrix 100 x 18 x 5. This consists of up to 100 operations up to 18 different products (or parts) sharing all or some of these operations, and up to 5 cycles per operation.

Grenzen integrierten Schaltungen (Limitations of integrated circuits), G. Kohn, *Proceedings of the IFAC/IFIP Symposium on Microminiaturization in Automatic Control Equipment and in Digital Computers,* Munich, p. 764 (1966).

Some limitations of integrated circuits are reviewed. From an engineering point of view, the relations between element size, packing density, signal level, power dissipation and speed are investigated.

Image Evaluation by Use of the Sampling Theorem† B. R. Frieden,* *Journal of the Optical Society of America* **56,** No. 10, 1355-1362 (1966).

Summation formulas are derived for the precise calculation of certain quality parameters of the image space: (a) radius of gyration of the point spread function, (b) O'Neill's sharpness criterion, and (c) the Linfoot quality parameters. These formulas are applicable to any optical system that exists either as a design or as a fabricated object. Also, in the case of a bandwidth-limited object spectrum it is shown that the image may be exactly represented by a summation —in place of the usual convolution integral—over the object space. All derivations employ the sampling theorem.

† Adapted from a dissertation presented by the author in partial fullfillment of the requirements of the Ph.D. degree.

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Interface Problems in Space Experimentation, R. F. Filipowsky and P. C. Green, *Supplement to IEEE Transactions on Aerospace and Electronics Systems* **AES-2,** No. 4, 237-255 (July, 1966).

Space experimentation is expanding rapidly. Unmanned satellites are being equipped with precision instruments of greater power, and manned space stations accommodating large crews are in the drawing-board stage. The interface problems between these sophisticated instruments and between man, the spacecraft, and the supporting ground stations are multidimensional. This paper analyzes the scientific/technical areas of space experimentation, and continues with a review of the subsystems and support systems required to supply and operate the large variety of instruments. Areas of major integration efforts are singled out and the requirements for further developments and improvements are listed. A bibliography of 95 references is enclosed to assist in the identification of more detailed reports on all vital aspects of space experimentation.

Joule and Wiedemann Effects—The Simultaneous Generation of Longitudinal and Torsional Stress Pulses in Magnetostrictive Materials, N. S. Tzannes, *IEEE Transactions on Sonics and Ultrasonics* **SU-13,** No. 2, 33-41 (July, 1966).

This study is a theoretical development and experimental verification of the phenomenon of simultaneously producing two different stress pulses in magnetostrictive materials. The one-dimensional Joule effect (longitudinal mangetostriction) is introduced and is subsequently extended to the two-dimensional Wiedemann effect (torsional magnetostriction). The conditions for the Wiedemann effect are established, and this leads to the existence of the combined Joule-Wiedemann effect. The practical usefulness of the simultaneous Joule-Wiedemann effect was verified by experimental means. Poisson's ratio and its variations are demonstrated to depend on measurable quantities when examined in a practical system using the Joule-Wiedemann effect. Poisson's ratios were measured for selected magnetostrictive materials. It is further demonstrated that information on the variations with temperature of Poisson's ratio can solve the problem of temperature stability of the time delay in magnetostrictive delay lines.

Laser-Induced Luminescence and Dissociation in Biphenyl, K. B. Eisenthal, W. L. Peticolas and K. E. Rieckhoff,* *Journal of Chemical Physics* **44,** No. 12, 4492-4497 (June 15, 1966).

The interaction of the radiation field of an unfocused ruby laser with molecules containing a phenyl-phenyl or benzyl-benzyl single bond is found to give rise to a new lumines-

cence. This luminescence is linearly dependent on the molecular concentration and proportional to either the second or the third power of the laser intensity. Thus it appears that a multiphoton absorption is occurring. The absorption does not appear to involve the electronic states of the molecules. This luminescence occurs throughout the visible region and bears no resemblance whatever to either the normal fluorescence or phosphorescence. Because of the exceedingly high laser intensities or electric fields necessary for electronic dielectric breakdown it appears that this mechanism is not of importance. It is suggested that multiphoton vibrational excitation to a dissociative state of the molecule may occur which leads to molecular fragmentation. This process is followed by a chemiluminescent emission. A quantitative comparison of the experimental results with a theoretical treatment of multiphoton vibrational dissociation is made.

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LISA—A Program for Linear Systems Analysis, K. L. Deckert and E. T. Johnson, *Proceedings of the Western Electronic Show and Convention (WESCON),* pp. 1/2/ 1-9 (1966).

LISA is an integrated package of experimental 7090/94 FORTRAN IV programs for analyzing linear systems using Laplace transform techniques. It will analyze electrical networks, two-block control systems, and any system of linear equations whose coefficient matrix has polynomial elements. Inputs may be a topological circuit description, transfer function, matrix equation, or block diagram. Outputs may be poles and zeros, frequency and transient response, root locus, or sensitivity. Both listings and plots may be obtained. LISA features a free format, applications-oriented input language, with extensive user control of output. This makes it suitable for terminal operation. Several computational and programming techniques extend the size of problems the program can handle, reduce computation time, and conserve storage. The program is organized to be open-ended so that new features may easily extend its capabilities.

Magnetoresistance of Thallium,† J. C. Milliken and R. C. Young,* *Physical Review* **148,** No. 2, 558-568 (August 12, 1966).

This paper presents a study of the magnetoresistance of several single crystals of high-purity thallium in magnetic fields up to 100 kG at liquid-helium temperatures. The experimental results are interpreted in terms of Soven's relativistic orthogonalized-plane-wave model for the Fermi surface of thallium. At low fields the magnetoresistance is in better agreement with the model than was previous work, while no evidence is found for an open orbit parallel to [0001]. Detailed results up to 54 kG are consistent with the model if incomplete magnetic breakdown is assumed and high-field results show that breakdown is not complete below 100 kG.

† Work was performed at the Ames Laboratory of the U. S. Atomic Energy Commission.
* Iowa State University.

La Méthode des éléments Finis en élasticité Bidimensionnelle (The Finite-Element Method in Two-Dimensional Elasticity), G. Dupuis* and W. Prager,** *Schweizerische Bauzeitung* **79,** No. 28, (July 13, 1966).

The finite-element method for the approximate determination of the displacement field of an elastic disc under given boundary tractions leads to a system of equations that is usually derived by intuitive arguments. The precise meaning of these equations within the framework of the mathematical theory of elasticity is established, and it is shown that the quality of the approximation can be improved without significant increase in numerical work. Explicit formulas are given for a grid that consists of isosceles right triangles. The extent to which the results of the finite element method can be improved is illustrated by a numerical example.

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Miniaturisierungsprobleme bei strömungsmechanischen Elementen (Problems in connections with miniaturization of fluid mechanic components), H. H. Glaettli, *Proceedings of the IFAC/IFIP Symposium on Microminiaturization in Automatic Control Equipment and in Digital Computers,* Munich, Paper 1.1., pp. 1-7 (1966).

Problems in connection with miniaturization of fluid mechanic components arise from fundamental relationships: Minimum values of operating pressure and power consumption increase, the minimum response time decreases. Even moderate Mach numbers, i.e., higher than 0.2 or 0.3 cause significant deviations in miniaturized components, denying experiments with large scale models. Curves showing the behavior of similar elements of various sizes are shown. An example of how to correct the geometry for higher Mach numbers is given.

Modular Isolation Diagnostic Analysis System, D. O. Boyd, D. E. Bunnell, A. W. Garrigan and K. R. Jones, *Annals of Reliability and Maintainability* **5,** 665-671 (July, 1966).

This paper presents new concepts for solving the problems of providing adequate systems test coverage for the diversified data processing systems of today. The paper also discusses the implementation of the concepts presented, and in so doing brings to light the relative position of the systems test within a total diagnostic package.

Necessary and Sufficient Conditions on Conditional Probabilities to Maximize Entropy, C. E. Radke, *Information and Control* **9,** No. 3, 279-284 (June, 1966).

Shannon showed that, by a proper choice of the conditional probabilities of the symbols in a discrete noiseless channel of the finite-state type (which possesses certain inherent constraints), the entropy of symbols on such a channel could be maximized. To date these known sufficient conditions on the conditional probabilities have been assumed to also be the necessary conditions. In this paper it is shown that the sufficient conditions as originally stated by Shannon are indeed also the necessary conditions for the range of symbol lengths which are of interest.

New Developments and Applications of the Closed-Loop Stepping Motor, T. R. Fredriksen, *Proceedings of the Joint Automatic Control Conference,* pp. 767-775 (1966).

This paper describes a new closed-loop control concept which captures inherent ability of a stepping motor to function as a mechanical memory. A type of single-phase operation produces the desired memory effect, as well as improving the response time of the two-phase motor. Step-to-step time-optimal control is implemented as a basic minor-loop operation generating a new set of closed-loop control inputs. This new type of closed-loop stepping motor forms the key element of a purely digital servomechanism which features a number of interesting operating modes. The paper outlines the instrumentation of this device in some detail and presents actual performance data.

Normal and Shearing Contract Stresses in Indented Strips and Slabs, H. D. Conway,* S. M. Vogel, K. A. Farnham and S. So, *International Journal of Engineering Science* **4,** No. 4, 343-359 (August, 1966).

A numerical method is developed for finding the distributions of contact stresses between two- and three-dimensional elastic bodies which are pressed together, the area of contact either being free from or subjected to frictional forces. The method is first applied to the plane-stress problem of a strip which is compressed by a rigid, axially-loaded, flat-ended indenter where the contact surfaces are either free to slide over one another (zero friction coefficient) or locked together (large friction coefficient). Numerical values of the contact stresses and displacements are computed in each case for several indenter-widths vs strip-depth ratios. Corresponding values for a finite-depth slab compressed by an axially loaded and flat-ended cylindrical indenter are also calculated. Finally, the method is extended to a case where the indentation area varies with the load, and numerical values are calculated for a strip compressed by a rigid circular roller.

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On Elastic, Perfectly Locking Materials, W. Prager,* *Proceedings of the Eleventh International Congress of Applied Mechanics,* Munich, p. 538 (1966).

The mechanical behavior of the elastic, perfectly locking material considered in this paper is described by a finite number of scalar functions of the strain components, which are called locking functions. The states of strain for which all locking functions assume nonpositive values are supposed to be represented by the points of a convex domain in strain space. Only states of strain that correspond to points of this domain can be attained in the material. In a state of strain that corresponds to an interior point of the domain, the solid responds in a purely elastic manner to all sufficiently small changes of stress. On the other hand, when the state of strain is represented by a boundary point of the domain, there exists a change of stress that will not be accompanied by a change of strain. This phenomenon is called locking. The mechanics of elastic, perfectly locking materials is developed on the basis of a simple mechanical model. A meaningful boundary value problem for elastic, perfectly locking materials is formulated and its solution is characterized by a variational principle. This principle contains as special cases two extremum principles that were established in an earlier paper ("Unilateral Constraints in Mechanics of Continua," atti del Simposio Lagrangiano, Acc. del Scienze di Torino, 1964, pp. 181-191).

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On-Line Processing of Library Materials with the IBM Administrative Terminal System, T. D. Phillips, *Proceedings of IFIP Congress 65,* Vol. 2, pp. 343-344 (1966).

Proceeding in experimental stages from a conventional manual system to simple punched-card procedures for isolated functions, and then to a computer-based system, integrating all the library functions, the library in the Los Gatos Laboratory of IBM's Advanced Systems Development Division has repeatedly faced the necessity of converting existing files to machine-readable form. The present system is designed to process library materials rapidly and to keep the records for each book accurate and current. In implementing this system, we have applied IBM's administrative Terminal System to several tasks with great advantage. ATS is a beginning answer to the troublesome problems of file conversion, and is particularly suited to on-line processing.

On Some Problems in Spherically Isotropic Elastic Materials, W. T. Chen, *Transactions of the ASME, Journal of Applied Mechanics* **33,** No. 3, 539-546 (September, 1966).

In this paper, the elasticity problem of a spherically isotropic elastic medium bounded by two concentric spherical surfaces is studied. General solutions in terms of infinite series are presented. Specifically, we consider some axisymmetric problems such as: concentrated force in an infinite medium, stress concentration due to a spherical cavity, and a steadily rotating shell. In all these cases, the infinite series terminate, and closed-form solutions are possible. Steady-state thermal stress problems are also considered.

On Some Problems in Transversely Isotropic Elastic Materials, W. T. Chen, *Transactions of the ASME, Journal of Applied Mechanics* **33,** No. 2, 347-355 (June, 1966).

This paper treats some problems in a homogeneous transversely isotropic elastic material, occupying an infinite space, or an infinitely long circular cylinder. The analysis is based upon the potential function method by Elliott with the addition of another potential function. The static solution is extended to include quasistatic, or steady-state problems. Closed-form solution is found for the problem of an arbitrarily oriented concentrated force in an infinite medium. The case of discontinuous pressure over an infinitely long circular cylinder is also studied with the aid of a numerical method of integration. The applied forces are assumed to be moving with uniform velocity along the anisotropic direction.

On Teleprocessing System Design—Part I: Characteristic Problems, W. P. Margopoulos and R. J. Williams, *IBM Systems Journal* **5,** No. 3, 134-141 (1966).

For analytical purposes, a teleprocessing system can be characterized as a digital computer with unscheduled inputs from a number of remote points. In the design of such a system, various queuing problems arise as a consequence of the unscheduled inputs, and the necessity of linking remote points to the central computer leads to a problem in combinatorial mathematics. To show the origin of these problems, a functional classification of teleprocessing applications is given, a schematic of a basic teleprocessing system is introduced, and the relative merits of mathematical analysis and digital simulation are discussed.

On Teleprocessing System Design—Part II: A Method for Approximating the Optimal Network, L. R. Esau and K. C. Williams, *IBM Systems Journal* **5,** No. 3, 142-147 (1966).

A teleprocessing system may include many low-speed terminals at great distances from the computing center. Specification of a communication network for connecting the remote terminals to the central computer constitutes an important design problem. An iterative method for obtaining an approximate solution to an optimum network is presented. The method assumes that an acceptable line utilization is given.

On Teleprocessing System Design—Part III: An Analysis of a Request-Queued Buffer Pool, J. P. Bricault and I. Delgalvis, *IBM Systems Journal* **5,** No. 3, 148-157 (1966).

The problem of allocating main storage for a message-segment buffer pool is considered. A queuing model that approximates the most typical mode of operation is formulated. Solutions for the number of buffers required by the pool are obtained. Although the solutions require iterative computational methods, they are not difficult to program. Inasmuch as the model and solution methods both involve approximations, the validity of the approach was checked by simulating a typical set of operating conditions. Although the computational results were found to be conservatively biased, the method is clearly adequate for most design purposes.

On Teleprocessing System Design—Part IV: An Analysis of Auxiliary-Storage Activity, P. H. Seaman, R. A. Lind and T. L. Wilson, *IBM Systems Journal* **5,** No. 3, 158-170 (1966).

Queues of requests for access to auxiliary storage play a major role in every teleprocessing application. Assuming that access requests are randomly distributed, a queuing model is formulated; formulas are obtained for the mean and variance of the response-time distribution, as well as for the utilization factors of the access channel and the storage modules. Samples of analytical and simulation results are given.

On Teleprocessing System Design—Part V: A Technique for Estimating Channel Interference, T. W. Gay, Jr., *IBM Systems Journal* **5,** No. 3, 171-174 (1966).

In typical teleprocessing applications, a large number of terminals communicate with the main-storage unit of a centrally located computer. The communication activities may reduce the processing capability of the computer by claiming a significant number of main-storage access cycles. If the number of cycles to be claimed is partially dependent upon channel-busy and request-pending conditions, the problem involves a probability analysis. Using a simple queuing model as a starting point, a usefully accurate solution method is developed. The SYSTEM/360 multiplexor channel is analyzed as an example.

On Teleprocessing System Design—Part VI: The Role of Digital Simulation, P. H. Seaman, *IBM Systems Journal* **5,** No. 3, 175-189 (1966).

As a tool for quantitative investigation, digital simulation is especially suited to the study of stochastic processes having many interdependent variables. Not only can a simulation model be modified to reflect structural changes in a process, but it can be used to gain insights during the design of the process. These properties recommend the use of digital simulators in the design of complex teleprocessing systems. This paper comments on the main considerations involved in choosing between general-purpose and special-purpose simulators.

A 110 Nanosecond Ferrite Memory, G. E. Werner and R. M. Whalen, *IEEE Transactions on Magnetics* **MAG-2,** No. 3, 584-588 (September, 1966).

The design of a large, very-high speed ferrite memory is described. The memory has a capacity of 8192 words, 72 bits per word and has a cycle time of 110 nanoseconds and an access time of 67 nanoseconds. The storage devices are miniature ferrite cores, size: 0.0075 in. by 0.0123 in. by 0029 in., and are operated in a two-core-per-bit mode. A planar array geometry with cores resting on a single ground plane was used to control drive line parameters. Device switching speed and bit line recovery are treated as special problems. The design criteria and operational characteristics of the core are presented as well as the approach taken on the bit line recovery problem.

Optical Properties of Thin Germanium Films in the Wavelength Range 2000-6000 Å,* P. M. Grant and W. Paul, *Journal of Applied Physics* **37,** No. 8, 3110-3120 (July, 1966).

Measurements have been made of the normal incidence reflectivity and transmissivity coefficients R and T of thin germanium films. Films were deposited *in vacuo* on fused quartz substrates where the crystalline perfection of the film was controlled by varying the substrate temperature so that the effect of crystalline order on reflectivity could be observed. Epitaxial films were grown on cleaved CaF_2 substrates to thicknesses in the range 100-3000Å. Structure in the reflectivity and transmission spectra showed these

* This research was supported by the U. S. Office of Naval Research and formed part of a thesis submitted by P. M. Grant to the Division of Engineering and Applied Physics, Harvard University, in partial fulfillment of the requirements for the Ph.D. degree.

films to possess bulk band properties. However, the amplitudes of R and T were affected by the presence of film surface roughness believed to originate from nucleation and growth phenomena. Also, compressive strain induced by the difference in thermal expansion coefficients between Ge and CaF_2 shifted interband transition structure to slightly higher energies. Values of the optical constants were deduced from R and T. When experimental and computational difficulties peculiar to the film method are accounted for, the results correspond closely to those of the Kramers-Kronig analyses of bulk reflectivity data.

Paper Machine Identification for Purposes of Computer Control, T. Bohlin, *Proceedings of the Paper, Rubber and Plastics Automation Congress,* Antwerp, pp. 1-23 (1966).

Results are presented of the application of a method of dynamic regression to the estimation of dynamics and disturbance characteristics of a kraft paper machine at a paper company in Sweden. The method is related to one developed by G.E.P. Box and G. M. Jenkins. The models obtained as results of the identification are in such a form that the optimal steady state control algorithms are immediate and simple. Among the relationships identified are models for control of basis weight, moisture and couch vacuum through refiners. The corresponding optimal control algorithms have been put into an IBM 1710 control computer attached to the process. The technique is fairly general and can be applied to stationary industrial processes. Equipment for data logging must be available.

Parallel Processing of Algebraic Expressions, H. Hellerman, *IEEE Transactions on Electronic Computers* **EC-15,** No. 1, 82-91 (February, 1966).

A classification of parallel processing is first offered. A compiler algorithm is given for translating algebraic expressions to concurrency groups of instructions for a parallel processor system. A machine organization to execute such a compiler program is described.

Payload Integration for Space Experimentation, P. C. Green and R. F. Filipowsky, *Supplement to IEEE Transactions on Aerospace and Electronic Systems* **AES-2,** No. 4, 256-270 (July, 1966).

Space experimentation requires an increasingly complex planning and systems engineering effort to meet the demand for highest precision and reliability of all measurements and observations. A companion paper (R. F. Filipowsky and P. C. Green, *IEEE Trans.* **AES-2,** 237 (1966) discusses the interfaces between the scientific/technical areas of space experimentation and the instruments, subsystems and support systems within the spacecraft.

This paper deals with the organization and the procedures which are needed to perform the difficult payload integration process for space experimentation. In the course of this process, experiments must be defined completely, to describe all instruments in terms of engineering specifications, to investigate the commonality of equipment, to group the experiments into mission compatible payloads, to specify acceptable loads on all subsystems and astronauts (when present) and to plan for all contingencies during the flight.

Photon Correlations in a Multiple Coherent and Overlapping Chaotic Radiation Field, H. Morawitz, *Zeitschrift für Physik* **195,** No. 1, 20-25 (July, 1966).

We propose a study of the second-order coherence properties of radiation, such as inelastically scattered laser light, by performing an excess photon coincidence rate experiment a la Hanbury Brown-Twiss. The calculation evaluates the second-order correlation function of the electromagnetic field for an arbitrary number of coherent modes overlapped in phase space by a chaotic radiation field. We discuss the application of the general result to a specific case, namely the case of a single mode laser, and the Stokes radiation produced in a Brillouin-active medium, and a suitable part of the spectrum produced by causing dielectric breakdown in air.

Precise Determination of Lattice Parameters by Step-Scanning X-Ray Diffractometry, M. A. Sanborn, *Journal of Materials* **1,** No. 3, 481-490 (September, 1966).

Most workers interested in the precise determination of lattice parameters have had available specimens ideally suited to their work. Where only weak, low-angle reflections are obtainable, as is the case, for example, with evaporated chromium thin films, the usual techniques cannot be applied. A method is described for providing a precision of one part in 4000 in angular location for reflections occurring near 50 deg 2-theta. This method uses internal standardization and least-squares curve-fitting techniques.

The Readback Process in Digital Magnetic Recording, J. R. Herbert, *IEEE Transactions on Magnetics* **MAG-2,** No. 3, 247-251 (September, 1966).

Losses in analog magnetic recording can be separated and analyzed by frequency response techniques: In digital recording these cannot readily be applied but, as this paper shows, useful results can be obtained from a time domain analysis of the readback process. The commonly accepted model of this process as a convolution of the media magnetization transition and the head field function is extended by the use of linear theory to include the electrical parameters of the head amplifier system. The resulting model is then analyzed to show how the three contributions to the readback process, the written transition, the head field, and electrical effects—might be separated by suitable experimental techniques. Electrical effects are readily separable and experimental results agree well both with the theory and with established head parameters. The separation of reading and writing effects is shown to be difficult to achieve under conditions likely to be encountered in practice, but an approximate method is discussed.

A Simulation Approach for Evaluating System Packaging, S. Fielden and A. Kimer, *Proceedings of the 7th International Electronic Circuit Packaging Symposium,* Section 3/8, pp. 1-11 (August, 1966).

A method is described which permits a study of a proposed packaging technology and its economic impact on a corporation. The simulation model is general in nature and evaluates the effects of such processes as the building of the product, field installation, field stocking, maintenance and engineering change activity, for a simulated time period. The aggregate measures made up of fixed costs and oper-

ating costs are deemed to represent the long term consequences of employing the strategy being simulated. Any change in input conditions, in simulated policies, or in options allowable in the model implies a change in strategy or packaging philosophy.

Size Effect and Electron-Phonon Interaction in the Lattice Conduction of Cu-Ge Alloys,† P. Lindenfeld,* E. A. Lynton,* D. S. McLachlan, and R. Soulen,* *Physical Review* **143,** No. 434-438 (March 11, 1966).

We have measured the lattice thermal conductivity between 0.35 and 4°K of annealed, polycrystalline specimens of Cu-Ge alloys with residual resistivities between 10 and 22 $\mu\Omega$-cm. This is an extension of earlier work to lower temperatures and higher resistivities. Over most of the measurement range the phonons are primarily scattered by electrons, and the main features continue to be well described by Pippard's relations for the phonon-electron interaction. There is a marked size effect, showing that scattering by the external boundaries is effective up to 4°K. There is some evidence for additional scattering, but the uncertainties of the analysis do not allow a definite conclusion on this point.

† Work performed at Rutgers University and supported by the National Science Foundation and the Rutgers University Research Council.

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Solid-to-Solid Diffusion in the Gallium Arsenide Device Technology, W. von Münch and H. Statz, *Solid-State Electronics* **9,** No. 10, 939-942 (October, 1966).

The technique of tin and zinc diffusion from doped pyrolytic SiO_2-layers has been used to form the base regions of planar *npn*- and *pnp*-GaAs transistors. By a suitable sequence of deposition and photo-resist processes it is possible to obtain a pattern of doped oxide layers which yield planar *npn* transistors in a single diffusion step.

Some Aspects of a Flat Elliptical Crack Under Shear Stress, W. T. Chen, *Journal of Mathematics and Physics* **45,** No. 2, 213-223 (June, 1966).

The linear elasticity problem of a flat elliptical crack in an infinite, homogeneous elastic medium is studied. The analysis is based upon the conjecture (which is later proved correct) that this problem is identical to that of an ellipsoidal distribution of displacement discontinuity in an infinite medium. The paper also shows how this problem may be solved by using another method based on some properties of Lamé functions.

Statistical Mechanics of a Superparamagnetic System, H. Thomas, *Zeitschrift für angewandte Physik* **21,** No. 1, 13-15 (June, 1966).

A statistical mechanical treatment is given of a system of superparamagnetic particles. The Néel theory for a single particle is confirmed except in extreme cases of plate-like and needle-shaped particles. The interparticle dipole interactions are treated in molecular field approximation. Upper and lower bounds are obtained for the effect of these dipole interactions. Observed deviations from the Néel theory falling outside of these bounds cannot be caused by dipole interactions.

Structure of Domain Walls in Multiple Films, J. C. Slonczewski, *Journal of Applied Physics* **37,** No. 3, 1268-1269 (March 1, 1966).

We derive an approximate solution of the micromagnetic equations for a Néel-type wall in multiple films. A small normal component of magnetization M permits most of the pole distribution to concentrate on the film surfaces. Thus, the magnetic-field energy resides mostly in the nonmagnetic gaps between magnetic films. The wall structure is found to consist of two "wings" having little exchange energy which flank a "kernel" in which only exchange and anisotropy energy terms are significantly involved. The kernel makes secondary contributions to the total width and energy of the wall. In first order, the wing shape is given by $M_x = M_0 \exp\{-[(K/\pi Db)^{1/2}|x|/M_0]\}$, where K = anisotropy, b = thickness of nonmagnetic layer, x = distance normal to the wall plane, and D = one magnetic layer thickness for a double film or one-half of a thickness for an infinite number of layers. The first-order energy per unit area is $2M_0(\pi KDb)^{1/2}$. This energy is lower than previous results and extends the region of stability for Néel walls (as opposed to Bloch walls) to greater D, especially for small b.

Superresolution Image for One-Dimensional Objects, M. A. Grimm and A. W. Lohmann, *Journal of the Optical Society of America* **56,** No. 9, 1151-1156 (September, 1966).

Objects which vary strongly as a function of x but only slowly in y occupy a cigar-shaped area in the spatial-frequency domain. Such an object spectrum is badly matched to the frequency-transfer domain of a lens, which is usually circular. By means of spatial modulation, the object spectrum can be adapted to the transfer domain of the lens. In this way, the one-dimensional resolution limit or bandwidth of the lens can be overcome, as shown by experiment and theory.

A Survey of Crystal-Growing Processes and Equipment, J. A. Lenard and E. J. Patzner, *Semiconductor Products and Solid State Technology* **9,** No. 8, 35-42, 61 (August, 1966).

The most widely used current processes for growing semiconductor single crystals are described. These include zone leveling, boat zone leveling, float zone, temperature gradient zone melting, the Czochralski method, web growth, and the cold crucible technique. A discussion of each process includes the growth mechanism utilized. Various types of crystal growing furnaces are also shown.

Systematic Generation of Hamiltonian Circuits, S. M. Roberts and B. Flores, *Communications of the ACM* **9,** No. 9, 690-694 (September, 1966).

For a combinatorial matrix which may specify both directed and non-directed arcs, the paper describes a computer program which generates systematically and exhaustively all the Hamiltonian circuits. Specific application is made to the "travelling salesman" problem.

Das Taylorsche Stabilitätsproblem mit Modulation (The Taylor stability problem with modulation), von B. Meister and W. Münzner, *Zeitschrift für angewandte Mathematik und Physik* **17,** No. 4, 537-540 (July, 1966).

The stability of the time-dependent flow between two concentric circular cylinders is considered, whereby the angular velocity of the inner cylinder is modulated sinusoidally. The initial value problem of the corresponding linearized differential equations for the perturbations is solved by means of the Galerkin method. The convergence of this method follows from an earlier investigation. The behavior in time of the perturbations is studied as a function of the moduation frequency. The results agree with experiments of Donnelly.

A Terminal Operated Production Program (TOPP) System, R. J. Hedger, A. G. Pontius, J. M. Seehof and G. G. Benson, *Proceedings of the ACM 21st National Convention,* pp. 167-177 (1966).

This paper describes an IBM 1050/7090 terminal system that allows remote execution of library programs (mathematic analysis, information retrieval, engineering design) utilizing the full capability of the IBM 7090. High efficiency is obtained by time-sharing the terminal input/output data transmission and library tape positioning with normal IBSYS background activity. Programs with limited input and output volume, written under IBJOB (FORTRAN IV, COBOL, MAP) can be readily adapted for terminal use. System applications, philosophy and limitations are discussed.

A Theoretical Model for a Quantitative Evaluation of Magnetic Recording Systems, B. Kostyshyn, *IEEE Transactions on Magnetics* **MAG-2,** No. 3, 236-242 (September, 1966).

In designing a digital magnetic recording system, it is necessary to consider a large number of parameters to produce optimum performance. Because of parameter interdependence, and the nonlinear nature of the recording process, experimental evaluation of a real system is cumbersome, time-consuming, and costly. To circumvent the usual trial and error techniques, a model has been developed based on earlier work of the author; it enables a rapid quantitative evalution to be made of the performance of a system employing saturation magnetic recording.

The analysis is separated into two parts: the first is designed to characterize the recording system, and the second, the encoding system. For the former, the signal amplitude and the harmonic content of a reference pattern are of interest; for the latter, the calculated signal traces of complex bit patterns are of interest.

Thermal Pressing Analysis, B. Best, *American Ceramic Society Bulletin* **45,** No. 7, 658-660 (July 7, 1966).

The optimum sintering or hot-pressing temperature of matter can be determined by thermal-pressing analysis. Data for thermal-pressing analysis curves are obtained from a dilatometer hot-pressing unit wherein pressure, temperature, and densification are continually recorded, when the sample temperature is increased at a constant rate and the sample is under a constant compressive load. The dilatometer hot-pressing unit used to obtain these data is described and thermal-pressing curves for Linde-A alumina, nickel powder, and raw petroleum coke are presented.

Tomorrow's Manager and Displays, D. A. Lehman, *Proceedings of the Data Processing Management Association* **11,** (1966).

A fully management-oriented information system must include immediate access to numerous data bases, and should present all needed information in one convenient form, whether the information comes from digital storage or from, for example, a magnetic image file. The computer power, image storage technology, conversion equipment, and software now available make such a system a practical possibility. With a television terminal in the executive office to accept inquiries and display responses, the system subordinates all other requirements to the needs of the user. Displaying alphanumeric, graphic and pictorial information on demand or as programmed (in an attention file, for instance), the terminal becomes the personal tool of the executive. The television screen itself is overlaid, in effect, by a touch matrix which identifies positions on the images displayed, and thus permits a simple but infinitely variable inquiry language.

Total Internal Reflection Light Deflector,† M. A. Habegger, T. J. Harris, and J. Lipp, *Applied Optics* **5,** No. 9, 1403-1405 (September, 1966).

A digital electro-optic light deflector is described whose deflection elements are an isotropic plate and an optically birefringent plate immersed in a refractive index matching oil. Total internal reflection or complete transmission takes place at the birefringent plate according to the linear polarization state of the light beam. The deflector is suited for large deflections and a broad band of wavelengths.

† This work was partially supported by United States Electronics Research & Development Laboratories, Fort Monmouth, New Jersey.

A 2.5D Ferrite Memory Sense Amplifier, A. M. Patel and J. W. Sumilas, *IEEE Journal of Solid-State Circuits* **SC-1,** No. 1, 58-63 (September, 1966).

In recent years, large-core memories have been developed that use two-wire arrays and are operated in a mode colloquially called 2.5D. The intrinsic noise problem in a 2.5D ferrite memory system is quite severe because the core signals must be sensed off an array line which is also conducting a half-select drive current. The resulting large pedestal and delta noise components, which are generated during the read cycle, severely limit the memory performance. While the delta noise can be strobed out of the sense amplifier, the pedestal noise must be eliminated by circuit techniques. To handle this noise problem, a delay and difference amplification technique is used that permits a short recovery from the pedestal noise and a corresponding increase in memory speed. The implementation of this circuit function is shown, in the final analysis, to be a relatively simple filter used in conjunction with a conventional difference amplifier and detector.

A Vestigial-Sideband FM Modem, E. Hopner, R. W. Calfee and L. P. West, *Proceedings of the National Electronics Conference* **22,** pp. 375-377 (1966).

An experimental VSB-FM modem, with three-level coding, can transmit 4800 bauds over leased telephone lines. It can also provide the CCITT-recommended binary double-sideband FM operation at 1200 bauds over switched networks.

Dotierte SiO_2-Schichten als Quelle für die Sn- und Zn-Diffusion in GaAs (Tin and zinc diffusion into gallium arsenide from doped silicon dioxide layers), W. von Münch, *Physikalische Verhandlungen* **17,** No. 4, 79 (April, 1966).

Influence of Charge-Transfer Complexing on the Donor's Phosphorescence, K. B. Eisenthal, *Journal of Chemical Physics* **45,** No. 5, 1850-1851 (September 1, 1966).

Isolated GaAs Transistors on High-Resistivity GaAs Substrate, W. von Münch, H. Statz and A. E. Blakeslee, *Solid-State Electronics* **9,** No. 8, 826-827 (August, 1966).

Isolierte GaAs Transistoren auf hochohmigen GaAs Substrat (Insulated GaAs transistors on high-resistivity GaAs substrates), W. von Münch and H. Statz, *Physikalische Verhandlungen* **17,** No. 4, 91 (April, 1966).

Kerr Constant Dispersion for an Electronic Absorption, J. C. Powers, *Journal of the American Chemical Society* **88,** No. 15, 3679-3680 (August, 1966).

Das magnetische Moment eines stromdurchflossenen Wismut-Zylinders (The magnetic moment of a current-carrying bismuth cylinder), R. Jaggi, *Physikalische Verhandlungen* **17,** No. 4, 102 (April, 1966).

Magnetische Widerstandsänderung in Au-Fe-Legierungen (Magnetoresistance of Au-Fe alloys), von H. Rohrer, *Helvetica Physica Acta* **39,** No. 3, 201 (1966).

Magnetoacoustic Birefringence in Rare-Earth Iron Garnets, J. R. Franz and B. Lüthi,* *Helvetica Physica Acta* **39,** No. 3, 202 (May, 1966).

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