NATIONAL BUREAU OF STANDARDS REPORT

10343

PROJECTS and PUBLICATIONS
of the
APPLIED MATHEMATICS DIVISION

A Semi-Annual Report

July through December 1969

NBS

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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NBS PROJECT
205.00

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IMPORTANT NOTICE

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U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

APPLIED MATHEMATICS DIVISION FUNCTIONS

Conduct research and provide consulting services to the Bureau and other Federal agencies in various fields of mathematics important to physical and engineering sciences, automatic data processing, and operations research with emphasis on statistical, numerical and combinatorial analysis, and mathematical physics. Develop tools for mathematical work such as mathematical tables, handbooks, manuals, mathematical models and computational methods, and advise on their use. Provide training in disciplines related to these functions.

NUMERICAL ANALYSIS SECTION: The advancement of computation and the theory of numerical analysis, particularly in the development of computing algorithms, approximations to functions, and methods to facilitate the use of high speed electronic computers by subject matter specialists. Design of mathematical tables; exploratory calculations on automatic machines. Consulting services and training, and preparation of manuals in these fields. Research in underlying branches of pure and applied mathematics, such as matrix algebra, combinatorial analysis, and number theory.

OPERATIONS RESEARCH SECTION: Development and application of mathematical and computational techniques for the analysis, improvement or optimization of complex systems or activity-patterns. This includes (1) research in specific relevant areas of mathematics, such as linear programming, the theory of linear graphs, and the theory of strategic contests, (2) investigations in the art of constructing useful mathematical models of complex systems, and of obtaining information about the system by applying analytic or simulation methods, and (3) application of these techniques to selected problems, of general methodological significance, arising in the work of the Bureau or of other Government agencies lacking specialized personnel in this field.

STATISTICAL ENGINEERING SECTION: Consulting services in the application of mathematical statistics to physical science experiments and engineering tests, particularly in the design of experiments and in the analysis and interpretation of data. Research on pertinent topics in probability and mathematical statistics. Preparation of reports, manuals, tables, studies of computational methods and other aids to the application of modern statistical methods.

SYSTEMS DYNAMICS SECTION: Research and consulting in applied mathematics basic to physics and engineering, with emphasis on analysis of the dynamic behavior of complex physical systems. This involves, primarily, the development and application of techniques for solving linear and non-linear systems of differential equations and integral equations, or combinations of both. Of concern also is simulation of the behavior of physical systems by means of electronic computers using approximation techniques and semi-analytic methods. Attention is given to problems in plasma dynamics and the behavior of solid matter and multicomponent liquid systems, with emphasis on developing mathematical methods of wide range of applicability beyond the scope of the immediate problem. Investigations are carried out on the special functions encountered in the analysis and algorithms for their evaluation are prepared.

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[o] Only unclassified material is included in this report.

APPLIED MATHEMATICS DIVISION

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Stephen J. Pierce, Ph.D.
Justin C. Schaffert*

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Lambert S. Joel, B.A.
David Klavan, B.A.*
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Jeffery C. Lagarias
Joel Levy, M.A.
Philip Meyers, Ph.D.*
Martin H. Pearl, Ph.D.*
Patsy L. Saunders, B.S.
Roger D. Traub, B.A.*

*Part-time
**Postdoctoral Research Associate
***Guest Worker

°On Leave of Absence
[1] E.O.D. November 5, 1969
[2] Retired October 31, 1969

Status of Projects

1. NUMERICAL ANALYSIS

RESEARCH IN NUMERICAL ANALYSIS AND RELATED FIELDS

Task 20501-12-2050110/55-55

11540

Origin: NBS
Authorized 8/29/54
Manager: Morris Newman
Full task description: July - September 1954 issue, p. 1

Status: CONTINUED. M. Newman has proved that if η is a unit in the cyclotomic number field $R(\zeta)$, where ζ is a primitive pth root of unity and p is a prime > 3, then η is the rth power of another unit only if $|r| \leq \log N/\log(2 \cos \frac{\pi}{p})$, where N is the maximum of the absolute values of η and its conjugates. This result was applied to prove that a number of diophantine equations involving cyclotomic units had only trivial solutions.

M. Newman and L. Greenberg have proved that the density (in a well-defined sense) of solvable groups generated by elements of odd order is zero.

M. Newman has prepared several versions of his "exact solutions" program using only basic FORTRAN. These can be used immediately on any machine with a word length of 36 or more bits. Some dozen copies of this program have been distributed by request.

S. Haber completed writing a survey of the literature on numerical evaluation of multiple integrals.

F.W.J. Olver has continued the study of the method of stationary phase for the asymptotic expansions of oscillatory integrals. An improved form of error analysis has been constructed and is being tested on illustrative examples.

K. Goldberg extended his results on similarity for formal power series over fields, substituting a matrix equation for the determinant equation previously found.

K. Goldberg extended his tables of the coefficients in formal power series for various operations including product, iteration, inversion, and the related power series $L_f(z)$ defined by $L_f(f(z)) = L_f(z) \cdot f'(z)$;

S. Pierce has determined all multiplicative maps of the 2×2 matrices over a Dedekind ring which do not send all singular matrices to 0.

S. Pierce has proved that all members of the orthogonal group of a real positive multilinear form have only eigenvalues of modulus 1 and only linear elementary divisors.

Status of Projects

S. Pierce and R. Merris have shown that associated transformations on higher degree symmetry classes of tensors regarded as representations of the full linear group are always reducible. Investigations for the case of degree one symmetry classes are continuing.

S. Pierce has given a short proof using the Hilbert reciprocity law that -1 is a sum of two squares in any cyclotomic field of order m when m is divisible by a prime $p \equiv 3$ or $5 \pmod 8$.

R. Merris discovered a generalization, T, of the trace of a matrix. If A and B are complex $m \times n$ matrices, $(A,B) = T(B^*A)$ is a positive semidefinite hermitian (psdh) form. Suppose $H = (H_{ij})$ is an $mn \times mn$ block psdh matrix where H_{ij} is $m \times m$. Then $(T(H_{ij}))$ is psdh.

R. Merris and S. Pierce proved the space of $m \times n$ matrices with the generalized trace form is regular only if T is the trace. Research in this area is continuing.

S. Pierce and R. Merris proved that if A is a complex matrix of sufficiently large rank and if all the elementary divisors of $K(A)$ are linear then all the elementary divisors of A are linear. Here $K(A)$ is an associated transformation based on a group and an irreducible character of arbitrary degree.

R. Merris and W. Watkins discovered some conditions forcing isomorphism between symmetry classes of tensors.

R. Merris discovered an inequality for generalized matrix functions and block hermitian matrices.

Publications:

(1) Stochastic quadrature formulas. S. Haber. To appear in Math. Comp.

(2) Sequences of numbers that are approximately completely equidistributed. S. Haber. Submitted to a technical journal.

(3) On the sum $\sum < \alpha n >^{-t}$ and numerical integration. S. Haber and C.F. Osgood. To appear in Pacific Jour. of Math.

(4) Numerical evaluation of multiple integrals. S. Haber. Submitted to a technical journal.

(5) Lectures on modular forms. J. Lehner. AMS 61 of the NBS.

(6) Automorphic integrals with preassigned periods. J. Lehner. J. of Research NBS, 73B, 153-161 (1969).

(7) On the multipliers of the Dedekind modular function. J. Lehner. J. of Research NBS, 72B, No. 4, 253-261 (1968).

(8) Subgroups of SL(t,z). M. Newman. J. of Research NBS, 73B, 143-144(1969).

(9) Some results on unitary matrix groups. M. Newman and M. Marcus. To appear in J. of Linear Algebra.

(10) Some results on roots of unity, with an application to a diophantine problem. M. Newman. Aequationes Math. 2, 163-166 (1969).

(11) Isometric circles of congruence groups. M. Newman. Amer. J. Math. 91, 648-656 (1969).

(12) Principal ideals in matrix rings (with S. Pierce). M. Newman. J. of Research NBS, 73B, 211-213 (1969).

(13) Normal subgroups of the modular group. L. Greenberg and M. Newman. Submitted to a technical journal .

(14) A diophantine equation. M. Newman. J. London Math. Soc., 43, 105-107(1968).

(15) A table of the first factor for prime cyclotomic fields. M. Newman. To appear in Math. of Computation.

(16) Some results on solvable groups. L. Greenberg and M. Newman. To appear in Arch. der Math.

(17) On Riemann surfaces with maximal automorphism groups. J. Lehner and M. Newman. Glasgow Mathematical Journal, Vol. 8, Part 2, 102-112 (1967).

(18) An enumeration problem for a congruence equation. M. Newman and R. Brualdi. To appear in J. of Research NBS.

(19) Why steepest descents? F.W.J. Olver. To appear in Proceedings of 1969 SIAM National Meeting, June 10-12, 1969.

(20) Bounded matrix groups. M. Newman and S. Pierce. To appear in Journal of Linear Algebra.

(21) Orthogonal groups of positive definite multilinear functionals. S. Pierce. To appear in Pacific Jour. of Math.

(22) Multiplicative maps of matrix semigroups over Dedekind rings. S. Pierce. Submitted to a technical journal.

(23) Orthogonal decompositions of tensors spaces. S. Pierce. To appear in J. of Research NBS.

(24) Trace functions I . R. Merris. Submitted to a technical journal.

(25) Elementary divisors of higher degree associated transformations. R. Merris and S. Pierce. Submitted to a technical journal.

(26) A class of representations of the full linear group. R. Merris and S. Pierce. Submitted to a technical journal.

(27) Isomorphic symmetry classes of tensors. R. Merris and W. Watkins. Submitted to a technical journal.

(28) Partitioned hermitian matrices. R. Merris. To appear in J. of Research NBS.

2. OPERATIONS RESEARCH

CONSULTATION IN MATHEMATICAL OPERATIONS RESEARCH

Task 205-12-2050151

Origin and Sponsor: NBS 11570 Authorized 12/30/60
Manager: A.J. Goldman
Full task description: October-December 1960 issue, p.3

Status: CONTINUED.

(1) Demand for miscellaneous consulting and advisory services remained heavy. Section staff provided such services in 99 recorded instances, 46 involving assistance to NBS staff. The 99 instances totalled to 695 recorded man-hours. Other agencies assisted included the Civil Service Commission, National Science Foundation, Office of Emergency Planning, Maritime Administration, Law Enforcement Assistance Agency, and Bureau of the Budget. Requests from universities, industry, professional groups and journals were also met.

(2) J. Gilsinn continued collaboration with the Information Processing Technology Division in a study, for the Federal Aviation Authority, to improve air traffic designation procedures. A previously-written simulation program was documented and applied to test an initial scheme for assigning radar beacon codes to airplane flights; the results were analyzed and documented. (Reported here for convenience; supported under Project 6505453.)

(3) A.J. Goldman, W.A. Horn, J. Levy and M.H. Pearl completed a collaborative effort with the Technical Analysis Division on another study for the FAA, this one to analyze a proposed new "capacity" concept for an airport runway and the associated final-approach airspace. For a single stream of customers, the concept was shown (using the theory of Markov renewal process) to be representable by a simple formula useful for planning and analysis purposes. The theoretical development and illustrative calculations were documented, and also presented orally at several briefings for interested FAA personnel. (Reported here for convenience; supported under Project 4314449.)

(4) W.G. Hall continued helping the Army Data Field Systems Command in planning, design and numerical-analysis aspects of a new tactical artillery-fire control system. Efforts included contractor monitoring, and design and testing of a short course in basic computer programming and numerical analysis for the Fort Sill Artillery Training School. (Reported here for convenience; supported under Project 6505425.)

(5) Goldman, Hall, Horn, and L.S. Joel continued assistance to the Post Office Department's Bureau of Research and Engineering in technical interfacing with contractors concerning computerized models and data analysis. P. Saunders began assistance to the Technical Analysis Division in a simulation study of Coast Guard search and rescue operations. (Reported here for convenience; supported under Project 4314561.)

(6) A.J. Goldman began service as Associate Editor of the Operations Research Society's "Transportation Science" journal, and Vice-Chairman of the Society's Transportation Science Section.

Publications

(1) M. Aronoff (Div. 431), A.J. Goldman *et al*. Analysis of a capacity concept for runway and final-approach path airspace. NBS Report 10 111, 11/69.

(2) R.D. Elbourn (Div. 650) and J.F. Gilsinn. Simulation of Air Traffic Control radar beacon code assignment plans (final report on Phase 1). NBS Report 10 117.

(3) A.J. Goldman and P.R. Meyers. Simultaneous contractification. Journal of Research NBS, 73B (1969), pp. 301-305.

(4) A.J. Goldman. Systems analysis and urban problems (Discussion). To appear in Proc. Symposium on Systems Analysis for Social Problems, 5/69.

(5) W.A. Horn. Some fixed point theorems for compact maps and flows in Banach spaces. To appear in Trans. Amer. Math. Soc.

(6) W.A. Horn. Convex homotopy. Submitted to a technical journal.

(7). W.A. Horn. Optimal design of sorting networks. NBS Report 10 146 (1/70).

COMBINATORIAL METHODS

Task 205-12-2050152

Origin and Sponsor: NBS 11540 Authorized 12/30/60
Manager: A.J. Goldman
Full task description: October-December 1964 issue, p.3; April-June 1962, p.15

Status: CONTINUED

(1) J. Gilsinn (and C. Witzgall of Boeing Scientific Research Labs) continued experiments and documentation on the comparison of shortest-path algorithms.

(2) A.J. Goldman continued studies relating to the optimal location of facilities in networks. He and C. Witzgall generalized the theorem that a single node, which produces half or more of the total flow, must itself be an optimal location.

(3) L.S. Joel initiated computer implementation of J. Edmonds' algorithm for minimum-cardinality partition of a matroid into independent sets. The program "frame" for general matroids, and the subroutine to make it applicable to graphical matroids, were programmed.

Publications

(1) J. Edmonds and D.R. Fulkerson (RAND). Bottleneck extrema. To appear in J. Combinatorial Theory.

(2) J. Edmonds and O. Shisha (Wright-Patterson A.F.B.). Acute bijections. To appear in J. Combinatorial Theory.

(3) A.J. Goldman. Optimal locations for centers in a network. Transportation Science 3 (1969), pp. 352-360.

LINEAR AND NON-LINEAR PROGRAMMING

Task 205-12-2050153

Origin and Sponsor: NBS 11540 Authorized 12/30/60
Manager: W.G. Hall
Full task description: October-December 1960 issue, p.3

Status: CONTINUED

(1) W.G. Hall and P. Saunders continued work to improve the capabilities for linear programming calculations at NBS. Testing has revealed flaws in several proposed programs; particularly hazardous are those in which an erroneous solution (or an incorrect "no solution" indicator) are given without warning.

(2) A.J. Goldman continued studying the minimax error selection of incompletely specified discrete probability distributions, examining the problem of disaggregating an exactly or approximately "given" distribution.

Publications

(1) A.J. Goldman. Minimax error selection of a univariate distribution with prescribed componentwise bounds and ranking. Journal of Research NBS, 73B (1969), pp. 225-230.

(2) A.J. Goldman. Minimax adjustment of a univariate distribution to satisfy componentwise bounds and/or ranking. Journal of Research NBS, 73B (1969), pp. 231-239.

(3) W.A. Horn. A theorem on convex hulls. Journal of Research NBS, 73B (1969), pp. 307-308.

SCHEDULING AND ROUTING IN INTER-URBAN TRANSPORT

Task 205-12-2058456

Origin: Technical Analysis Division, NBS 21550
Sponsor: Northeast Corridor Transportation Project, Dept. of Transportation
Manager: P.B. Saunders

Full task description: This is one of three projects into which our work for the Northeast Corridor Transportation project has been split. Its objective is to continue the development, computer implementation and application of methods to obtain "good" operating rules for transport systems.

Status: NEW

(1) P. Saunders continued work on integrating rail scheduling algorithms and demand forecasting models. Contractor reports on rail and air-flight scheduling were reviewed.

(2) D. Klavan programmed and debugged the algorithm developed by G. Nemhauser (Johns Hopkins U.) for jointly optimal scheduling of local and express service along a line of stations. A slightly revised version, to handle two "locals" which compete over some interior links of the line, was also developed.

Publication

(1) D.R. Young (now of Stanford U.). Passenger transportation scheduling. NBS Report 10 049 (6/69).

PASSENGER DEMAND MODELS FOR INTER-URBAN TRANSPORT

Task 205-12-2050457

Origin: Technical Analysis Division, NBS 21550
Sponsor: Northeast Corridor Transportation Project, Dept. of Transportation
Manager: A.J. Goldman

Full task description: This is one of three projects into which our work for the Northeast Corridor Transportation Project has been split. Its objective is to develop, calibrate and prototype-test improved passenger-demand forecasting models.

Status: NEW

(1) L.S. Joel began an analysis of the promise for model use of various additional explanatory variables describing characteristics of the transport system. He and J. Lagarias initiated an investigation of the relationship between intercity passenger trip volumes and telephone-call volumes.

(2) A.J. Goldman and R. Ku (Division 431) examined two model modifications: one reflecting the idea that auto-driver fatigue increases more than linearly with trip time, the other revising the modal-split submodel to incorporate a probabilistic lower limit on acceptable conductance. Neither change significantly improved the fit to the present data set.

(3) J. Gilsinn, A.J. Goldman and R. Traub reviewed contractor reports and related literature. Ku completed a summary chapter on the model currently used by the Corridor Project; Goldman (with M. Cheslow of DOT) began a more extensive documentation.

Publication

(1) J. Gilsinn. Roles of demand models in the Northeast Corridor Transportation Project. NBS-NECTP Working Paper No. 12, 7/69.

MISCELLANEOUS MATH SERVICES CONCERNING INTER-URBAN TRANSPORT

Task 205-12-2058458

Origin: Technical Analysis Division, NBS 21550
Sponsor: Northeast Corridor Project, Department of Transportation
Manager: A.J. Goldman

Full task description: This is one of three projects into which our work for the Northeast Corridor Transportation Project has been split. Its objective is to provide miscellaneous mathematical services and exploratory research for the Northeast Corridor Transportation Project (NECTP).

Status: NEW

(1) J. Levy and M.H. Pearl continued developing methods for evaluating feedback vs. non-feedback flow regulation at a merge point in a transport network. A comparison of the performance of non-feedback, feedback, and "prophesying" control was begun.

(2) W.A. Horn completed studying an approach to the design of transport networks when minimizing the number of access points is of prime concern. He also assisted in review of contractor documents.

(3) A.J. Goldman assisted in editing the first draft of the NECTP 12/69 Report.

Publications

(1) J. Levy and M.H. Pearl. Feedback regulation of traffic at an intersection of two streams. NBS-NECTP Working Paper No. 11 (9/69).

(2) M. Krakowski (Tulane U.). Adaptive switching and routing in transport networks. NBS-NECTP Working Paper No. 13 (10/69).

(3) W.A. Horn. Optimal Networks Joining N Points in the Plane. Strassenbau und Strassenverkehrstechnik, 86 (1969), (Beitrage zur Theorie des Verkehrsflusses), pp. 161-166.

3. PROBABILITY AND MATHEMATICAL STATISTICS

RESEARCH IN PROBABILITY AND MATHEMATICAL STATISTICS

Task 20503-12-2050131/63-1259
1150

Origin: NBS
Manager: Joan Raup Rosenblatt
Full task description: July - December 1962

Authorized 10/1/62

Status: CONTINUED. Brian L. Joiner and Eleanor S. Brown, in collaboration with Bert Levy (Harry Diamond Labs.) and N. F. Laubscher (National Research Inst. for Math. Sciences, South Africa), completed the preparation of a combined author and permuted title index for seven statistics journals, including articles published since the most recent cumulative subject index to each of the journals. The index was prepared using a computer program written by the late W. W. Youden (NBS Center for Computer Sciences and Technology).

James J. Filliben is completing a study of the nature of the percent point function (ppf)--the inverse cumulative distribution function. It is shown that a number of statistical procedures have a simpler and more natural expression in terms of the ppf rather than in terms of the cumulative distribution function. Various simplifications in probability theory and order statistic theory are presented. The use of the ppf in random number generation and probability plots is discussed. An alternative set of measures of distributional characteristics based on the ppf, rather than on the moments, is introduced. The behavior of the ppf under various types of transformations is considered. The use of the ppf in generating distributions with pre-specified tail length is demonstrated.

Publications:

(1) The median significance level and other small sample measures of test efficacy. B. L. Joiner. J. Amer. Statist. Assoc., 64 (1969), 971-985.

(2) Student-t deviate corresponding to a given normal deviate. B. L. Joiner J. Res. NBS - C. Engineering and Instrumentation, 73C (1969), 15-16.

(3) Some properties of the range in samples from Tukey's symmetric lambda distributions. Brian L. Joiner and Joan R. Rosenblatt. Submitted to a technical journal.

(4) An author and permuted title index to selected statistical journals. Brian L. Joiner, N. F. Laubscher (Nat'l. Res. Inst. for Math. Sciences, S. Africa), Eleanor S. Brown, and Bert Levy (Harry Diamond Labs., U. S. Army). To appear as NBS Special Pub. 321.

(5) Approximating discrete probability distributions. H. H. Ku and S. Kullback (G.W.U.). IEEE Transactions on Information Theory, IT-15 (1969), 444-447.

(6) Analysis of multi-dimensional contingency tables. H. H. Ku, R. N. Varner and S. Kullback (George Washington Univ.). To appear in Proc. 14th Conf. on Design of Experiments in Army Research Development and Testing.

(7) An application of minimum discrimination information estimation to a problem of Grizzle and Berkson on the test of "no interaction" hypothesis. H. H. Ku and S. Kullback (G.W.U.). Submitted to a technical journal.

(8) Symmetry and marginal homogeneity of an r x r contingency table. C. T. Ireland, S. Kullback (G.W.U.), and H. H. Ku. To appear in J. Amer. Statist. Assoc.

(9) An evaluation of linear least squares computer programs. Roy H. Wampler. J. Res. NBS-B. Math. Sciences, 73B (1969), 59-90.

(10) An evaluation of linear least squares computer programs: A summary report. Roy H. Wampler. To appear in Proc. 14th Conf. on Design of Experiments in Army Research Development and Testing.

(11) A report on the accuracy of some widely used least squares computer programs. Roy H. Wampler. To appear in J. Amer. Statist. Assoc.

DEVELOPMENT OF "OMNITAB"

Task 20503-12-2050131
11550

Origin and Sponsor: NBS Authorized 11/1/68
Managers: David Hogben, Sally T. Peavy
Full task description: July - December 1968

Status: CONTINUED. David Hogben, Sally T. Peavy, Ruth N. Varner and Shirley G. Bremer continued work on the development of the OMNITAB system. M. Stuart Scott developed a command for correlation analysis with detailed automatic printing. Eight new versions have been implemented successively. Details of the changes made appeared in the three Newsletters issued. A set of twelve instructions for performing operations on magnetic tape were added to the system. R. C. McClennon (Office of Standard Reference Data) contributed two commands for array operations. Other commands were added for printing data and Gauss quadrature.

Many improvements were made in the printing and curve fitting commands. Results are now normally printed according to the "readable" format. The automatic printing for the least squares instructions has many valuable additions, in particular, one page containing four different plots of standardized residuals.

An important change was made in the word length of alpha/numeric data so that OMNITAB is now as machine independent as the state of the art will permit.

Publications:

(1) The use of OMNITAB for statistical analysis of tabular data. Joan R. Rosenblatt, Brian L. Joiner, and David Hogben. To appear in Census Tract Papers: Papers Presented at the Conference on Small-Area Statistics, American Statistical Association, New York, August 21, 1969.

4. STATISTICAL ENGINEERING SERVICES

COLLABORATION ON STATISTICAL ASPECTS OF

NBS RESEARCH AND TESTING

Task 13911-612050950/51-1
99500

Origin: NBS Authorized 7/1/50
Managers: H. H. Ku, J. R. Rosenblatt
Full task description: July - September 1950 issue, p. 60

Status: CONTINUED. This is a continuing project involving cooperation with other Bureau scientists on the statistical aspects of their investigations. These services vary from short (one-hour) sessions to extended collaborations involving several man-months; and are concerned primarily with statistical design of experiments, analysis and interpretation of data, and the use of computers in statistical analysis of data. Typical examples of the services performed are the following.

Brian L. Joiner is on detail to the Boulder Laboratories for one year, at the request of the NBS Office of Measurement Services. His primary mission is to help them establish cooperative calibration programs and to provide better information to support the uncertainty statements on the reports of calibration. So far effort has concentrated on the analysis of existing data and the planning of experiments to obtain further data on coaxial and microwave bolometers.

Brian L. Joiner presented a talk on "Error Analysis" at a Laser Power and Energy Measurement Seminar sponsored by the Quantum Electronics Section of the Radio Standards Physics Division.

Brian L. Joiner assisted John Dean and Douglas Mann (Cryogenic Metrology Section) in the planning and analysis of experiments to evaluate cryogenic flow meters.

The Statistical Engineering Laboratory continues to distribute within the Bureau occasional notes on useful subroutines and documentation aids, for computer users who are not primarily computer specialists. Three recent notes, for example, describe and give details for using plotting subroutines and programs applicable with equipment available at the Bureau. Sally T. Peavy and Ruth N. Varner are the chief contributors to the series, but notes have also been written by other members of the Statistical Engineering Laboratory and by persons in other Bureau divisions.

Roy H. Wampler and Joan R. Rosenblatt are collaborating with G. L. Howett (NBS Office of Colorimetry) on the analysis of the latest in a series of cooperative paired comparison experiments conducted by the Committee on Uniform Color Scales of the Optical Society of America.

Joan R. Rosenblatt collaborated with M. A. Bond, Jr. (NBS Library) to develop and execute a simple sample design to estimate the distribution by publication date of the library's books (not including journals).

Mary G. Natrella presented three lectures on "Statistics of Measurement" for senior technicians from the State Weights and Measures Departments of Hawaii, California, and Illinois. Staff members of the NBS Office of Weights and Measures also attended the lectures.

James J. Filliben collaborated with George Hicho (312.01) and Harvey Yakowitz (312.03) in the preparation and testing design of specimens for X-ray diffraction standards -- about 1000 pellets compacted from 5 weight percent 310 stainless steel powder and 95 weight percent 430 stainless steel powder.

Publications:

(1) Interlaboratory comparison of the potential heat test method. D. Gross (Fire Research Section) and M. G. Natrella. Submitted to a technical journal.

STATISTICAL SERVICES

Task 20503-40-2050132/58-346
11550

Origin and Sponsors: Various Agencies Authorized 3/31/58
Manager: J. R. Rosenblatt
Full task description: January - March 1958 issue, p. 45

Status: CONTINUED. This is a continuing project which involves providing, upon request, statistical services to other governmental agencies, universities, industrial organizations, and other non-governmental agencies. Approximately 30 such requests are handled per month ranging from short conferences to collaboration involving several days work.

Janace A. Speckman used OMNITAB to perform 144 least squares straight line fits to data on the Federal Court of Appeals workload, in response to a request from James A. McCafferty of the Division of Procedural Studies and Statistics, Administrative Office of the United States Courts. Projections for 1970 to 1975 were computed and plotted for all 11 circuits combined and for each circuit separately for 6 variables -- (total number of appeals, number of prisoner petitions, etc.) using data from 1960 to 1969. Projections were also made using only the data from 1965 to 1969 to see if the trends have changed.

The Statistical Engineering Laboratory was asked by the NBS Center for Computer Sciences and Technology to participate in one of a series of orientation meetings for a group of foreign trainees (sponsored by the Agency for International Development) from the Census Bureau's Office of International Statistical Programs. The group included several computer programmers with particular interest in statistical computations.

In response to requests, twenty-two copies of the OMNITAB program were distributed.

5. SYSTEMS DYNAMICS

RESEARCH IN SYSTEMS DYNAMICS
AND RELATED FIELDS

Task 20540-12-2050141/55-57

Origin: NBS
Manager: H. J. Oser
Full task description: July-September 1954 issue, p. 27

Authorized 9/1/54

In consultation with Dr. J. A. Simmons of the Metallurgy Division (312.05) and Dr. E. A. Kearsley of the Mechanics Division (213.05), J. T. Fong proved that the problem of the finite deformation of a memory-dependent material continuum of the Bernstein-Kearsley-Zapas type (Trans. Soc. Rheology, 7, 391-410 (1963) is equivalent to a variational problem for a rheonomic system, i.e. the local Lagrangian depends on the time t explicitly. A manuscript entitled "On the existence of an action principle for a dissipative continuum" is being prepared for review and discussion.

In collaboration with Mr. L. J. Zapas of the Mechanics Division (213.05), J. T. Fong showed that the classical theory of plasticity in which the time t is not a physical variable but a mathematical parameter, can be modeled after the Bernstein-Kearsley-Zapas' theory of a memory-dependent material provided the elastic potential of the BKZ theory is a homogeneous function of the variable t' of degree -1, where t' is the difference between the current time and some time in the past. Work is continuing to derive some basic features of a special plasticity theory from a class of the memory-dependent elastic potentials of the BKZ theory.

Progress is also being made in a long-term project to find the necessary and sufficient conditions for the equivalence of the geometric theory of an "imperfect" material continuum due to Kondo, Bilby, Kroner, etc. and the history-dependent kinematic theory of a "simple" material due to Truesdell, Noll, Wang, etc. To discuss some of his findings, J. T. Fong visited Professor Y. C. Wong of the Department of Mathematics, University of Hong Kong, as a guest worker with the title of Visiting Research Fellow from July 5 to July 12, 1969 during which J. T. Fong also delivered the following two talks:

"Microscopic Theories of Engineering Materials" - University of Hong Kong:
Department of Civil Engineering Seminar, July 4, 1969;
"Applications of Differential Geometry in Continuum Physics" - University
of Hong Kong: Dept. of Mathematics Seminar, July 9, 1969.

R. S. Kraft obtained a constructive existence proof for a pure initial-value problem associated with a linear transport equation. A paper on this subject is being prepared. Ideas for deriving a-priori bounds for an approximation scheme associated with a boundary-initial problem for a linear transport equation have been obtained.

The study of a finite-difference scheme for the Nernst-Planck equations is continuing. Techniques for establishing the positivity and convergence of the non-linear iterates are being examined.

R. S. Kraft discovered also a possibility for generalizing a method of reflecting solutions of elliptic systems. The method, if feasible, would allow continuation across an analytic boundary when the solution of the system satisfies very general conditions on the boundary.

H. J. Oser completed, jointly with J. E. McKinney of the Rheology Section (213.05), two manuscripts dealing with acoustic propagation in viscous and inviscid, heat-conducting media. The authors show that certain solutions of the underlying fourth-order partial differential equation are not stable, a result which has not been reported heretofore in the literature. In viscous fluids the instability does not occur if the viscosity exceeds a certain critical value which depends on the ratio of the specific heats, the Prandtl number, and the viscosity.

Continuing his effort to provide an improved automatic numerical integration routine for OMNITAB, D. W. Lozier produced and checked out a Fortran program that uses an adaptive Simpson procedure. He also completed and submitted to American University a paper entitled "Fréchet Differential Calculus" as the final requirement for the MA degree, which was awarded in August. In another project, he developed an algorithm, and produced an implementing Fortran program, to determine with a high degree of precision the volume of a nearly perfect sphere from experimental data taken by measuring deviations from roundness of great circles on the sphere. This work was done for P. E. Pontius and H. A. Bowman of 213.31 (Mass and Volume Section, Metrology Division). Several test cases were run to check out both the algorithm and the program. Finally, he provided mathematical and computer programming support for W. L. Sadowski and other staff members of NBS.

Z. G. Ruthberg compared the efficiencies of several matrix inversion programs and two programs for finding roots of polynominals. This effort is intended to involve the Section more deeply in the program for algorithm testing and development.

Z. G. Ruthberg also continued work on the binomial operator $[a(x,y)\frac{\partial}{\partial x} + b(x,y)\frac{\partial}{\partial y}]^n$. A FORTRAN program is now available that produces the successive powers n of this operator. This new program is far more efficient (concerning the storage requirement) and faster than the earlier LISP program.

Consultations to and cooperative activities with other Bureau units continued throughout the period. These involved contacts with the Metrology Division (now a part of the Atomic Physics Division), the Mechanics Division, the Electronic Technology Division and the Heat Division. The Mass and Volume Section of the Metrology Division is concerned with determining with high precision the volume of almost perfect spheres. A method was developed with that group to determine the volume corrections numerically from a suitable number of traces along approximate great circles of the pseudo sphere. The results appear to offer a new and considerably more economical way of obtaining precise volumes for purposes of density and mass determinations.

Another effort for the Laser group in the Metrology Division is devoted to checking whether anomalous light propagation may take place in certain laser optical arrangements. There is some speculation that such might be the case. The investigations are not conclusive so far.

Work with J. E. McKinney (213.05) was completed on the propagation of sound in viscous and inviscid media. A paper dealing with viscous case will appear in Jour. of Acoustical Society of America in the January 1970 issue. The paper on the inviscid case was submitted to the Washington Editorial Review Board for approval to appear in the NBS Journal of Research.

Shorter consultations with members of the Heat Division and the Electronic Technology Division involved the solution of integral equations and boundary value problems.

H. J. Oser served as editor and translator of a book on the theory and computation of boundary layers, published by M.I.T. Press Inc.

Publications:

(1) Stability of Acoustic Waves within a Viscous, Compressible, Heat-Conducting Fluid. J. E. McKinney and H. J. Oser. To appear in the Jour. of Acoustical Society of America, Vol. 47, No. 1, Jan. 1970.

(2) A. Walz (edited and translated by H. J. Oser): Boundary Layers of Flow and Temperature. M.I.T. Press, Inc., October 1969.

MATHEMATICAL METHODS IN PLASMA PHYSICS

Task 20504-12-2050140/59-442
11540

Origin: NBS
Manager: Walter L. Sadowski
Full task description: October-December 1961 issue, p. 12

Authorized 10/13/61

A high-order Taylor series expansion in the time variable for the numerical solution of the Vlasov equation has been developed. The expansion permits the use of a smaller number of Hermite polynominals and has a very small truncation error. The error is explicitely calculated. In addition to the higher speed, the algorithm makes it possible to study truncation errors in both Fourier and Hermite space.

The results show that the use of the electric field as a criterion for numerical stability is wholly inadequate, numerically unstable runs giving substantially the same value of the electric field as stable runs. This indicates that numerical studies of processes that are highly dependent on kinetic effects in plasma, such as bump on tail, must be re-examined to insure that the results obtained were numerically accurate.

Work is in progress to determine the minimum size of eigenfunction expansion sets for various values of parameters. A paper on this topic is in preparation.

A one-day workshop was held at NBS on October 15, 1969. The workshop dealt with the numerical solution of the Vlasov equation. Among the topics discussed were the relative merits of the different methods of solving the equation, reliability of results, numerical difficulties encountered and ways of dealing with these.

During this conference the participants decided that a file of preprints should be held at NBS and a newsletter be sent out to the participants to keep them informed on what the various groups around the country are doing. No agreement on intercomparison of results has been reached, but a two-week working session, possibly at NBS, has been suggested for the summer of 1970 and the matter will be taken up again.

Publications

(1) Temperature Renormalization in the Non-Linear Vlasov Equation. W. L. Sadowski and Z. G. Ruthberg. J. of Research NBS, Vol. 73B, pp. 281-291, Dec. 1969.

(2) Selective Excitation of Harmonics in a Collisionless Plasma by Two Counterstreaming Electron Beams. W. L. Sadowski and Z. G. Ruthberg. J. of Research NBS, Vol. 73B, pp. 293-300, Dec. 1969.

BIOMEDICAL IMAGE AND LANGUAGE PATTERN PROCESSING

Task 20500-12-2050404

51560

Origin: NBS
Sponsor: National Institutes of Health
Manager: Russell A. Kirsch
Full task description: January-June 1964 issue, p. 19

Authorized 1/21/64

Status: CONTINUED. The general procedure developed on the Q32 computer for automatic segmentation of quantized images which yields as output a partial ordering (induced by the inclusion relation) of all morphological objects in an image was continued as elements of this partial ordering served as inputs for a higher level syntactic analysis. These procedures were applied to optical serial section photographs of a double neuron which were made using a programmable microscope stage and focus connected to the LINC-PDP-8 computer. The sections were then reconstructed and the morphological analyzer was also used to reconstruct an optical intensity photograph of two chromosomes.

SCANNING MICROSCOPE PROCESSING

Task 20500-2050408

51560

Origin: NBS
Sponsor: National Institutes of Health
Manager: Russell A. Kirsch
Full task description: July-December 1968 issue, p. 14

Authorized 6/18/68

Status: CONTINUED. Progress was made in the study of the use of a programmable scanning microscope controlled by a PDP-8 digital computer.

CHEMICAL BIOLOGICAL INFORMATION PROCESSING

Task 20500-2050410

51560

Origin: NBS
Sponsor: National Institutes of Health
Manager: Russell A. Kirsch
Full task description: July-December 1968 issue, p. 14

Authorized 6/27/68

Status: CONTINUED. Further efforts were made to coordinate the use of remote computers in communicating pharmacological information regarding chemical structure and biological activity among a group of collaborating pharmacologists. Advisory work continued on Chemical Biological Information Handling techniques.

MATHEMATICAL TABLES

Task 20500-40-2050121/57-216

11550

Origin and Sponsor: NBS
Manager: I. A. Stegun
Full task description: July-December 1964 issue, p. 4.

Status: CONTINUED. Consultation continued with the staff of NBS, other government agencies, industry and universities. The topics covered were tables of special functions, general computing techniques and computational pitfalls.

I. A. Stegun and R. Zucker, with emphasis on special functions, have continued(1) the file maintenance of available algorithms, approximations and programs (2) the critical examination of available algorithms and approximations (3) the testing of the implementing subroutines. A paper has been prepared on automatic computing methods for special functions- in particular- the error and complementary error function. The FORTRAN program yielding full machine accuracy for both functions over the entire range will be presented together with the test program and sample results.

In the course of the testing of subroutines, hardware and software errors have been detected. In particular, double precision multiplication yielded incorrect single precision results under certain conditions; the compiler set up the computation of an external factor as an internal factor in a summation. In collaboration with the Center for Computer Sciences and Technology, the hardware error was corrected and the software error is being further analyzed.

Lectures and Technical Meetings

Workshop on Vlasov Equations

October 15, 1969

Some of the aspects discussed were as follows:

Dawson, J.	(Princeton University) Particle vs. distribution function models
Armstrong, T.	(University of Kansas) Intercomparison of eigenfunction expansion with the Los Alamos codes
Feix, M.	(University of Nancy, France) The waterbag model
Danovitt, J.	(NRL) Fourier-Fourier transform method for the solution of the Vlasov equation
Meier, H.	(Oak Ridge Laboratory) On some aspects of truncation in Fourier-Fourier transforms of the Vlasov equation
Kruskal, M.	(Princeton University) Some remarks on the stability
Symon, K.	(Madison, Wisconsin) Bit pushing for simulation of particle models
Sádowski, W.	(Systems Dynamics Section) Setting up of a coordination center and the problem of intercomparison of numerical results

Systems Dynamics Seminar

Shere, Kenneth D.	NASA-Goddard Space Flight Center and University of Nebraska, Lincoln, Nebraska. Oscillation Theorems for a Class of Delay Equations. July 23.
Gilsinn, David	Melpar, Inc. (A Division of American Standard Co.), Falls Church, Va. Domains of Stability of Integral Manifolds for Some Nonlinear Differential Equations. Nov. 12.
Martin, Monroe H.	Institute for Fluid Dynamics, University of Maryland. A New Method for Finding Exact Solutions of the Navier-Stokes Equations. Dec. 10.

Mathematics Division Expository Lectures

HOGBEN, D.	Computing for the Countless. July 23.
WALKER, J. C.	(Center for Computer Sciences and Technology) Categorical Algebra as a New Approach to Mathematics. September 17.
OLVER, F. W. J.	The Method of Chester, Friedman and Ursell -- Asymptotic Expansion of Definite Integrals Having Two Nearly Coincident Saddle-Points. October 22.
SADOWSKI, W. L.	The Numerical Solution of Differential Equations by an Nth-Order Runge-Jutta Method. December 3.
JOEL, L. S.	Loose Ends in the Theory of Games. December 17.

NBS Graduate School, Fall Semester

PEAVY, S. T.	Fortran Programming for Beginners

Papers and Invited Talks Presented by Members of the Staff at Meetings of Outside Organizations

FILLIBEN, James J.	Simple and robust estimation of the location parameter of a symmetric distribution. Institute of Mathematical Statistics, New York, August 21.
FONG, J. T.	Microscopic theories of engineering materials. University of Hong Kong, Department of Mathematics seminar. July 9.
GOLDMAN, A. J.	The adequacy of management science technology for non-military applications in the Federal Government. American Society for Public Administration, seminar on Management Science in the Federal Civilian Government. Sept. 18.
HOGBEN, David	Computing for the countless. American Statistical Association, New York, August 19.
JOINER, Brian L.	The use of OMNITAB for statistical analysis of tabular data. American Statistical Association, Conference on Small Area Statistics, New York, August 21.
KIRSCH, R. A.	Using computers as visual rather than verbal devices. D. C. Teachers' College, October 16.
KIRSCH, R. A.	Computer determination of the constituent structure of biological images. Computer Science Colloquium, Rutgers University, December 5.
KRAFT, R. S.	Convergence of semi-discrete approximations of linear transport equations. University of Oregon, Eugene, Oregon, August 29.
KU, H. H	Analysis of multidimensional contingency tables: An information theoretic approach. International Statistical Institute, London, September 5.
NEWMAN, M.	Number theoretic subroutines for high speed digital computers, Oxford, England, August 20.
	Computational problems connected with certain matrix groups, Oxford, England, August 21.
	Normal subgroups of the modular group, Madison, Wisconsin, October 28.
VARNER, Ruth N.	OMNITAB. Washington Statistical Society and Urban Regional Information Systems Association, September 30.

PUBLICATIONS ACTIVITIES

1.0 PUBLICATIONS THAT APPEARED DURING THIS PERIOD

1.2 Monograph

Lectures on Modular Forms. J. Lehner. AMS 61.

1.3 Technical Papers

Minimax Error Selection of a Univariate Distribution with Prescribed Componentwise Bounds and Ranking. A. J. Goldman. J. of Research NBS, 73B (1969), pp. 225-230.

Minimax Adjustment of a Univariate Distribution to Satisfy Componentwise Bounds and/or Ranking. A. J. Goldman. J. of Research NBS, 73B (1969), pp. 231-239.

Simultaneous Contractification. A. J. Goldman and P. R. Meyers. J. of Research NBS, 73B (1969), pp. 301-305.

Optimal Locations for Centers in a Network. A. J. Goldman. Transportation Science 3, (1969), pp. 352-360.

A Theorem on Convex Hulls. W. A. Horn. J. of Research NBS, 73B (1969), pp. 307-308.

Optimal Networks Joining N Points in the Plane. W. A. Horn. Strassenbau und Strassenverkehrstechnik, 86 (1969), (Beitrage zur Theorie des Verkehrsflusses), pp. 161-166.

The Median Significance Level and Other Small Sample Measures of Test Efficacy. B. L. Joiner. J. Amer. Statist. Assoc., 64 (1969), 971-985.

Student-t Deviate Corresponding to a Given normal Deviate. B. L. Joiner. J. of Research NBS, 73C (1969), pp. 15-16.

Approximating Discrete Probability Distributions. H. H. Ku and S. Kullback (G.W.U.) IEEE Transactions on Information Theory, IT-15 (1969), 444-447.

Automorphic Integrals with Preassigned Periods. J. Lehner. J. of Research NBS, 73B, 153-161 (1969).

On the Multipliers of the Dedekind Modular Function. J. Lehner. J. of Research NBS, 72B, No. 4, 253-261 (1968).

On Riemann Surfaces with Maximal Automorphism Groups. J. Lehner and M. Newman. Glasgow Mathematical Journal, Vol. 8, Part 2, 102-112 (1967).

Some Results on Roots of Unity with an Application to a Diophantine Problem. M. Newman. Aequationes Math. 2, 163-166 (1969).

Subgroups of SL(t,z). M. Newman. J. of Research NBS, 73B, 143-144 (1969).

Isometric Circles of Congruence Groups. M. Newman. Amer. J. Math., 91, 648-656 (1969).

Principal Ideals in Matrix Rings. M. Newman and S. Pierce. J. of Research NBS, 73B, 211-213 (1969).

Temperature Renormalization in the Non-Linear Vlasov Equation. W. L. Sadowski and Z. G. Ruthberg. J. of Research NBS, Vol. 73B, No. 4, pp. 281-291, (Dec. 1969).

Selective Excitation of Harmonics in a Collisionless Plasma by Two Counterstreaming Electron Beams. W. L. Sadowski and Z. G. Ruthberg. J. of Research NBS. Vol. 73B, No. 4, pp. 293-300, (Dec. 1969).

An Evaluation of Linear Least Squares Computer Programs. Roy H. Wampler, J. of Research NBS, 73B (1969) 59-90.

1.5 Books

A. Walz (edited and translated by H. J. Oser): Boundary Layers of Flow and Temperature. M.I.T. Press, Inc. October 1969.

2.0 MANUSCRIPTS IN THE PROCESS OF PUBLICATION

2.3 Technical Papers

Normal Subgroups of the Modular Group. L. Greenberg and M. Newman. Submitted to a technical journal.

Some Results on Solvable Groups. L. Greenberg and M. Newman. To appear in Arch. der Math.

Sequences of Numbers that are Approximately Completely Equidistributed. S. Haber. To appear in J. of Assoc. for Computing Machinery.

Numerical Evaluation of Multiple Integrals. S. Haber. Submitted to a technical journal.

On the Sum $\sum <n\alpha>^{-t}$ and Numerical Integration. S. Haber and C. F. Osgood. To appear in Pacific J. of Math.

Symmetry and Marginal Homogeneity of an r x r Contingency Table. C. T. Ireland, S. Kullback (G.W.U.), and H. H. Ku. To appear in J. Amer. Statist. Assoc.

Some Properties of the Range in Samples from Tukey's Symmetric Lambda Distributions. Brian L. Joiner and Joan R. Rosenblatt. Submitted to a technical journal.

On the Analysis of Multi-Dimensional Contingency Tables. H. H. Ku, R. N. Varner and S. Kullback (George Washington Univ.). To appear in Proc. 14th Conf. on Design of Experiments in Army Research Development and Testing.

Stability of Acoustic Waves within a Viscous, Compressible, Heat-Conducting Fluid. J. E. McKinney and H. J. Oser. To appear in the J. of Acoustical Society of America. Vol. 47, No. 1, January 1970.

Trace Functions I. R. Merris. Submitted to a technical journal.

Partitioned Hermetian Matrices. R. Merris. To appear in J. of Research, NBS.

Elementary Divisors of Higher Degree Associated Transformations. R. Merris and S. Pierce. Submitted to a technical journal.

A Class of Representations of the Full Linear Group. R. Merris and S. Pierce. Submitted to a technical journal.

Isomorphic Symmetry Classes of Tensors. R. Merris and W. Watkins. Submitted to a technical journal.

A Table of the First Factor for Prime Cyclotomic Fields. M. Newman. To appear in Math. of Computation.

An Enumeration Problem for a Congruence Equation. M. Newman and R. Brualdi. To appear in J. of Research NBS.

Bounded Matrix Groups. M. Newman and S. Pierce. To appear in J. of Linear Algebra.

Why Steepest Descents? F. W. J. Olver. To appear in Proc. of 1969 SIAM National Meeting, June 10-12, 1969.

Orthogonal Groups of Positive Definite Multilinear Functionals. S. Pierce. To appear in Pacific J. of Math.

Multiplicative Maps of Matrix Semigroups over Dedekind Rings. S. Pierce. Submitted to a technical journal.

Orthogonal Decompositions of Tensors Spaces. S. Pierce. To appear in J. of Research NBS.

The Use of OMNITAB for Statistical Analysis of Tabular Data. Joan R. Rosenblatt, Brian L. Joiner, and David Hogben. To appear in Census Tract Papers' Papers Presented at the Conference on Small-Area Statistics, American Statistical Assoc., New York, August 21, 1969.

An Evaluation of Linear Least Squares Computer Programs: A summary report. Roy H. Wampler. To appear in Proc. 14th Conf. on Design of Experiments in Army Research Development and Testing.

A Report on the Accuracy of Some Widely Used Least Squares Computer Programs. Roy H. Wampler. To appear in J. Amer. Statist. Assoc.

2.4 Notes, Reviews

Systems Analysis and Urban Problems (Discussion). A. J. Goldman. To appear in Proc. Symposium on Systems Analysis for Social Problems, 5/69.

2.5 Books

An Author and Permuted Title Index to Selected Statistical Journals. Brian L. Joiner, N. F. Laubscher (Nat'l. Res. Inst. for Math. Sciences, S. Africa), Eleanor S. Brown, and Bert Levy (Harry Diamond Labs., U. S. Army). To appear as NBS Special Pub. 321.

NBS TECHNICAL PUBLICATIONS

PERIODICALS

JOURNAL OF RESEARCH reports National Bureau of Standards research and development in physics, mathematics, chemistry, and engineering. Comprehensive scientific papers give complete details of the work, including laboratory data, experimental procedures, and theoretical and mathematical analyses. Illustrated with photographs, drawings, and charts.

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NONPERIODICALS

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Technical Notes. This series consists of communications and reports (covering both other agency and NBS-sponsored work) of limited or transitory interest.

Federal Information Processing Standards Publications. This series is the official publication within the Federal Government for information on standards adopted and promulgated under the Public Law 89–306, and Bureau of the Budget Circular A–86 entitled, Standardization of Data Elements and Codes in Data Systems.

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