

**NATIONAL BUREAU OF STANDARDS REPORT**

4658

PROJECTS and PUBLICATIONS  
of the  
APPLIED MATHEMATICS DIVISION

A Quarterly Report  
January through March, 1956



**U. S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS**

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U. S. DEPARTMENT OF COMMERCE

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NATIONAL BUREAU OF STANDARDS

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**Chemistry.** Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Gas Chemistry. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

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**Mineral Products.** Porcelain and Pottery. Glass. Refractories. Enameled Metals. Concrete Materials. Constitution and Microstructure.

**Building Technology.** Structural Engineering. Fire Protection. Heating and Air Conditioning. Floor, Roof, and Wall Coverings. Codes and Specifications.

**Applied Mathematics.** Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

**Data Processing Systems.** Components and Techniques. Digital Circuitry. Digital Systems. Analogue Systems.

**Cryogenic Engineering.** Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

**Radio Propagation Physics.** Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services.

**Radio Propagation Engineering.** Frequency Utilization Research. Tropospheric Propagation Research.

**Radio Standards.** High Frequency Standards. Microwave Standards.

● Office of Basic Instrumentation

● Office of Weights and Measures

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\*Only unclassified projects are included in this report.



# **NATIONAL BUREAU OF STANDARDS REPORT**

**NBS PROJECT**

**NBS REPORT**

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4658

## **PROJECTS and PUBLICATIONS of the APPLIED MATHEMATICS DIVISION**

January through March, 1956



**U. S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS**

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January 1 through March 31, 1956

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# Status of Projects

March 31, 1956

## 1. NUMERICAL ANALYSIS

### RESEARCH IN THEORIES OF DISCRETE STRUCTURES

Task 1100-10-5116/56-159

Origin: NBS

Authorized 9/30/55

Sponsor: Office of Naval Research

Manager: O. Taussky-Todd

Full task description: July-Sept 1955 issue, p. 1

Status: CONTINUED. O. Taussky continued her investigations concerning the higher commutators of a matrix  $A$  and its transposed and conjugate  $A^*$ . For  $3 \times 3$  matrices examples were constructed which show that the second, fourth, fifth, or sixth order commutator  $(A, A, \dots, A, A^*)$  of  $A$  and  $A^*$  can be the first one to vanish. If none of these vanishes, then no commutator of any order will vanish. Group matrices with vanishing fourth order commutators were also studied.

M. Newman and O. Taussky had proved earlier that a unimodular circulant of integers of the form  $AA'$  is also of the form  $CC'$  when  $C$  is again a circulant of integers. They now have shown that the weaker condition of positive definiteness does not suffice for circulants of order  $n \geq 8$ . A manuscript has been prepared.

M. Newman and O. Taussky are studying hermitian matrices and their decomposition into the form  $AA^*$  where  $A$  may be rectangular.

#### Publications:

- (1) On a generalization of the normal basis in abelian algebraic number fields. M. Newman and O. Taussky. Comm. Pure Appl. Math. (New York University) 2, 85-91 (1956).
- (2) A note on group matrices. O. Taussky. Proc. Amer. Math. Soc. 6, 984-986 (1955).
- (3) The formal power series for  $\log(e^X \cdot e^Y)$ . K. Goldberg. To appear in the Duke Mathematical Journal.
- (4) The number of absolute points of a correlation. A. Hoffman, M. Newman, E. Straus, O. Taussky. To appear in the Pacific Journal of Mathematics.
- (5) Some computational problems in algebraic number theory. O. Taussky. To appear in the Proceedings of the American Mathematical Society Sixth Symposium on Applied Mathematics, held at Santa Monica, California, 1953.
- (6) Bounds and asymptotic behavior of the coefficients in the series  $\log(e^X e^Y)$ . K. Goldberg. In manuscript.
- (7) Algebraic equations satisfied by roots of natural numbers. E. G. Straus (University of California at Los Angeles) and O. Taussky. To appear in Pacific Journal of Mathematics.
- (8) Pairs of matrices with property L, II. T. S. Motzkin and O. Taussky. Trans. Amer. Math. Soc. 80, 387-401 (1955).
- (9) Generation and testing of pseudo-random numbers. O. Taussky and J. Todd. To appear in the Proceedings of a Symposium on Monte Carlo Methods, held at Gainesville, Florida, 1954.



## Status of Projects

- (10) On the Hilbert matrix. T. Kato. Submitted to a technical journal.
- (11) Commutators of A and A\*. T. Kato and O. Taussky. J. Wash. Acad. Sci. 46, 38-40 (1956).
- (12) Some free subgroups of the modular group. K. Goldberg and M. Newman. In manuscript.
- (13) Classes of positive definite unimodular circulants. M. Newman and O. Taussky. In manuscript.

## RESEARCH IN NUMERICAL ANALYSIS AND RELATED FIELDS

Task 1101-10-1104/55-55

Origin: NBS

Authorized 8/13/54

Managers: J. Todd, P. Davis

Revised 8/29/54

Full task description: July-Sept 1954 issue, p. 1

Status: CONTINUED. H. A. Antosiewicz has continued his work on the survey of conditions for the stability of solutions of ordinary differential equations which are based on Lyapunov's second method. Particular emphasis has been paid to those conditions that guarantee stability "in the large." Among them and related to them are criteria for the ultimate boundedness of every solution. The concept of ultimate boundedness is important in many cases of practical interest: For non-linear differential equations of the second order it has been investigated previously by G. E. Reuter and for more general equations by T. Yoshizawa. The latter's method of attack is closely related to Lyapunov's method.

P. Davis and Ky Fan have completed the present phase of their study on inequality and approximation in function spaces. It will probably be resumed when Professor Ky Fan returns to the Bureau in the summer.

J. Todd has continued his survey of various topics in the theory of approximation that are applicable in numerical analysis. Arising out of this, J. Todd has planned a new tabulation of the Cauey parameters, with an independent variable different from that used by Glowatski. These parameters arise in the design of electrical circuits and are expressed in terms of elliptic functions, the modular parameter of which depends, in the case of filters for example, on the permissible width of the frequency band in the pass-and-stop interval.

K. Goldberg continued his study of iterated convolutions.

## Publications:

- (1) Stable systems of differential equations with integrable perturbation term. H. Antosiewicz. To appear in the Journal of the London Mathematical Society.
- (2) On the Lerch zeta function. F. Oberhettinger. To appear in the Pacific Journal of Mathematics.
- (3) A subroutine for computations with rational numbers. P. Henrici. J. Assoc. Comp. Mach. 3, 6-9 (1956).
- (4) A direct approach to the problem of stability in the numerical solution of partial differential equations. J. Todd. To appear in the Proceedings of a Symposium on Partial Differential Equations, held at Berkeley, California, 1955.
- (5) Some Monte Carlo experiments for computing multiple integrals. P. Davis and P. Rabinowitz. To appear in Mathematical Tables and Other Aids to Computation.
- (6) Abscissas and weights for Gaussian quadratures of high order. P. Davis and P. Rabinowitz. J. Res. NBS 56, 35-37 (1956), RP2645.
- (7) Numerical experiments in potential theory using orthonormal functions. P. Davis and P. Rabinowitz. J. Wash. Acad. Sci. 46, 12-17 (1956).
- (8) Complete sequences and approximations in normed linear spaces. P. Davis and K. Fan. Submitted to a technical journal.
- (9) A matrix with real characteristic roots. K. Goldberg. To appear in Journal of Research, NBS.



- (10) Note on bounds for determinants. E. V. Haynsworth. In manuscript.  
 (11) On asymptotic stability. H. A. Antosiewicz. In manuscript.

RESEARCH IN MATHEMATICAL TOPICS APPLICABLE TO  
 NUMERICAL ANALYSIS

Task 1101-10-5116/55-56

Origin: NBS

Sponsor: Office of Naval Research

Managers: J. Todd, M. Newman

Full task description: July-Sept 1954 issue, p. 5

Authorized 8/13/54

Revised 8/29/54

Status: CONTINUED. Some experiments in inverting matrices and solving linear systems (using the floating point routines for these purposes, described previously) were undertaken by M. Newman and I. Stegun. It was found that even for matrices of orders as high as 60, round-off error remained negligible. Comparing these results with those obtained from fixed point routines, the conclusion seems to be that both time-wise and accuracy-wise floating point routines are to be preferred. A more or less detailed description and evaluation of various codes for matrix operations is being prepared.

Some new floating point routines for computing such functions as  $\log x$ ,  $e^x$ , have been prepared by M. Newman.

A. J. Hoffman has completed an expository article (see publication (22) below) on linear programming, summarizing the highlights of the theory, computing procedures and applications of the subject.

Ky Fan, I. Glicksberg (University of Notre Dame), and A. J. Hoffman, have completed a manuscript (publication (23) below) on systems of inequalities involving convex functions. Questions relating to the consistency, independence, and so forth, of a system of inequalities  $f_i(x) < 0$ , where the  $f_i$  are convex functions defined on a convex set in a real linear space, are shown to be resolvable almost as simply as the corresponding questions for systems of linear inequalities that they generalize.

A. J. Hoffman has shown (in publication (24)) that a simple combinatorial lemma yields a generalization of a well-known theorem of König on systems "representing" two partitions of a given set. The lemma states that if the incidence matrix of points vs. subsets for a given set  $R$  and family of subsets  $\{S_1, \dots, S_m\}$  has the unimodular property that every square sub-matrix is singular or unimodular, and  $0 < \alpha < 1$ , then there exists a set  $C \subseteq R$  such that  $|C \cap S_i| - \alpha |S_i| < 1$ . ( $\bar{A}$  denotes the cardinality of the set  $A$ .)

Publications:

- (1) The normalizer of certain modular subgroups. M. Newman. Canadian Math. J. 8, 29-31 (1956).
- (2) Generalizations of identities for coefficients of certain modular forms. M. Newman. To appear in Journal of the London Mathematical Society.
- (3) Compactification of completely regular spaces. Ky Fan and F. Wagner (University of Notre Dame). In manuscript.
- (4) On dominant eigenvalues of positive matrices. T. Kato. In manuscript.
- (5) A comparison theorem for eigenvalues of normal matrices. Ky Fan. Pac. J. Math. 5, 911-913 (1955).
- (6) On generating functions of the Jacobi polynomials. P. Henrici. Pac. J. Math. 5, 923-931 (1955).
- (7) Error bounds for eigenvalues of symmetric integral equations. H. Wielandt. To appear in the Proceedings of the American Mathematical Society Sixth Symposium on Applied Mathematics, held at Santa Monica, California, 1953.

## Status of Projects

- (8) On systems of distinct representatives. A. J. Hoffman and H. W. Kuhn. (Bryn Mawr College). To appear in Annals of Mathematics Study 38.
- (9) Systems of linear inequalities. Ky Fan. To appear in Annals of Mathematics Study 38.
- (10) Systems of distinct representatives and linear programming. A. J. Hoffman and H. W. Kuhn (Bryn Mawr College). To appear in the American Mathematical Monthly.
- (11) Dilworth's theorem on partially ordered sets. G. B. Dantzig (RAND Corporation) and A. J. Hoffman. To appear in Annals of Mathematics Study 38.
- (12) On "overshoot" in the "furthest hyperplane" method. R. Bryce. In manuscript.
- (13) Notes on some scheduling programs. A. J. Hoffman. In manuscript.
- (14) On block relaxation. L. S. Joel. In manuscript.
- (15) On the minimization of concave and convex functionals. G. B. Dantzig (RAND Corporation), A. J. Hoffman, W. Hirsch (New York University). In manuscript.
- (16) The lowest frequency of a free square plate. H. Fujita (University of Tokyo), T. Kato, Y. Nakata (University of Tokyo), and M. Newman. In manuscript.
- (17) An inclusion theorem for modular subgroups. M. Newman. Submitted to a technical journal.
- (18) A table of the coefficients of the powers of  $\eta(\tau)$ . M. Newman. To appear in the Proceedings of the Royal Netherlands Academy of Sciences.
- (19) On the existence of identities for the coefficients of certain modular forms. M. Newman. To appear in Journal of the London Mathematical Society.
- (20) An alternative proof of a theorem on unimodular groups. M. Newman. Proc. Amer. Math. Soc. 6, 998-1000 (1955).
- (21) Integral boundary points of convex polyhedra. A. J. Hoffman and J. B. Kruskal (Princeton University). To appear in the Annals of Mathematics Study 38.
- (22) Linear programming. A. J. Hoffman. To appear in Applied Mechanics Reviews.
- (23) Systems of inequalities involving convex functions. Ky Fan (University Notre Dame), I. Glicksberg (RAND Corporation), and A. J. Hoffman. In manuscript.
- (24) Generalization of a theorem of König. A. J. Hoffman. In manuscript.

ANALYTIC STUDY OF WAR GAMES  
Task 1101-10-5116/55-83

Origin and Sponsor: Armament Branch, ARDC, USAF      Authorized 12/29/54  
 Manager: H. A. Antosiewicz  
 Full task description: Oct-Dec 1954 issue, p. 7  
 Status: INACTIVE.

STUDY OF DIFFERENTIAL EQUATIONS FOR NERVE EXCITATION  
Task 1101-10-5116/56-148

Origin and Sponsor: National Institutes of Health      Authorized 9/30/55  
 Bethesda, Md.  
 Manager: H. A. Antosiewicz  
 Full task description: July-Sept 1955 issue, p. 7

Status: CONTINUED. A new method has been adopted for the determination of the values of the parameter K for which the solutions of the basic system of differential equations have a prescribed behavior. The previously used method was based on an approximation to the positive eigenvalue, and its corresponding eigenvector, of the  $5 \times 5$  matrix which represents the linear part of the system of differential equations. Now, this positive eigenvalue and its eigenvector are computed for each value of the parameter K, and the initial conditions determining the particular solution are then chosen for the eigenvector. The change in the computation was felt necessary because the bounds for the derived values of K found by the old procedure were so close that further approximations might have yielded spurious results.

About 30 cases, both for temperatures  $6.3^{\circ}\text{C}$  and  $18.5^{\circ}\text{C}$ , were run during this quarter and were submitted to the sponsor.



## 2. MATHEMATICAL TABLES AND PROGRAMMING RESEARCH

### TABLES OF $E_1(z)$ , ( $z=x+iy$ )

Task 1102-40-1110/43-3

Manager: I. Stegun

Authorized 7/1/47

Full task description: Apr-June 1949 issue, p. 41

Status: CONTINUED. The introduction to the tables has been prepared and checking is in progress.

### TABLES OF COULOMB WAVE FUNCTIONS

Task 1102-40-1110/47-2

Origin: NBS

Authorized 7/1/47

Manager: M. Abramowitz

Full task description: Apr-June 1949 issue, p. 45

Status: CONTINUED. The code is being revised to carry out computations of the functions for a range of values of  $\rho$  corresponding to given  $\eta$  and  $L$ .

### TABLES OF POWER POINTS OF ANALYSIS OF VARIANCE TESTS

Task 1102-40-1110/51-8

Origin: Section 11.3, NBS

Authorized 3/26/51

Manager: S. Peavy

Full task description: Apr-June 1951 issue, p. 49

Status: INACTIVE. For status to date, see Oct-Dec 1955 issue, p. 8.

### REVISION OF MATHEMATICAL TABLES

Task 1102-40-1110/52-7

Origin: NBS

Authorized 8/10/51

Managers: W. F. Cahill, I. Stegun

Full task description: July-Sept 1951 issue, p. 41

Status: CONTINUED. Revision of "Tables of natural logarithms," vol. IV, Mathematical Table MT12 (1941), for reissue in the Applied Mathematics Series was completed, and the manuscript is ready for submittal for publication.



TABLE OF ARCSIN FOR COMPLEX ARGUMENTS  
Task 1102-40-1110/52-14

Origin: NBS

Authorized 10/1/51

Manager: B. Urban

Full task description: July-Sept 1951 issue, p. 41

Status: TERMINATED. It was decided to discontinue preparation of the table for publication because a more comprehensive table of the function was recently published elsewhere.

TABLE OF THE MODIFIED AIRY INTEGRAL  
Task 1102-40-1110/52-23

Origin: NBS

Authorized 10/4/51

Manager: I. Stegun

Full task description: July-Sept 1951 issue, p. 42

Status: CONTINUED. Checking of the completed manuscript is in progress.

TABLE OF ERROR FUNCTION FOR COMPLEX ARGUMENTS  
Task 1102-40-1110/52-25

Origin: NBS

Authorized 10/5/51

Manager: W. Hall

Full task description: July-Sept 1951 issue, p. 42

Status: INACTIVE. For status to date, see Oct-Dec 1954 issue, p. 11.

SPHEROIDAL WAVE FUNCTIONS  
Task 1102-40-1110/52-37

Origin: NBS

Authorized 11/28/51

Manager: D. Liepman

Full task description: Oct-Dec 1951 issue, p. 38

Status: INACTIVE.

SIEVERT'S INTEGRAL  
Task 1102-40-1110/52-57

Origin: NBS

Authorized 2/12/52

Managers: M. Paulsen, P. O'Hara

Full task description: Jan-Mar 1952 issue, p. 46

Status: CONTINUED. Checking of the tabular values and preparation of the introductory material continued.

## Status of Projects

## L-SHELL CONVERSION COEFFICIENTS

Task 1102-40-1110/53-52

Origin: Oak Ridge National Laboratory

Authorized 5/20/53

Manager: W. Hall

Full task Description: Apr-June 1953 issue, p. 45

Status: CONTINUED. Computations for the  $L_{III}$  shell were completed for  $z = 65$  for all values of  $k$ ; for  $z = 95$ ,  $k = .05, 0.1$ ; and for the  $L_I$  shell for  $z = 55$ ,  $k = .05$ .

## AUTOMATIC CODING

Task 3711-60-0009/55-65

Origin: NBS

Authorized 9/29/54

Manager: J. Wegstein

Full task description: July-Sept 1954 issue, p. 11

Status: CONTINUED. A new Base code, BASE 11, has been completed. It is intended to be used specifically for small problems involving integrals. In it the 1-, 2- and A-orders of Base 00 are replaced by two-word "integrate" orders completely specifying an integration of the form  $\int_a^b f(x)dx$  except for the coding of  $f(x)$ . (See July-Sept 1955 issue, p. 13.)

By the use of the three integration orders general expressions of the form  $\iiint f(x,y,z)dxdydz$  can be coded using only two words to specify each integration and the coding necessary to compute the various functions. The integration rule is Gaussian quadrature, and 2-, 4-, 8-, and 16-point rules for any interval may be specified.

Base 11 should be useful in coding small problems quickly where the behavior of the functions involved is well known and only one integration is involved or separation of variables cannot be effected. It may also be used for larger problems provided the necessary numerical analysis is carried out.

In addition to the integration routines, Base 11 also contains all of the service routines and subroutines of Base 01 (see Oct-Dec 1955 issue, p. 10.)

Work was begun on the BUIC system for SEAC. It is a generating routine which accepts problems stated in a notation written directly from the flow diagram of the problem. Algebraic expressions are accepted directly by the computer in the same form that they can be understood by any mathematician. Complete logical details have been worked out for the algebra encoder portion of this system. The feasibility of building a computer which will operate at high speed directly on algebraic and flow chart symbols is also being studied.

## MATHEMATICAL SUBROUTINES

Task 3711-60-0009/56-160

Origin: NBS

Authorized 9/30/55

Managers: Staff

Full task description: July-Sept 1955 issue, p. 13

Status: CONTINUED. The development of a base code for matrices which may be used in problems requiring several types of operations on small

matrices was started. The code will be similar to the Base 00 and will use most of the Base 00 operations. It will contain subroutines to add and multiply matrices, to compute the value of determinants, to orthonormalize a set of vectors, and to compute the inverse of a given matrix. The elements of the matrices will be expressed in floating binary point form. During this quarter, the addition, multiplication, and determinant evaluation subroutines were written and code checking of these routines was started.

### 3. PROBABILITY AND MATHEMATICAL STATISTICS

#### BIBLIOGRAPHY AND GUIDE TO STATISTICAL LITERATURE

Task 1103-10-1107/49-1a

Origin: NBS

Authorized 1/9/49

Manager: L. S. Deming

Full task description: Apr-June 1949 issue, p. 75

Status: CONTINUED. For a description of the continuing activity on this task, see the Jan-Mar 1954 issue, p. 49.

#### MANUAL ON FITTING STRAIGHT LINES

Task 1103-10-1107/50-2

Origin: NBS

Authorized 3/1/50

Manager: F. S. Acton

Full task description: Jan-Mar 1950 issue, p. 42

Status: COMPLETED. The manual on the fitting of straight lines has been completed and is being edited for publication by a commercial house. Some material from it is being abstracted for use by the ASTM in their handbook on the "Presentation of Data." The straight line manual is divided into ten chapters whose titles are:

Chapter I - General introduction

II - X - Without error - Classical ideas

III - Several values of y for each x

IV - Bivariate normal population

V - Both variates in error

VI - Several lines - The analysis of variance

VII - Orthogonal polynomials - Curvature

VIII - Transformations

IX - Rejection of data

X - Cumulative data

#### TABLES TO FACILITATE DRAWING RANDOM SAMPLES

Task 1103-10-1107/51-1

Origin: NBS

Authorized 7/1/50

Managers: C. Eisenhart, L. S. Deming

Full task description: July-Sept 1950 issue, p. 57

Status: INACTIVE. For status to date, see July-Sept 1952 issue, p. 64.



MISCELLANEOUS STUDIES IN PROBABILITY AND STATISTICS  
Task 1103-10-1107/51-2

Origin: NBS

Authorized 7/1/50

Manager: C. Eisenhart

Full task description: July-Sept 1950 issue, p. 58

Status: CONTINUED. For a description of the continuing activity on this task, see the Oct-Dec issue, p. 12.

## Publications:

- (1) Chaînes de Markof dans les ensembles abstraits et applications aux processus avec régions absorbantes et au problème des boucles. (Formerly, "Time-discrete stochastic processes in arbitrary sets, with applications to processes with absorbing regions and to the problem of loops in Markoff chains.") D. van Dantzig. Annales de l'Institut Henri Poincaré 14, 145-199 (1955).
- (2) A note on the normal distribution. S. Geisser. To appear in the Annals of Mathematical Statistics.
- (3) A comparison between the mean successive differences and the root mean square successive difference. S. Geisser. Withdrawn from publication.
- (4) Inequalities for probabilities associated with the multivariate normal distribution. I. R. Savage. Withdrawn from publication.

STUDIES IN THE MATHEMATICS OF EXPERIMENT DESIGN  
Task 1103-10-1107/53-1

Origin: NBS

Authorized 10/15/52

Manager: W. S. Connor

Full task description: Oct-Dec 1952 issue, p. 60

Status: CONTINUED. R. C. Burton has written a note on "Some existence theorems for dualized designs."

## Publications:

- (1) Partially replicated Latin squares. W. J. Youden and J. S. Hunter (American Cyanamid Co.) Biometrics 11, 399-405 (Dec. 1955).
- (2) Contributions on partially balanced incomplete block designs with two associate classes. W. H. Clatworthy. To appear as NBS Applied Mathematics Series 47.
- (3) Exact tests of significance for combining inter- and intra-block information. M. Zelen. Submitted to a technical journal.
- (4) On the analysis of covariance. M. Zelen. Submitted to a technical journal.
- (5) Fractional factorial experiment designs for factors at two levels. To appear as NBS Applied Mathematics Series 48.
- (6) Design of experiments in research and development. W. J. Youden. To appear in Proceedings of the 1955 Conference on the Design of Experiments in Army Research, Development, and Testing.
- (7) Some examples of the use of high speed computers in statistics. J. M. Cameron. To appear in Proceedings of the 1955 Conference on the Design of Experiments in Army Research, Development, and Testing.
- (8) The principle of randomization in the design of experiments. C. Eisenhart. To appear in Proceedings of the 1955 Conference on the Design of Experiments in Army Research, Development, and Testing.

RESEARCH ON MATHEMATICAL ASPECTS OF ORDER  
STATISTICS METHODS  
Task 1103-10-1107/55-110

Origin: NBS

Authorized 3/3/55

Manager: J. Lieblein

Full task description: Jan-Mar 1955 issue, p. 31

Status: CONTINUED. J. Lieblein consulted with E. L. Brancato and W. F. Gauster of the Naval Research Laboratory on the application of extreme-value theory to data on breakdown voltage of transformer oil.

Dr. Lieblein also corresponded, among others, with N. T. Uzgoren (University of Istanbul, Turkey) on theoretical aspects of the asymptotic development of the distribution of extreme values, and with E. Gassner (Darmstadt, Germany) on the fit of a formula used in fatigue-life testing of ball bearings.

The final report (see Jan-Mar 1955 issue, p. 33) to Subcommittee 7 (Load Ratings) of the American Standards Association Committee B-3 (Ball and Roller Bearings), on "Statistical investigations of the fatigue life of deep groove ball bearings" has been developed into an article for submittal to a technical journal.

Publication:

- (1) Application of extreme value theory to cobbles and boulders in gravel deposits. W. C. Krumbein (Northwestern University) and J. Lieblein. Submitted to a technical journal.

STUDY OF NON-PARAMETRIC STATISTICAL TECHNIQUES  
Task 1103-10-1107/56-170

Origin: NBS

Authorized 12/15/55

Manager: Joan R. Rosenblatt

Full task description: Oct-Dec 1955 issue, p. 14

Status: CONTINUED. A paper is being prepared on the power of some rank order two-sample tests.

A talk on the efficiency of statistical tests was given at a Statistical Engineering Laboratory Seminar on February 17.

Work was continued on the distribution of Burrow's statistic.

Publications:

- (1) Easily used simultaneous confidence limits for a line. W. S. Connor. Submitted to a technical journal.
- (2) Contributions to the theory of rank order statistics--two-sample case. I. R. Savage. To appear in the Annals of Mathematical Statistics.
- (3) Simultaneous tests of randomness and other hypotheses. I. R. Savage. To appear in the Journal of the American Statistical Association, under the title "On the independence of tests of randomness and other hypotheses."

MEASUREMENT OF RELIABILITY  
Task 1103-10-1130/56-182

Origin: NBS  
Manager: M. Zelen

Authorized: 3/23/56

**Objective:** To conduct research on the mathematical and statistical aspects of the definition, measurement, and specification of the reliability of components and assemblies, with particular attention to the evaluation of the reliability of electronic components and systems.

**Background:** The improvement of the reliability of electronic equipment, civilian as well as military, is one of the major problems of science and technology today. It is highly desirable that electronic computers and communications equipment operate with satisfactory reliability over relatively long periods of continuous or intermittent use. On the other hand, electronic systems of guided missiles, for example, are required to withstand a long "shelf-life" yet perform with high reliability during their very brief period of use. While it is widely recognized that reliability is primarily a probability problem, and that the measurement of reliability is largely a statistical problem, only a beginning has been made in applying recent developments in statistical inference, experiment design, and statistical analysis, to the definition and measurement of the reliability of complex assemblies.

**Status:** NEW. Examples of the literature on measurement and prediction of reliability are being collected and reviewed.

Work is being done on methods for obtaining confidence limits for the product of binomial parameters.



#### 4. MATHEMATICAL PHYSICS

##### RESEARCH IN MATHEMATICAL PHYSICS AND RELATED FIELDS Task 1104-10-1115/55-57

Origin: NBS

Authorized 9/1/54

Manager: R. F. Dressler

Full task description: July-Sept 1954 issue, p. 27

Status: CONTINUED. New methods have been developed by P. Henrici to speed up the convergence of the Quotient-Difference Algorithm and to apply it to the numerical determination of the residues of a meromorphic function. Also some applications were made of I. N. Vekva's theory of elliptic differential equations with analytic coefficients. Several representations for the complex Riemann function of the equation

$$\Delta u + \frac{\nu}{y} \frac{\partial u}{\partial y} + k^2 u = 0,$$

have been obtained.

As a continuation of previous work on addition theorems P. Henrici has obtained several new addition theorems for Lommel functions. These are of importance in the solution of the inhomogeneous wave equation.

##### Publications:

- (1) Comparison of theories and experiments for the hydraulic dam-break wave. R. F. Dressler. Publication No. 38 de l'Association Internationale d'Hydrologie (Assemblee generale de Rome, 1954, tome III, p. 319-328). Extrait.
- (2) Entropy changes in rarefaction waves. R. F. Dressler. Submitted to a technical journal.
- (3) A discussion of the paper, "Design of corrugated diaphragms," by J. A. Haringx. R. F. Dressler. To appear in the Transactions of the American Society of Mechanical Engineers.
- (4) On generating functions for the Jacobi polynomials. P. Henrici. Pac. J. Math. 5, 923-931 (1955).
- (5) On the representation of a certain integral involving Bessel functions of hypergeometric series. P. Henrici. Submitted to a technical journal.
- (6) On the domain of regularity of generalized axially symmetric potentials. P. Henrici. To appear in the Proceedings of the American Mathematical Society.
- (7) The quotient-difference algorithm. P. Henrici. In manuscript.

##### RESEARCH IN ELECTROMAGNETIC THEORY Task 1104-10-5160/54-47

Origin and Sponsor: Diamond Ordnance Fuze Laboratory,  
Department of the Army

Authorized 6/29/54  
Revised 9/29/54

Manager: F. Oberhettinger

Full task description: July-Sept 1954 issue, p. 28

Status: INACTIVE.



RESEARCH IN MATHEMATICAL ELASTICITY  
Task 1104-10-5160/55-85

Origin: NBS

Authorized 12/27/54

Sponsor: Office of Scientific Research, ARDC, USAF

Manager: R. F. Dressler

Full task description: Oct-Dec 1954 issue, p. 30

Status: CONTINUED. The second phase of the corrugated diaphragm project is being continued,--to analyze a sequence of diaphragms with a fixed shape for a range of different thicknesses in order to determine the relative importance of bending and stretching effects. The problem originally solved by R. F. Dressler and W. Cahill was for a thickness  $h = .007$  inches. Now the case  $3h$  has been completely solved also and exhibits the following interesting property: For average thicknesses, all stresses causing stretching vary with the same frequency as the corrugation profile shape, whereas all bending stresses vary with a double frequency. However, for the thick diaphragm the present results indicate that the double frequency behavior almost disappears for all bending stresses. The next case, now being analyzed, corresponds to  $h/3$ . For this problem all four homogeneous solutions were computed, but the general solution is not yet completed.

On the vibrating triangular wing project, I. Rhodes and U. Hochstrasser satisfactorily rectified the difficulty in the code for obtaining higher eigenvalues and eigenvectors for the basic  $78 \times 78$  asymmetric matrices. On small test matrices the second eigenvalues were obtained with high accuracy; this code is to be applied to the large matrices describing the wing problem.

J. L. Synge worked on a geometrical approach to problems of forced vibrations in elasticity, the solution appearing as the intersection of two orthogonal linear subspaces in a suitable function space. This approach led to methods of approximate solution. A paper on this work is to be presented at the Eighth Symposium on Applied Mathematics, Chicago, April 12-13.

J. L. Synge has applied tensor methods to the study of the general theory of linear elastic waves in completely anisotropic media, developing a theory of Rayleigh surface waves in such media. A report on this investigation was prepared.

J. L. Synge and W. Cahill engaged on an approximate numerical solution on SEAC of the elastic torsion problem for the hollow square. The solution uses the Prager-Synge hypercircle method, which gives upper and lower bounds for the torsional rigidity. Final calculations on the SEAC for this problem are in progress.

## Publications:

- (1) Investigations of the properties of corrugated diaphragms. W. A. Wildhack (NBS OBI), R. F. Dressler, and E. C. Lloyd (NBS Mechanics Division). To appear in the Transactions of the American Society of Mechanical Engineers. (Now available as ASME Preprint No. 55-A-181.)
- (2) Stationary principles for forced vibrations in elasticity and electromagnetism. J. L. Synge. Submitted to a technical journal.
- (3) Elastic waves in anisotropic media. J. L. Synge. In manuscript.

FOURIER TRANSFORMS OF PROBABILITY DISTRIBUTION FUNCTIONS  
Task 1104-10-5160/56-154

Origin: NBS

Authorized 9/30/55

Sponsor: Office of Naval Research

Managers: F. Oberhettinger, J. Lieblein

Full task description: July-Sept 1955 issue, p. 20

Status: CONTINUED. Further examples have been added to the collection of Fourier transforms of distribution functions. This completes the present compilation, which contains some previously underived results. The whole material is in systematic form ready for book publication when the accompanying text is written.

RESEARCH IN FLUID DYNAMICS OF TWO-PHASE FLOWS  
Task 1104-10-5160/56-155

Origin: Office of Naval Research

Authorized 9/30/55

Sponsor: " "

Manager: R. F. Dressler

Full task description: July-Sept 1955 issue, p. 21

Status: CONTINUED. Relations between the states on both sides of an interface separating two phases of a moving fluid have been determined for the cases in which the phase transition is brought about by heat removal and/or cold liquid addition at the interface. If the specific volume of the liquid state is neglected in comparison with the specific volume of the vapor state and the enthalpy of the liquid state is given as a linear function of the temperature alone, then an explicit solution has been found for the liquid state variables in terms of the other parameters. For more accurate results, a rapidly converging iterative scheme has been developed which utilizes directly thermodynamic tables of the vapor and liquid. Some calculations have been made for the specific case of a steam-water interface. For a stationary interface and fixed thermodynamic state of the vapor, upper and lower bounds for heat removal or mass addition rates have been found as a function of the incoming steam velocity. Conversely, for given heat removal or mass addition, bounds have been obtained for the steam velocity. A paper on this first aspect of the investigation has been prepared.

Publication:

- (1) Condensation interfaces in two-phase flow. P. Chiarulli and R. F. Dressler. In manuscript.

RESEARCH IN MATHEMATICAL GEOPHYSICS  
Task 1104-10-5160/56-156

Origin: The American University

Authorized 9/30/55

Sponsor: Office of Naval Research

Manager: R. Stoneley

Full task description: July-Sept 1955 issue, p. 21

Status: CONTINUED. The investigation of the variation of amplitude with depth for Rayleigh waves in a continent with a double surface layer has been completed by R. Stoneley and U. Hochstrasser. The results show that a nodal point for the amplitude may exist in either of the two surface

layers depending upon the relative sizes of the various parameters. This work was presented at the meeting of the Seismological Society of America, Reno, Nevada, March 30-31.

A paper dealing with the hydrodynamical aspects of turbidity currents in oceans was also completed by R. Stoneley.

The problem of the propagation of Rayleigh waves across an ocean floor in which there are two rocky layers has been programmed by U. Hochstrasser for computation by the SEAC.

Four lectures by R. Stoneley presented at an NBS seminar on the general theory of elastic surface waves have been written up as notes by P. Henrici. This will also be incorporated in a Monograph on elastic waves which is now in preparation.

#### Publications:

- (1) The transmission of Rayleigh waves across an ocean floor with two surface layers. Part I. R. Stoneley. To appear in the Bulletin of the Seismological Society of America.
- (2) On the propagation of turbidity currents. R. Stoneley. To appear in the Vening Meinesz Jubilee Volume.
- (3) Lectures on elastic surface waves. R. Stoneley. In manuscript.

#### RESEARCH IN RADIATION THEORY

Task 1104-10-5160/56-175

Origin: NBS

Authorized 12/28/55

Sponsor: Office of Naval Research

Manager: F. Oberhettinger

Full task description: Oct-Dec 1955 issue, p. 18

Status: CONTINUED. Investigations concerning the asymptotic behavior of certain integrals describing the far zone field of electromagnetic waves diffracted by a wedge are continuing. The case of an incident plane wave field (see J. Math. Phys. 34, 1956) is being extended to take care of an incident cylindrical and spherical wave field. This involves reduction of integrals of the form

$$I(\delta, \alpha) = -\frac{1}{2\alpha} \sin(\pi\delta/\alpha) \int_0^{\infty} \frac{H(x) dx}{\cosh(\pi x/\alpha) - \cos(\pi\delta/\alpha)}$$

with

$$H(x) = \begin{cases} H_0^{(2)}[k(\rho^2 + \rho'^2 + 2\rho\rho' \cosh x)^{\frac{1}{2}}] \\ \text{or} \\ \frac{\exp(-ik[\rho^2 + \rho'^2 + (z-z')^2 + 2\rho\rho' \cosh x]^{\frac{1}{2}})}{[\rho^2 + \rho'^2 + (z-z')^2 + 2\rho\rho' \cosh x]^{\frac{1}{2}}} \end{cases}$$

into an asymptotic series for large  $\rho$ .



## 5. MATHEMATICAL AND COMPUTATIONAL SERVICES

### 1102-40-5126/50-13 RAY TRACING

Origin and Sponsor: NBS, Section 2.2

Manager: E. Haynsworth, P. Walsh

Full task description: Jan-Mar 1950 issue, p. 33

Status: Continued. It was found necessary to compute the inverse of a given matrix ( $n \leq 28$ ) which was stored in fixed binary point form. A code was written in two parts: (1) To read in the matrix and convert it to floating binary point form. A previously written code for computation of the inverse in floating binary point form was then used. (2) To convert the inverse of the matrix from floating binary point form, and to transfer the matrix to wire by rows. The two sections of the code are being checked out.

### 1102-40-5126/51-37 MOLECULAR STRUCTURE, III

Origin and Sponsor: Naval Research Laboratory, USN

Manager: P. O'Hara

Full task description: July-Sept 1951 issue, p. 50

Status: Continued. Additional analyses were performed to determine the structures of the spurite and dimethoxybenzophenone crystals.

### 1102-40-5126/52-44 CALCULATIONS FOR d SPACINGS

Origin and Sponsor: NBS, Division 9

Full task description: Oct-Dec 1951 issue, p. 47

Manager: R. Zucker

Status: Continued. Calculations for d-spacings were performed for 3 tetragonal, 9 hexagonal and 20 orthorhombic crystals. Also determination of unit cell constants was carried out by least squares fitting to measured d-spacings for 7 tetragonal, 6 hexagonal, and 23 orthorhombic crystals.

### 1102-40-5126/53-27 COMPUTATION OF THERMODYNAMIC FUNCTIONS

Origin and Sponsor: NBS, Section 3.2

Manager: E. Marden

Full task description: Jan-Mar 1953 issue, p. 57

Status: Continued. Thermodynamic functions were re-computed for zinc ( $Zn$ ), making use of revised input constants. Under another code thermodynamic functions were computed for trans-difluorodichloroethylene.

### 1102-40-5126/53-51 RADIATION DIFFUSION

Origin: NBS, Section 4.8

Sponsor: Atomic Energy Commission

Manager: J. Doggett (4.8)

Full task description: Apr-June 1953 issue, p. 57 (Neutron Diffusion III)

Status: Continued. The data obtained from the Mott formula code for the elastic scattering of electrons and positrons by nuclei have been checked by interpolation schemes and reruns. A manuscript on the results has been



submitted to a technical journal.

The basic codes for the generation of collision density patterns of gamma radiation by Monte Carlo methods have been revised. Preliminary runs indicate an increase by a factor of two in the operational efficiency of the code.

1102-40-5126/54-13 AWARD OF PROCUREMENT CONTRACTS BY LINEAR PROGRAMMING

Origin and Sponsor: New York Quartermaster Procurement Agency

Manager: H. Bremer

Full task description: Oct-Dec 1953 issue, p. 43

Status: Continued. Analysis of contract award problems continued to be processed on SEAC as they were submitted by the sponsor. During this quarter, the awards for approximately 15 contracts were determined.

3711-60-0009/54-17 DEPOLYMERIZATION

Origin: NBS, Section 7.6

Manager: U. Hochstrasser

Full task description: Oct-Dec 1953 issue, p. 44

Status: Continued. Some additional cases were run with new values of the parameters  $\sigma$  and  $\epsilon$  as needed in further investigations under way by the originator.

3711-60-0009/54-22 ENERGY DISTRIBUTIONS ON OPTICAL IMAGE

Origin: NBS, Section 2.2

Manager: L. S. Joel

Full task description: Jan-Mar 1954 issue, p. 43

Status: Continued. The new code was verified as correct for  $W = \arctan (y/x)$ ,  $W = 9x(x^2+y^2)$ .

3711-60-0009/54-30 SPECTRUM ANALYSIS

Origin: NBS, Division 4

Manager: S. Prusch

Full task description: Jan-Mar 1954 issue, p. 46

Status: Continued. Searching for pairs of lines for approximately 14 common differences was carried out for Ruthenium I.

3711-60-0009/54-38 COMPRESSIBILITY FACTORS OF DRY AIR

Origin: NBS, Section 3.2

Manager: M. Paulsen

Full task description: Jan-Mar 1954 issue, p. 48

Status: Inactive. For status to date, see Apr-June 1955 issue, p. 12.

1102-40-5126/55-39 MOLECULAR VIBRATIONS

Origin and Sponsor: NBS, Section 3.2

Manager: K. Goldberg

Full task description: July-Sept 1954 issue, p. 16

Status: Inactive.

1102-40-5126/54-43 CHARACTERISTICS OF CONDUCTING RESISTORS

Origin and Sponsor: NBS, Section 1.6

Manager: B. G. Urban

Full task description: Apr-June 1954 issue, p. 40

Status: Inactive. For status to date, see Apr-June 1955 issue, p. 12.

## 3711-60-0009/55-53 ELECTRONIC FUNCTIONS

Origin: NBS, Section 4.5Manager: W. G. HallFull task description: Apr-June 1955 issue, p. 12Status: Continued. The tabular material was typed, and the final readying of the manuscript for publication was almost completed.

## 1102-40-5126/55-58 ELECTROMAGNETIC RADIATION FROM LIGHTNING

Origin and Sponsor: NBS, Section 82.1Manager: B. G. UrbanFull task description: Jan-Mar 1955 issue, p. 17Status: Inactive. For status to date, see Jan-Mar 1955 issue, p. 17.

## 1102-40-5126/55-61 ELASTIC CROSS SECTION FOR NEUTRON SCATTERING

Origin and Sponsor: Naval Research LaboratoryManager: I. StegunFull task description: Oct-Dec 1954 issue, p. 18Status: Inactive. For status to date, see Apr-June 1955 issue, p. 13.

## 3711-60-0009/55-66 RECONSTITUTION OF MONOCHROMATIC LIGHT INTENSITIES

Origin: NBS, Division 30Manager: H. BremerFull task description: July-Sept 1954 issue, p. 18Status: Inactive. For status to date, see Oct-Dec 1954 issue, p. 19.

## 3711-60-0009/55-68 CRYSTAL STRUCTURE CALCULATIONS

Origin: NBS, Division 9Manager: R. ProsenFull task description: Jan-Mar 1955 issue, p. 18Status: Continued. A general program applicable to all crystallographic space groups is being written that will calculate least squares refinements for atomic positions as well as individual anisotropic temperature factor parameters for each atom. Code-checking of the general structure factor routine is progressing satisfactorily. The code for the general Fourier routine to calculate three-dimensional electron density maps has been punched and is ready for checking.

## 1102-40-5126/55-74 LIQUID-VAPOR TRANSITION, II

Origin and Sponsor: Naval Medical Research InstituteManager: S. PruschFull task description: Jan-Mar 1955 issue, p. 19Status: Inactive.

## 3711-60-0009/55-75 PARAMETER OF THE DISPERSION EQUATION FOR OPTICAL GLASS

Origin: NBS, Section 2.2Manager: R. ZuckerFull task description: Jan-Mar 1955 issue, p. 20Status: Continued. For a given set of observed wavelength  $\lambda$ , and index of refraction  $n$ , the constant of dispersion  $k_i$  was determined by the method of least squares, using the original code. A new code was written and checked to set up a table of the computed values of  $n_c$ ,

$$n_c = 1 + \sum_{i=1}^5 \frac{k_i^2}{\lambda^2 - \lambda_i^2}$$

The table of  $n_c$  was prepared for  $\lambda = .54(.02)2(.2)20(.1)40$  for given values of  $\lambda_i^2$  and  $k_i$ .

## 1102-40-5126/55-81 COMBINING TESTS FOR SIGNIFICANCE

Origin: NBS, Section 11.3Manager: L. S. JoelFull task description: Oct-Dec 1954 issue, p. 23Status: Continued. The bulk of the results for the table have been transmitted to the sponsor. It remains to compute and check scattered values.

## 3711-60-0009/55-82 THERMOMETER CALIBRATIONS

Origin: NBS, Section 3.1Manager: S. PruschFull task description: Jan-Mar 1955 issue, p. 20Status: Continued. Calibration tables were run on approximately 49 thermometers under test.

## 1102-40-5126/55-88 STRESSES IN A WALL FOUNDATION

Origin and Sponsor: NBS, Section 10.1Managers: E. Marden, G. HawkinsFull task description: Jan-Mar 1955 issue, p. 22Status: Inactive.

## 1102-40-5126/55-103 MISSOURI RIVER PROBLEM

Origin and Sponsor: Missouri River Division, Corps of Engineers, U.S. ArmyManager: H. BremerFull task description: Jan-Mar 1955 issue, p. 26Status: Continued. New data from the sponsor was processed on UNIVAC using codes already set up.

## 1102-40-5126/55-105 AERONOMIC TIDAL WINDS OF THERMAL ORIGIN

Origin and Sponsor: NBS, Section 82.1Managers: B. G. Urban, H. H. Howe (82.1)Full task description: Jan-Mar 1955 issue, p. 26Status: Inactive. For status to date, see Jan-Mar 1955 issue, p. 26.

## 1102-40-5126/55-113 REACTOR DESIGN

Origin: Westinghouse Atomic Power DivisionSponsor: Atomic Energy CommissionManager: U. HochstrasserFull task description: Jan-Mar 1955 issue, p. 28Status: Continued. Some changes in the code were made in order to be able to iterate on the equations for high and low energy level flux separately. A change in the computation of the eigenvalues was prepared. Several additional runs with the original code were made in order to complete the study of the best choice of an over-relaxation factor.

## 1102-40-5126/55-117 ATTENUATION OF PRESSURE PULSES OF FINITE AMPLITUDE

Origin: NBS, Section 3.2Sponsor: Bureau of Aeronautics, U. S. NavyManager: M. PaulsenFull task description: Apr-June 1955 issue, p. 18Status: Inactive. For status to date, see July-Sept 1955 issue, p. 30.



## Status of Projects

## 1102-40-5126/55-118 THERMOMETER CALIBRATION, II

Origin and Sponsor: NBS, Section 3.1Manager: B. G. UrbanFull task description: Apr-June 1955 issue, p. 18

Status: Continued. An additional code to compute certain constants and differences formerly computed by hand was completed and checked out. Tables for eight thermometers were computed and transmitted to sponsor. A supplementary code to edit finished results is being written.

## 1102-40-5126/55-121 ELECTRON PENETRATION

Origin: NBS, Section 4.8Sponsor: Atomic Energy CommissionManager: S. PeavyFull task description: Apr-June 1955 issue, p. 19Status: Continued. Preparation of the code continued.

## 1102-40-5126/55-122 SOLUTION OF NORMAL EQUATIONS

Origin: Advisory Committee on Weather ControlSponsor: U. S. Weather BureauManager: M. NewmanFull task description: Apr-June 1955 issue, p. 20Status: Inactive.

## 1102-40-5126/55-123 TEMPERATURE DISTRIBUTION

Origin: NBS, Section 6.4Sponsor: NBS, Section 6.4Manager: W. G. HallFull task description: Apr-June 1955 issue, p. 19Status: Inactive. For status to date, see Oct-Dec 1955 issue, p. 24.

## 1102-40-5126/55-124 EVALUATION OF INTEGRALS RELATED TO GAS FLOW

Origin: NBS, Section 3.2Sponsor: Bureau of Aeronautics, U. S. NavyManager: J. CooperFull task description: Apr-June 1955 issue, p. 20

Status: Reactivated. The project was reopened to compute values of the integrals  $R_1$  and  $R_2$  for new parameters. In addition, the code was modified so that the times taken to fill containers could be computed directly. This involved computing the following quantities for each value of  $a$ , instead of  $R_1$  and  $R_2$ .

$$t_1 = a\sqrt{3} R_1 + t_c$$

$$t_2 = a R_2 + t_c$$

$$\text{where } t_c = 14.022 [(1-x_c)^{-1/7} - 1]$$

$$\text{and } x_c = a \left[ \frac{.528(1+.005a)}{1+.528a} - 0.005 \right]$$

Calculations were made for 12 values of  $a$  ranging from 0.1130 to 0.9040 and for  $\beta = .533(.05).033, .963, .983$ .



## 1102-40-5126/55-126 AERODYNAMIC HEATING

Origin and Sponsor: Diamond Ordnance Fuze Laboratory, Dept. of the ArmyManagers: B. Walter, R. CapuanoFull task description: July-Sept 1955 issue, p. 31Status: Continued.  $T_w$  was calculated with the following modifications:

$B_o h_e \Delta t$  increased by 2% and  $T_{AW}$  increased 8°F for each of the four missile trajectories. The corresponding variations of  $T_w$  and of the  $T_w$  intersections were calculated and compared with the modifications described in the Oct-Dec 1955 issue, p. 24.

A table of  $W$  as a function of  $L$ ,  $M$ , and  $\Delta S$  was calculated for each of the four trajectories from the equation,

$$\Delta W = \frac{\frac{M}{L} - W_1}{\frac{1}{L\Delta S} + \frac{1}{2}},$$

where  $M = 19.62 \cos \left[ \frac{\theta_1 + \theta_2}{2} \right],$

$$L = (C_{D_1} + C_{D_2})(\rho_1 + \rho_2)1.186 \cdot 10^{-3},$$

$$\Delta S = V\Delta t,$$

and tables of  $\theta$ ,  $\rho$ ,  $C_D$  were given. Based on the computed values of  $W$ , the original velocity was then checked against the velocity obtained by the relation,

$$\Delta V = \frac{V_1}{2} \frac{\Delta W}{W_1} \left[ 1 - \frac{1}{4} \frac{\Delta W}{W_1} + \frac{1}{8} \left( \frac{\Delta W}{W_1} \right)^2 - \frac{5}{64} \left( \frac{\Delta W}{W_1} \right)^3 + \dots \right],$$

where  $W_1 = V_1^2.$

Then  $L$  was increased by 2%, which is equivalent to increasing the ambient density by 2%, and the change in  $V$  was determined in accordance with the above equations.

The values of  $T_w$  as a function of time were calculated for the modified density and velocity conditions in accordance with the procedure previously outlined (Oct-Dec 1955 issue) for two of the ranges. The intersections of the two strip temperatures were then compared with those obtained for the unmodified conditions.

## 1102-40-5126/55-127 VIBRATIONS OF CIRCULAR DISC

Origin and Sponsor: Evans Signal LaboratoryManager: U. HochstrasserFull task description: July-Sept 1955 issue, p. 32

Status: Continued. A set of solutions for the equations described in the July-Sept 1955 issue has been obtained. The code has been changed in order to eliminate the singularities on the lefthand side of the mentioned equation.

## 3711-60-0009/56-131 RAY TRACING

Origin: NBS, Section 2.2Manager: E. MardenFull task description: July-Sept 1955 issue, p. 33Status: Continued. Code checking is in progress.

## Status of Projects

## 1102-40-5126/56-133 COMPLEX EIGENVALUES

Origin: Moore School of EngineeringSponsor: Office of Naval ResearchManager: I. StegunFull task description: July-Sept 1955 issue, p. 33.Status: Continued. The largest eigenvalues for two matrices of order ten were obtained, together with the successive vectors.

## 1102-40-5126/56-134 TRANSMISSION-DELAY TIMES

Origin: NBS, Section 82.1Sponsor: NBS, Section 82.1Managers: B. G. Urban, H. H. Howe (82.1)Full task description: July-Sept 1955 issue, p. 34Status: Continued. The bulk of the tables have been computed.

## 1102-40-5126/56-136 CALCULATION OF WAVE FUNCTIONS BY HARTREE METHOD

Origin: Naval Research LaboratorySponsor: " " "Manager: S. PeavyFull task description: July-Sept 1955 issue, p. 34Status: Continued. The new code was checked out, and the results were transmitted to the sponsor. The simplification of the equations reduced the SEAC time considerably. This made it possible to carry out the computation for certain cases to many iterations.

## 1102-40-5126/56-137 STABILITY OF SUPPORTED PLATES

Origin and Sponsor: National Advisory Committee on AeronauticsManager: R. ZuckerFull task description: July-Sept 1955 issue, p. 35Status: Continued. Computations were continued for  $r=3$  and  $r=2$  for various combinations of  $k_c$ ,  $k_s$ , and  $\beta$ . The calculations are now extended for negative values of  $k_c$  and  $k_s$ . As answers are obtained, they are submitted to the sponsor.1102-40-5126/56-139 STUDY OF INTERNUCLEAR POTENTIAL FOR  $H_3$ Origin and Sponsor: NBS, Section 3.2Manager: E. HaynsworthFull task description: July-Sept 1955 issue, p. 36Status: Inactive. For status to date, see Oct-Dec 1955 issue, p. 26.

## 1102-40-5126/56-140 MULTIPLE CORRELATION ROUTINES

Origin and Sponsor: Agricultural Economics Division, Department of AgricultureManagers: H. Bremer, M. PaulsenFull task description: Oct-Dec 1955 issue, p. 26Status: Continued. A program has been set up for the sponsor to do the computations on SEAC for least squares regression problems and the evaluation of correlation coefficients. This program consists of three basic routines.

For each regression problem the variables may or may not undergo any of the following transformations,--logarithm of original variables, the first difference of the variable or its logarithm. Using these transformed variables the moment matrix is then computed. This part of the program is designated as Routine I.

Routine II consists of existing codes for matrix inversion and



is used to compute the inverse of the moment matrix.

Routine III takes the inverse matrix and computes the

- a) regression coefficient
- b) standard errors of the partial regression coefficients
- c) partial correlation coefficient
- d) multiple correlation coefficient
- e) standard errors of estimate and the constant for the regression equation.

So far nine problems have been submitted by the sponsor and were processed by the above program. Each problem took approximately 20 to 40 minutes depending upon the number of variables and number of observations. It is hoped that this running time will be reduced by about one third when the routines are better integrated. Also considerable time will be saved if a matrix conversion code is written so that the entire problem can be done in the internal memory.

It is planned that some additional routines will be written to aid the sponsor in fitting systems of equations by the limited information approach.

1102-40-5126/56-143 CHARGED PARTICLE TRAJECTORIES IN THE MAGNETIC FIELD OF THE EARTH

Origin and Sponsor: Naval Research Laboratory

Manager: J. H. Wegstein

Full task description: Oct-Dec 1955 issue, p. 27

Status: Continued. The trajectories for 22 more sets of initial conditions were computed with the NORC and were sent to the sponsor.

1102-40-5126/56-147 GROUND WAVE ATTENUATION

Origin and Sponsor: NBS, Section 82.1

Managers: B. G. Urban, H. H. Howe (82.1)

Full task description: Oct-Dec 1955 issue, p. 29

Status: Inactive. For status to date, see Oct-Dec 1955 issue, p. 30.

1102-10-5126/56-151 MULTIPLE SCATTERING IN CROSS SECTION MEASUREMENTS

Origin and Sponsor: Naval Research Laboratory

Manager: I. Rhodes

Full task description: Oct-Dec 1955 issue, p. 30

Status: Continued. Of the 16 sets of parameters, assigned computations on four have been completed. Computing time takes from 25 to 40 minutes, depending on the number of trials required.

1102-40-5126/56-152 COST ACCOUNTING OPERATIONS FOR HIGH SPEED COMPUTERS, II

Origin and Sponsor: Bureau of Supplies and Accounts, Department of the Navy

Manager: G. Hawkins

Full task description: July-Sept 1955 issue, p. 38

Status: Continued. The code for editing and presenting the output was finished. Because time on the UNIVAC in the Washington area is practically impossible to obtain, a total of only three hours of code checking was available during the quarter. Debugging of the codes was thus delayed.

1102-40-5126/56-157 DAMAGE ASSESSMENT

Origin and Sponsor: Office of the Assistant Secretary of Defense (Supply and Logistics)

Managers: A. J. Hoffman, H. Bremer

Full task description: Oct-Dec 1955 issue, p. 31

Status: Continued. Meetings have been held with the sponsors in order to



## Status of Projects

reformulate the model so that new and more extensive programs could be written that will more nearly represent the problem. Some of the input programs are being written at present. There is also an interim code to be written which will adapt routines of the past to conform with a better representation of the input data.

1102-40-5126/56-158 FEDERAL RESERVE DATA

Origin and Sponsor: Federal Reserve Board

Manager: E. Marden

Full task description: Oct-Dec 1956 issue, p. 31

Status: Continued. Five codes were written, together with some needed auxiliary service routines that were unavailable at the UNIVAC installations where these tabulations were performed.

It became increasingly difficult to obtain sufficient UNIVAC time to accomplish the desired objectives, and even time on auxiliary machines was in short supply.

The Air Force card-to-tape machine was used to convert the information on the approximately 200,000 punched cards to 55 UNIVAC magnetic tapes, which were then processed (and to some extent compressed) to form new data tapes for use in the actual tabulations. UNIVAC's at the Census Bureau, the Army Map Service, and the Du Pont Company (in Newark, Delaware) were used for this purpose. Tabulations, making use of the processed data, are under way on the Du Pont UNIVAC.

1102-40-5126/56-162 STRESSES IN A WALL RESTING ON A FOOTING

Origin and Sponsor: NBS, Section 10.1

Manager: I. Stegun

Objective: To evaluate on SEAC coefficients in a stress function  $\phi$  which is used in obtaining the stresses and strains due to shrinkage in a concrete wall resting on a footing.

Background: The interior of a wall can be considered to be an elastic slab which obeys the equation of elasticity. In the equation

$$\frac{\partial^4 \phi}{\partial x^4} + 2 \frac{\partial^4 \phi}{\partial x^2 \partial y^2} + \frac{\partial^4 \phi}{\partial y^4} = 0, \quad (1)$$

$\phi$  is the stress function which gives the stresses in the wall by the following relationships:

$$\sigma_x = \frac{\partial^2 \phi}{\partial y^2} = \text{stress in x-direction,}$$

$$\sigma_y = \frac{\partial^2 \phi}{\partial x^2} = \text{stress in y-direction,}$$

$$\tau_{xy} = - \frac{\partial^2 \phi}{\partial x \partial y} = \text{shear stress.}$$

No single expression satisfying equation (1) above and the boundary conditions of the problem could be found. Therefore it has been decided to obtain a solution in the form of a series of expressions, each of which will identically satisfy equation (1) and the sum of which can be made to satisfy the boundary conditions to any desired degree of accuracy. The equation for the stress function used is

$$\phi = \sum_{n=1,3,\dots} \sum_{m=1,2,\dots} a_{mn} \sin \frac{m\pi x}{a} \sin \frac{n\pi y}{b},$$

$$w, e \begin{matrix} a_{mn} \\ (n \text{ odd}) \end{matrix} = \frac{n k_m + m t_n + (-1)^{\frac{n-1}{2}} p_m}{(m^2 \frac{b}{a} + n^2 \frac{a}{b})^2}$$

$$a_{mn} \begin{matrix} \\ (n \text{ even}) \end{matrix} = \frac{n \ell_m + m t_n + (-1)^{\frac{n}{2}} n s_m}{(m^2 \frac{b}{a} + n^2 \frac{a}{b})^2}$$

The coefficients  $k_m$ ,  $\ell_m$ ,  $t_n$ ,  $p_m$ , and  $s$  are to be determined by the boundary conditions. This necessitates the solution of 40 simultaneous equations for a wall twice as high as it is long, and of 60 simultaneous equations for a square wall. (For the computation of the stress function, see task 1102-40-5126/55-88, Jan-Mar 1955 issue, p. 22.)

Status: New. The solutions have been obtained for the rectangular wall (40 simultaneous equations) and the square wall (60 simultaneous equations). The matrix inversion codes were employed restricting the number of vectors to two--the vector of the unknowns and a check vector.

#### 1102-40-5126/56-163 ANGULAR DISTRIBUTIONS AND POLARIZATION EFFECTS IN NUCLEAR SCATTERING

Origin and Sponsor: Naval Research Laboratory

Manager: I. Stegun

Full task description: Oct-Dec 1955 issue, p. 32

Status: Continued. The code was completed, and various sample problems are being run to check approximation formulae.

#### 1102-40-5126/56-165 INTEGRALS FOR SCATTERING FUNCTIONS

Origin and Sponsor: Naval Research Laboratory

Manager: R. Zucker

Full task description: Oct-Dec 1955 issue, p. 32

Status: Continued. For  $\xi \gg 1$ , the value of

$$I_{\text{LIMIT}} = \frac{8\xi}{p^2} \frac{1}{[\ln(4\theta^2 \xi) - 1]}$$

was verified for several sets of  $p$  and  $\xi$ . The code was checked out, and a sample case was run for a given set of parameters.

#### 1102-40-5126/56-166 SCF-LCAO SOLUTION OF SOME HYDRIDES

Origin and Sponsor: NBS, Section 5.9

Manager: E. Haynsworth

Objective: To find the eigenvalues,  $\epsilon_i$ , and eigenvectors,  $C_i$  of the secular equation

$$(H+G)C = \epsilon SC$$

where  $H$ ,  $G$ , and  $S$  are  $n \times n$  symmetric matrices,  $n \leq 6$ .  $H$  and  $S$  are constant, but the elements of  $G$  are quadratic functions of the eigenvectors  $C_i$ .

Background: The eigenvectors are the coefficients of the atomic orbital in the LCAO approximation to a molecular orbital, and the secular equation results from minimization of the expression for the ground state energy for the molecules considered with respect to the coefficients. (See C.C.J. Rootham, Rev. Modern Phys. 23, 69 (1951).) The problem was

requested by Morris Krauss (5.9).

Status: New. The main code has been written but has not been checked as a whole. Most of the subroutines involved, such as matrix multiplication and addition, calculation of determinants, orthonormalization of vectors, have been checked.

#### 1102-40-5126/56-169 CRYSTAL FIELD EFFECTS FOR ATOMS

Origin and Sponsor: NBS, Division 3

Manager: I. Stegun

Objective: To compute eigenvalues and eigenvectors of matrices as functions of parameters describing various crystal fields.

Background: The calculations arise in the study of the effect of the combinations of crystal field and spin-orbit coupling on the optical and magnetic properties of solids. The problem was transmitted by C. M. Herzfeld (3.0).

Status: New. For heavy atoms the matrix for the combined crystal field effect and spin-orbit coupling is a  $33 \times 33$  matrix. This matrix factors directly into three  $8 \times 8$  matrices and one  $9 \times 9$ . The eigenvalues and eigenvectors were obtained for ten  $8 \times 8$  matrices and five  $9 \times 9$  matrices.

For nitrogen atoms the eigenvalues and eigenvectors were obtained for fifteen  $5 \times 5$  matrices.

#### 1102-40-5126/56-171 COLLISION INTEGRALS USED IN TRANSPORT THEORY

Origin and Sponsor: NBS, Section 3.2

Manager: J. Cooper

Full task description: Oct-Dec 1955 issue, p. 33

Status: Continued. A short code to compute the value of

$$x = \pi - 2b \int_{r_m}^{\infty} \frac{dr/r^2}{\sqrt{1 - \left(\frac{b}{r}\right)^2 - \frac{\phi(r)}{g^2}}}$$

for various values of  $g$  and  $b$  was written to determine the behavior of  $x$  using the Morse potential:

$$\phi(r) = 4e^{\beta(1-r)}(e^{\beta(1-r)} - 1).$$

To find  $r_m$  (the largest root of the denominator) the equation  $r_{n+1} = r_n - f(r_n)$ ,

where  $f(r)$  is the expression under the radical sign in the above equation, was solved by iteration. In order to improve convergence it was found convenient to replace  $f(r)$  by  $\frac{f(r)}{f'(r)}$  and iterate using the form

$$r_{n+1} = r_n - \frac{f(r_n)}{f'(r_n)}.$$

Convergence using this form in conjunction with an iteration accelerator technique was rapid, and the process converged for all cases tried except when  $\beta$  in the Morse potential was large.

The integration was performed using 16-point Gaussian quadrature on the interval 0 to  $1/r_m$ , transforming the integral using  $\rho = 1/r$ .

However, due to the singularity at the upper limit the accuracy was not sufficient. The code has now been modified to compute the integral using the transformation  $\frac{1}{r} = \frac{\sin \rho}{r_m}$ , which removes the singularity except for

certain values of the parameters  $b$ ,  $g$  and  $\beta$ .



1102-40-5126/56-172 NUMERICAL EVALUATION OF SPECIAL INTEGRAL EXPRESSIONS

Origin and Sponsor: Diamond Ordnance Fuze Laboratory, Department of the Army

Managers: P. Henrici, L. Joel

Objective: To evaluate some principal value integrals of the form

$$P \int_0^{\infty} \frac{f(x^2)}{x^2 - a^2} J_0(xy) x dx$$

where  $f(x^2)$  is an elementary differentiable function for  $0 < x < \infty$ .

Background: Integrals of this type occur in the theory of elastic vibrations.

In a report by P. M. McQuinlan, "Elastic theory of soil dynamics," p. 3

(Symposium on Dynamic Testing of Soils, ASTM Special Technical Publication

No. 156, 1953), simple cases of transmission of tremors or vibrational

disturbances through surface soils are presented. The current study is

an attempt to complete the analysis of one unresolved aspect in this

report as expressed in the above integral. The integral gives the soil

vibration amplitude at a distance from the source as a function of soil

parameters and experimental conditions. The results of this evaluation

of Quinlan's integral will be compared with other experimental data

obtained at the NBS in an attempt to check the validity of the analysis.

The problem was requested by E. N. Skomal.

Status: New. In order to avoid the singularity in the numerical integration, one introduces the function

$$g(x^2) = \frac{f(x^2) - f(a^2)}{x^2 - a^2}$$

The integral can then be written

$$\int_0^{\infty} g(x^2) T_0(xy) x dx + f(a^2) P \left\{ \int_0^{\infty} \frac{1}{x^2 - a^2} J_0(xy) x dx \right\},$$

where  $P \{ \}$  denotes the principal part of the integral. Here the first integral has a regular integrand, and the second can be evaluated explicitly in terms of the Neumann functions.

1102-40-5126/56-173 COMPUTATIONS FOR JOB SATISFACTION INVENTORY

Origin and Sponsor: Public Health Service

Manager: S. Prusch

Objective: To determine and compare distributions of data in a job satisfaction inventory, and to compute the  $\chi^2$  distribution for each of 215 items in the inventory.

Background: The computations arise in connection with the study of a job satisfaction inventory for five groupings of personnel in three hospitals.

An attempt is being made to check the relative validity of the 215 items with a view to reducing the number to 100. To aid in this it is necessary

(1) to determine how the distribution of individuals with favorable and

unfavorable responses to each item compares with the distribution of

individuals with high and low scores, and (2) to determine how the

distribution of individuals with favorable and unfavorable responses

to an item compares with the distribution of individuals who are satisfied

or dissatisfied as determined by special criteria. This was specifically

requested by B. Buchbinder of the Public Health Service.

Status: New. The problem was coded, and code-checking is in progress.

## Status of Projects

1102-40-5126/56-176 MODEL GOVERNMENT PAYROLL ON HIGH SPEED COMPUTERS

Origin and Sponsor: NBS, Section 12.5

Manager: G. Hawkins

Objective: To investigate the feasibility of translating the Government payroll computations to electronic computer operations. This investigation is to be effected by studying in particular the conversion of the operations of the NBS payroll system (1) to a large general-purpose computer, and (2) to a drum computer, and then comparing the efficiency of these two systems with each other and with an IBM mechanized system.

Background: The NBS payroll system was recently mechanized with IBM equipment. Biweekly time cards for each employee are submitted to the Payroll Section. From these, time cards and paychecks are computed and processed; and various division and bureau reports are derived and used for time distribution analyses and general accounting procedures. The present investigation aims to determine whether further time-saving and efficiency is possible if the material were to be processed on a digital electronic computer.

Status: New. Coding of the problem for UNIVAC is in progress.

## 6. STATISTICAL ENGINEERING SERVICES

### COLLABORATION ON STATISTICAL ASPECTS OF NBS RESEARCH AND TESTING Task 3737-60-0002/51-1

Origin: NBS

Authorized 7/1/50

Managers: W. J. Youden, J. Cameron

Full task description: July-Sept 1950 issue, p. 60

Status: CONTINUED. During this quarter members of the Section provided statistical assistance and advice to a number of Bureau personnel. The following are representative examples:

- (1) A 3x3 factorial experiment in 9 blocks of 3 units each was analyzed for J. Wachtman, Section 9.1, to evaluate the characteristics of the modulus of rupture of sapphire single crystals with respect to loading rates and temperatures.
- (2) Statistical analyses were made on SEAC for H. C. Allen, Section 4.2; W. G. Eicke, Section 1.8; G. W. Cloek, Section 9.2; J. Hilsenrath, Section 3.2; A. Friedman, Section 3.2; M. D. Burkhard, Section 6.1; and R. S. Jessup, Section 3.2. In the last two instances special codes were written for SEAC.
- (3) Members of the staff consulted with personnel of the Fire Protection Section (10.2) on the scheduling of tests of fire protecting finishes for building materials.
- (4) W. J. Youden has been working with W. B. Mann, Section 4.9, on experiment designs for the intercomparison of radium standards from several national laboratories.
- (5) An analysis of the data on lengths of meter bars was made for Section 2.4 to determine the improvement in precision due to improved methods of marking lines on the newer bars.
- (6) M. Zelen served as statistical consultant to the members of Section 12.5 who are studying the sorting operations of the Post Office.

#### Publications:

- (1) National physical standards and design of experiments. W. J. Youden. To appear in Revue de l'Institut International de Statistique.
- (2) More scientists. W. J. Youden. Submitted to a technical journal.
- (3) A simplified calibration of platinum versus platinum-rhodium thermocouples. B. E. Squires (3.1) and M. Zelen. In manuscript.

### STATISTICAL SERVICES FOR COMMITTEE ON SHIP STEEL, NRC Task 1103-40-5105/52-1

Origin and Sponsor: Ship Structure Committee, NRC

Authorized 12/1/51

Manager: W. J. Youden

Full task description: Oct-Dec 1951 issue, p. 58

Status: CONTINUED. A multiple regression study of the effect of chemical composition on ship steel was nearly completed.



## Status of Projects

**RESEARCH IN APPLICATIONS OF MATHEMATICAL STATISTICS TO  
PROBLEMS OF THE CHEMICAL CORPS  
Task 1103-40-5118/52-1**

Origin and Sponsor: Biological Laboratories, Authorized 10/1/51  
Chemical Corps, Dept. of the Army

Manager: C. Eisenhart

Full task description: Oct-Dec 1951 issue, p. 57

Status: CONTINUED. A report giving a collection of formulas for computing probabilities from common statistics was submitted.

Work on tabulating a function related to problems of diffusion in the atmosphere was begun.

**STATISTICAL ANALYSIS AND DESIGN OF EXPERIMENTS  
FOR THE U. S. GEOLOGICAL SURVEY  
Task 1103-40-5140/54-1**

Origin and Sponsor: U. S. Geological Survey, Authorized 10/9/53  
Department of Interior

Managers: C. Eisenhart, W. J. Youden

Full task description: Oct-Dec 1953 issue, p. 50

Status: CONTINUED. Some quick and easy methods for estimating the direction of gradient and the properties of such estimators are being worked out.

Data supplied by Dorothy Carroll of the Beltsville Laboratories concerning counts of different kinds of minerals in samples taken from tributaries of the South River in Virginia were analyzed for the most abundant mineral, the "opaques," with the aim of deciding how many samples should be taken from each location in order to get the most information for a given cost.

Consultations were held with J. Hack on application of extreme values and other statistical methods (including order statistics) to pebble deposits.

C. Eisenhart visited the U. S. Geological Survey Center, Menlo Park, California, March 19-24, at their request (i) to acquaint the geologists at Menlo Park with the uses and usefulness of statistical methods in laboratory and field studies, and with the necessity of giving adequate consideration to statistical aspects of such studies in the planning stage; (ii) to discover in what particular phases of the work going on at Menlo Park statistical methods might be most advantageously applied; and (iii), to make some tentative plans for provision of statistical assistance to the geologists at Menlo Park in the future. While there he gave five lectures to the staff of the center as follows: (1) Evolution of statistical method as a research tool; (2) Some canons of sound experimentation; (3) Principles of sampling; (4) Variance components and optimum allocation of sampling effort; and (5) Experiment designs. On the final day he presided over an informal meeting at which (1) representatives from the Department of Statistics, Stanford University, and the Statistical Laboratory, University of California, Berkeley, outlined the statistical courses of potential value to geologists available at these two neighboring educational institutions, and (2) geologists from the center outlined some of their problems to the statisticians and sought their advice on them.

MANUAL ON EXPERIMENTAL STATISTICS  
FOR ORDNANCE ENGINEERS  
Task 1103-40-5146/55-93

Origin and Sponsor: Office of Ordnance Research

Authorized 12/29/54

Manager: C. Eisenhart

Full task description: Oct-Dec 1954 issue, p. 28

Status: CONTINUED. Drafts of the following sections have now been completed: "Estimating average performance from a sample," "Estimating the variability of performance from a sample," "Statistical tests concerning averages and dispersions." A draft of the section "Description, prediction, and correlation" is nearly completed, and some work has been done on the sections "Simple control charts for means and ranges," "Estimating true proportions or percentages," and "Statistical tests concerning proportions."

APPLICATION  
of  
NATIONAL BUREAU OF STANDARDS AUTOMATIC COMPUTER (SEAC)

The record of SEAC operations for tasks of the Applied Mathematics Division for the period January 1 through March 31 is as follows:

Task No.	Title	Hours Used:	
		Code Checking	Productive Operation
<b>NBS:</b>			
1104/55-55	Research in numerical analysis	6	
5116/56-148	Nerve fiber reaction		20
1110/47-2	Tables of Coulomb wave functions	9	25
1110/52-57	Sieverts integral		2
1110/53-51	Radiation diffusion III	17	42
1110/53-52	L-Shell conversion coefficients		24
1110/55-65	Automatic coding	2	
5126/52-44	Calculations for d-spacings		14
5126/53-29	Dynamic behavior of aircraft structure	5	19
0009/54-17	Depolymerization	1	16
5126/54-30	Spectrometer analysis	1	1
0009/55-53	Electronic functions		10
0009/55-75	Parameter of the dispersion equation for optical glass	1	3
5126/55-81	Combining tests for significance	2	55
5126/55-87	Crystal structure	10	
5126/55-97	High temperature properties of air	39	22
5126/55-118	Thermometer calibrations	14	4
5126/55-121	Electron penetration	2	
5126/55-124	Evaluation of integrals related to gas flow	6	4
5126/55-127	Vibrations of circular disc	10	19
5126/56-166	SCF-LCAO solution of some hydrides	13	
0009/56-131	Ray tracing	69	85
5126/56-134	Transmission delay times		1
5126/56-139	Study of internuclear potential for H <sub>3</sub>	10	13
5126/56-150	Mathematical expression		3
5126/56-169	Crystal field effects for atoms		20
5126/56-171	Collision integrals used in transport theory	6	4
5126/56-179	Normal propagation constant	27	51
5126/56-178	Cytac	3	2
0002/52-1	Statistical aspects of administrative operations	6	36
Misc.	Training		1
"	Least squares		2
<b>Other:</b>			
5126/53-45	Application of game theory	4	5
5126/54-13	Award of procurement contracts for linear programming		12



<u>Task No.</u>	<u>Title</u>	<u>Hours Used:</u>	
		<u>Code</u> <u>Checking</u>	<u>Productive</u> <u>Operation</u>
<u>Other:</u>			
5126/55-104	"Fuse" problem	1	58
5126/55-113	Reactor design	3	78
5126/55-119	Field rocket problem	10	
5126/56-130	Aircraft responses	6	2
5126/56-133	Complex eigenvalues	1	3
5126/56-136	Calculation of wave functions	6	32
5126/56-137	Stability of supported plates		22
5126/56-138	Crystal counter efficiency	3	
5126/56-140	Multiple correlation routines	15	5
5126/56-149	Logical matrix multiplication	4	3
5126/56-151	Cross section measurements	1	41
5126/56-163	Nuclear scattering	9	5
5126/56-165	Integrals for scattering functions	13	1
5126/56-167	Multiple regression	1	
5126/56-172	Special integral expressions	1	
5126/56-173	Job satisfaction inventory	9	
5126/56-181	Coulomb - AEC		27
5160/55-85	Mathematical elasticity	3	106
5160/56-156	Mathematical geophysics	13	7

## Lectures and Symposia

Note: In general, copies of papers or talks listed in this section are not available from the National Bureau of Standards. If and when a paper is to be published, it will be listed in the section of this report on Publication Activities.

### Participation in NBS Scientific Staff Meetings

STONELEY, R. (Cambridge University) The thickness of the continents.  
February 10.

SYNGE, J. L. (Institute for Advanced Studies, Dublin) The concept of time. March 9.

### Applied Mathematics Division Seminar

ARONSZAJN, A. (University of Kansas) Survey of the work in progress on partial differential equations, in particular eigenvalue problems at the University of Kansas. March 9.

### Seminar: Special Topics in Numerical Analysis

(Offered by the Department of Mathematics of The American University in collaboration with the Graduate School of the National Bureau of Standards)

TODD, J. (1) The theorems of Markoff. January 10. (2) The theorem of Zolotareff. January 17.

### Algebra Seminar

(Offered by the Department of Mathematics of The American University in collaboration with the Graduate School of the National Bureau of Standards)

GORN, S. (Moore School of Electrical Engineering, University of Pennsylvania) Computations in cubic field. February 13.

NEWMAN, M. A theorem of Mordell concerning positive quadratic forms, I, II. February 20, 29.

TODD, J. Number theory in quaternions. March 7.

TAUSSKY-TODD, O. Mordell's theory of positive binary quadratic form. March 14.

MARSHALL, L.C. (Department of Defense) General theory of binary quadratic form I, II. March 21, 28.

Statistical Theory Seminar

(Offered jointly by the National Institutes of Health and the National Bureau of Standards.)

CORNFIELD, J. (NIH). Models in the analysis of variance. January 17.

ROSENBLATT, J. R. (NBS) The efficiency of statistical tests. February 17.

Applied Statistics Seminar

(Offered jointly by the National Institutes of Health and the National Bureau of Standards.)

MEIER, P. (Johns Hopkins University) Some statistical aspects of safety testing of vaccines. March 16.

Mathematical Physics Section Seminar

STONELEY, R. (Cambridge University) Theory of elastic surface waves. Three lectures: February 9, 16, 23.

SYNGE, J. L. (Institute for Advanced Studies, Dublin) Elastic waves in anisotropic media. March 8.

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

ABRAMOWITZ, M. The evaluation of special functions on high speed computers. Presented at the Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, February 8.

CHIARULLI, P. Applied mathematics and the atomic bomb. Presented at a meeting of Sigma Pi Sigma, Howard University, Washington, D.C., January 18.

EISENHART, C. (1) Evolution of statistical method as a research tool. (2) Some cannons of sound experimentation. (3) Principles of sampling. (4) Variance components and optimum allocation of sampling effort. (5) Experiment designs. A series of lectures presented to the staff of the U. S. Geological Survey Center, Menlo Park, California, March 19-23.

HOCHSTRASSER, U. Methods and tools in applied mathematics. (1) Presented at a meeting of Sigma Pi Sigma, Howard University, Washington, D. C., February 17, and (2) Presented to the Research and Development Group, Naval Powder Factory, Indian Head, Md., February 29.

HOFFMAN, A. J. (1) Cross sections of two families of sets. Presented at a meeting of the Logistics Research Project, George Washington University, Washington, D. C., February 2. (2) Integral solutions of linear programming problems. Presented to the Industrial Engineering Department of Johns Hopkins University,



Baltimore, Md., February 15. (3) Representatives of sets. Presented at a Combinatorial Problems Seminar, Princeton University, Princeton, N. J., March 19.

STONELEY, R. (Guest Worker, from Cambridge University).

(1) The interior of the earth. Presented at the National Academy of Sciences, Washington, D. C., January 10. (2) The propagation of elastic waves over the surface of a cubic crystal. Presented at the Exploration and Production Research Laboratory, Shell Development Co., Houston, Tex., January 17. (3) The thickness of continents. Presented at the Agricultural and Mechanical College of Texas, College Station, Texas, January 19. (4) The variation of amplitude with depth in Rayleigh waves. Presented before the Seismological Society of America, Reno, Nevada, March 30.

SYNGE, J. L. (Guest Worker, from Institute for Advanced Studies, Dublin).

(1) Classical dynamics and de Broglie waves. Presented at New York University, February 6; at Princeton University, February 7; at Brown University, February 9; at the Ballistic Research Laboratory, Aberdeen Proving Ground, Md., February 21; at the Carnegie Institute of Technology, Pittsburgh, Pa., March 1; at the Institute for Fluid Dynamics and Applied Mathematics, University of Maryland, March 28. (2) Geometrical optics in moving media. Presented at Harvard University, Cambridge, Mass., March 6. (3) Classical dynamics and optics: de Broglie waves and photons. Presented to the Department of Mathematics, University of California at Los Angeles, March 13, 14. (4) Elastic waves in anisotropic media. Presented at the Massachusetts Institute of Technology, Cambridge, Mass., March 7. Also presented at the Geophysical Institute, University of California at Los Angeles, March 15-16.

TAUSSKY-TODD, O. (1) Pencils of matrices. Presented at the Institute for Fluid Dynamics, University of Maryland, College Park, Md., February 17. (2) Characteristic roots of sums and products of finite matrices. Presented at the Naval Ordnance Laboratory, White Oak, Md., January 18.

YODEN, W. J. (1) Design of experiments in the physical sciences. Presented at the Nuclear Power Division of the Bureau of Ships, Washington, D. C., January 3. (2) Interpretation of chemical data. Presented before the local chapter of the American Chemical Society, Morgantown, W. Va., January 9. (3) Control of experimental error by statistical design. Presented before the local chapters of the American Chemical Society in Charleston, W. Va.; Cincinnati, Ohio; and Lexington, Ky., January 10-12. (4) Making good measurements. Presented before the Indianapolis Chapter of the American Statistical Association, Indianapolis, Ind., January 13. (5) Experimental designs for the physical sciences. Presented before a joint meeting of the Minnesota ASQC and the American Institute of Chemical Engineers, St. Paul, Minn., January 17, and also before a group of scientists and engineers at the Westinghouse Electric Corp., Bettis Plant, Pittsburgh, Pa., March 2. (6) Improvement in the technique of learning. Presented before the professional staff of the Baltimore County Board of Education, Towson, Md., January 30. (7) Dice, data, and deductions. Presented before the Physics Club and Chemical and Mathematics Societies of Trinity College, Washington, D. C., February 1, and also before the Mathematics Club, Woodrow Wilson High School, Washington, D. C., February 28.

(8) Statistics for novices. Presented at the Sixth Annual Convention Textile Division, ASQC, Charlottesville, Va., February 13.

(9) Design of experiments. Presented before the Youngstown Section of ASQC, Youngstown, Ohio, March 1. (10) Design of experiments in research and development. Presented before the Washington Chapter, American Society for Metals, March 12.

(11) Cubes, colors, and computations. Presented before the Roosevelt High School Science Club, Washington, D. C., March 19.

## Publication Activities

### 1. PUBLICATIONS THAT APPEARED DURING THE QUARTER

#### 1.3 Technical Papers

- (1) Analytic study of war games. H. Antosiewicz. Naval Research Logistics Quart. 2, 181-215 (Sept. 1955).
- (2) Chaînes de Markoff dans les ensembles abstraits et applications aux processus avec régions absorbantes et au problème des boucles. (Formerly, Time-discrete stochastic processes in arbitrary sets, with applications to processes with absorbing regions and to the problem of loops in Markoff chains.) D. van Dantzig. Ann. Inst. H. Poincaré 14, 145-199 (1955).
- (3) Abscissas and weights for Gaussian quadratures of high order. P. Davis and P. Rabinowitz. J. Res. NBS 56, 35-37 (Jan. 1956), RP2645.
- (4) Numerical experiments in potential theory using orthonormal functions. P. Davis and P. Rabinowitz. J. Wash. Acad. Sci. 46, 12-17 (1956).
- (5) Comparison of theories and experiments for the hydraulic dam-break wave. R. F. Dressler. Publication No. 38 de l'Association Internationale d'Hydrologie (Assemblée generale de Rome, 1954, tome III, p. 319-328). Extrait.
- (6) Heat flow in a fluid with eddying flow. W. H. Durfee (now at Mt. Holyoke College). Condensed version appears in J. Aero. Sci. 23, 188-189 (Feb. 1956).
- (7) A comparison theorem for eigenvalues of normal matrices. K. Fan. Pac. J. Math. 5, Supp. 2, 911-913 (1955).
- (8) A subroutine for computations with rational numbers. P. Henrici. J. Assoc. Comp. Mach. 3, 6-9 (Jan. 1956).
- (9) Automatic computations with power series. P. Henrici. J. Assoc. Comp. Mach. 3, 10-15 (Jan. 1956).
- (10) On generating functions of the Jacobi polynomials. P. Henrici. Pac. J. Math. 5, 923-931 (1955).
- (11) Commutators of  $A$  and  $A^*$ . T. Kato (University of Tokyo) and O. Taussky. J. Wash. Acad. Sci. 46, 38-40 (1956).
- (12) Pairs of matrices with property L, II. T. S. Motzkin (University of California at Los Angeles) and O. Taussky. Trans. Amer. Math. Soc. 80, 387-401 (Nov. 1955).
- (13) An alternative proof of a theorem on unimodular groups. M. Newman. Proc. Amer. Math. Soc. 6, 998-1000 (1955).



- (14) The normalizer of certain modular subgroups. Canadian J. Math. 8, 29-31 (1956).
- (15) On a generalization of the normal basis in abelian algebraic number fields. M. Newman and O. Taussky. Comm. Pure Appl. Math. (NYU) 9, 85-91 (1956).
- (16) On asymptotic series for functions occurring in the theory of diffraction of waves by wedges. F. Oberhettinger. J. Math. Phys. 34, 245-255 (Jan. 1956).
- (17) Determinanten mit ueberwiegender Hauptdiagonale und die absolute Konvergenz von linearen Iterationsprozessen. A. M. Ostrowski. Comment. Math. Helv. 30, 175-210 (1956).
- (18) Contributions for inverse osculatory interpolation. H. E. Salzer. (Department of the Army). J. Res. NBS 56, 51-54 (Jan. 1956), RP2647.
- (19) A note on group matrices. O. Taussky. Proc. Amer. Math. Soc. 6, 984-986 (1955).
- (20) Partially replicated latin squares. W. J. Youden and J. S. Hunter (American Cyanimid Co.). Biometrics 11, 399-405 (Dec. 1955).

## 2. MANUSCRIPTS IN THE PROCESS OF PUBLICATION MARCH 31, 1956

### 2.1 Mathematical Tables

- (1) A table of the coefficients of the powers  $\eta(\tau)$ . M. Newman. To appear in the Proceedings of the Royal Netherlands Academy of Sciences.

### 2.2 Manuals, Bibliographies, and Indices

- (1) Analyzing straight line data. F. S. Acton. To appear as a book in the Applied Statistics Series of the Wiley Publications in Statistics.
- (2) Fractional factorial experimental designs for factors at two levels. W. S. Connor, M. Zelen, L. Deming, and W. H. Clatworthy. To appear as NBS Applied Mathematics Series 48.

### 2.3 Technical Papers

- (1) On the differential equation  $\ddot{x} + k(f(x) + g(x)\dot{x})\dot{x} = ke(t)$ . H. A. Antosiewicz. Submitted to a technical journal.
- (2) Stable systems of differential equations with integrable forcing term. H. A. Antosiewicz. To appear in the Journal of the London Mathematical Society.
- (3) Easily used simultaneous confidence limits for a line. W. S. Connor. Submitted to a technical journal.
- (4) Dilworth's theorem on partially ordered sets. G. B. Dantzig (RAND) and A. J. Hoffman. To appear in "Papers on linear inequalities and related systems," Annals of Mathematics Study 38.
- (5) Uniqueness theory for asymptotic expansions in general regions. P. Davis. To appear in the Pacific Journal of Mathematics.

- (6) Complete sequences and approximations in normed linear spaces. P. Davis and K. Fan. Submitted to a technical journal.
- (7) Some Monte Carlo experiments in computing multiple integrals. P. Davis and P. Rabinowitz. To appear in *Mathematical Tables and Other Aids to Computation*.
- (8) Entropy changes in rarefaction waves. R. F. Dressler. Submitted to a technical journal.
- (9) On systems of linear inequalities. K. Fan. To appear in "Papers on linear inequalities and related systems," *Annals of Mathematics Study* 38, ed. by H. W. Kuhn and A. W. Tucker.
- (10) Systems of inequalities involving convex functions. Ky Fan. Submitted to a technical journal.
- (11) A note on the normal distribution. S. Geisser. To appear in *Annals of Mathematical Statistics*.
- (12) A matrix with real characteristic roots. K. Goldberg. To appear in the *Journal of Research (NBS)*.
- (13) The formal power series for  $\log e^x e^y$ . K. Goldberg. To appear in the *Duke Journal of Mathematics*.
- (14) On the domain of regularity of generalized axially symmetric potentials. P. Henrici. To appear in the *Proceedings of the American Mathematical Society*.
- (15) On the representation of a certain integral involving Bessel functions by hypergeometric series. Submitted to a technical journal.
- (16) On systems of distinct representatives. A. J. Hoffman and H. W. Kuhn (Bryn Mawr College). To appear in "Papers on linear inequalities and related systems," *Annals of Mathematics Study* 38.
- (17) Systems of distinct representatives and linear programming. A. J. Hoffman and H. W. Kuhn (Bryn Mawr College). To appear in the *American Mathematical Monthly*.
- (18) The number of absolute points of a correlation. A. J. Hoffman, M. Newman, E. G. Straus, O. Taussky. To appear in the *Pacific Journal of Mathematics*.
- (19) On the Hilbert matrix. T. Kato. Submitted to a technical journal.
- (20) Applications of extreme value theory to cobbles and boulders in gravel pits. W. C. Krumbein (Northwestern University) and J. Lieblein. Submitted to a technical journal.
- (21) Solvability and consistency for linear equations and inequalities. H. W. Kuhn (Bryn Mawr College). To appear in the *American Mathematical Monthly*.
- (22) An inclusion theorem for modular groups. M. Newman. Submitted to a technical journal.
- (23) Generalizations of identities for the coefficients of certain modular forms. M. Newman. To appear in the *Journal of the London Mathematical Society*.

- (24) On the existence of identities for the coefficients of certain modular forms. M. Newman. To appear in the Journal of the London Mathematical Society.
- (25) The diophantine equation  $ax^m - by^n = c$ . M. Newman. Submitted to a technical journal.
- (26) On the Lerch zeta function. F. Oberhettinger. To appear in the Pacific Journal of Mathematics.
- (27) On Gauss' speeding up device in the theory of single step iteration. A. M. Ostrowski. Submitted to a technical journal.
- (28) On the convergence of Gauss' alternating procedure in the method of the least squares, I. A. M. Ostrowski. Submitted to a technical journal.
- (29) Contributions to the theory of rank order statistics. I. R. Savage. To appear in the Annals of Mathematical Statistics.
- (30) On the independence of tests of randomness and other hypotheses. I. R. Savage. To appear in the Journal of the American Statistical Association.
- (31) The transmission of Rayleigh waves across an ocean floor with two surface layers. R. Stoneley. Submitted to a technical journal.
- (32) Algebraic equations satisfied by roots of natural numbers. E. G. Straus (University of California at Los Angeles) and O. Taussky. To appear in the Pacific Journal of Mathematics.
- (33) Some computational problems in algebraic number theory. O. Taussky. To appear in the Proceedings of the American Mathematical Society Sixth Symposium on Applied Mathematics, held at Santa Monica City College, August 1953.
- (34) Generation and testing of pseudo-random numbers. O. Taussky and J. Todd. To appear in the Proceedings of a Symposium on Monte Carlo methods, held at Gainesville, Fla., 1954.
- (35) A direct approach to the problem of stability in the numerical solution of partial differential equations. To appear in the Proceedings of a Symposium on Partial Differential Equations held at Berkeley, California, 1955.
- (36) National physical standards and design of experiment. W. J. Youden. To appear in Revue de L'Institut International de Statistique (The Hague).
- (37) Exact tests of significance for combining intra- and inter-block information. M. Zelen. Submitted to a technical journal.
- (38) On the analysis of covariance. M. Zelen. Submitted to a technical journal.

## 2.5 Miscellaneous items

- (1) Development of automatic computers. F. L. Alt. To appear in the Proceedings of the American University Institute on Electronics in Management, held in Washington, D. C., November 1955.



- (2) Contributions on partially balanced incomplete block designs with two associate classes. W. H. Clatworthy. To appear as NBS Applied Mathematics Series 47.
- (3) More scientists. W. J. Youden. Submitted to a technical journal.

## **THE NATIONAL BUREAU OF STANDARDS**

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The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the front cover.

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Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards (\$1.25) and its Supplement (\$0.75), available from the Superintendent of Documents, Government Printing Office. Inquiries regarding the Bureau's reports and publications should be addressed to the Office of Scientific Publications, National Bureau of Standards, Washington 25, D. C.

