NATIONAL BUREAU OF STANDARDS REPORT

5433

PROJECTS and PUBLICATIONS
of the
APPLIED MATHEMATICS DIVISION

A Quarterly Report

April through June 1957

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
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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.
PROJECTS and PUBLICATIONS of the
APPLIED MATHEMATICS DIVISION
April through June 1957

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April 1 through June 30, 1957

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*Only unclassified projects are included in this report.
Status of Projects
June 30, 1957

1. NUMERICAL ANALYSIS

RESEARCH IN THEORIES OF DISCRETE STRUCTURES
Task 1100-11-5170/56-159

Origin: NBS
Sponsor: Office of Naval Research
Manager: O. Taussky-Todd
Full task description: July-Sept 1955 issue, p. 1

Status: CONTINUED. O. Taussky-Todd noticed that the incidence matrix of a finite projective geometry has the property that a sufficiently large power has positive elements only. Alternative proofs were subsequently communicated by H. J. Ryser (Ohio State) and M. Newman.

O. Taussky-Todd continued work on the coding of a problem concerning the 3-class group of imaginary quadratic number fields. E. C. Dade is collaborating with her on this problem, using a new approach of his own with a new code.

O. Taussky-Todd collaborated with A. Lax (New York University) and with M. Gerstenhaber (University of Pennsylvania) on problems both connected with pairs of matrices with property L.

E. C. Dade prepared a manuscript, "Abelian groups of unimodular matrices." This paper gives a very strong generalization of the theorem of K. Goldberg (J. Washington Acad. Sci. 46 (1956) 337-338), which states that any two commutative unimodular 2 x 2 matrices with rational integral elements are powers of another matrix of this type. An alternative proof of this was obtained by J. Todd and O. Taussky-Todd. They also generalized the theorem to matrices with coefficients in an imaginary quadratic field and found that certain complications occur. Analyzing these complications, Dade studied the general case of commutative n x n matrices with elements in the ring of integers of an arbitrary algebraic number field and the determinant a unit in this field. His method consists in imbedding the matrices into a commutative algebra formed by n x n matrices with elements in the ring of integers of an algebraic number field. The structure of the group of units of this algebra is then investigated.

Alternative proofs for Goldberg's original result have been obtained in the meantime by abstract group theory using the fact that the modular group in two dimensions is a free product (by A. Karrass and D. Solitar).
and also by non-Euclidean geometry (by H.S.M. Coxeter).

Publications:
(1) Incidence algebras. E. C. Dade and K. Goldberg. In manuscript.
(10) Abelian groups of unimodular matrices. E. C. Dade. In manuscript.

RESEARCH IN NUMERICAL ANALYSIS AND RELATED FIELDS
Task 1101-12-1104/55-55

Origin: NBS
Managers: J. Todd, P. Davis
Full task description: July-Sept 1954 issue, p. 1

Authorized 8/13/54
Revised 8/29/54

Status: CONTINUED. H. A. Antosiewicz is preparing a manuscript, "Reducible linear differential systems, I." It presents the results he has obtained so far concerning the reducibility of systems \( \dot{x} = [C+B(t)]x \) to \( \dot{y} = Cy \) by use of differentiable matrices \( Z(t) \) that are bounded together with \( Z^{-1}(t) \) on \([0, \infty)\).

J. Todd discussed the condition of the matrices associated with certain discretizations of the two-dimensional Laplacian operator, in particular, two nine-point approximations. These have condition numbers of the same order \( O(n^2) \) as the usual five-point approximations, so that decisions on which are most suitable to use in practice will depend rather on the corresponding truncation errors: these do not appear to be known in the nine-point cases.

E. Brauer and J. Gager are collaborating with J. Todd in connection with experiments to determine the radius of univalence of certain functions. They are also checking some tables of high order Legendre polynomials using the IBM 704.
C. Spector is working on a predicative theory of denumerable sets, hyperarithmetic predicates, constructive ordinals, and permanents of doubly stochastic matrices.

M. Pearl is studying the characterizations of normal matrices over arbitrary fields.

M. Marcus and M. Newman are considering the following problem suggested by H. Ryser: Let $p(X)$ denote the permanent of the square matrix $X$. What is $\min_{X \in S_n^\mathbb{N}} p(X)$, where $S_n$ is the totality of all $n$-square doubly stochastic matrices? It is conjectured that $J_n = (1/n)$ is the unique minimizing matrix with $\min p = n!/n^n$. Thus far the following preliminary results have been established:

(i) There is at most one interior relative extreme value for $p$ on $S_n^\mathbb{N}$, and this is a relative minimum at $J_n$. Hence, if the minimum of $p(X)$ occurs in the interior of $S_n^\mathbb{N}$ it must be at $J_n$.

(ii) The result is true for $n$ equal to 2 and 3. Under an inductive hypothesis, any minimizing matrix $X$ must have all permanental cofactors corresponding to non-zero elements of $X$ equal, and all corresponding to zero elements equal.

(iii) $\frac{1}{2n} \leq \min_{X \in S_n^\mathbb{N}} p(X) \leq 1.$

Publications:


(11) On normal and $E^{Pr}$ matrices. M. Pearl. In manuscript.

(13) Reducible linear differential systems, I. H. A. Antosiewicz. In manuscript.


RESEARCH IN MATHEMATICAL TOPICS APPLICABLE TO NUMERICAL ANALYSIS
Task 1101-12-5116/55-56

Origin: NBS
Sponsor: Office of Naval Research
Managers: J. Todd, M. Newman
Full task description: July-Sept 1954 issue, p. 5

Status: CONTINUED. M. Newman and J. Todd are continuing with experiments in connection with their report on the evaluation of matrix inversion programs [see Oct-Dec 1956 issue, pp. 2, 3], which were postponed because of the Training Program. Various norms for the errors obtained in the inversion of twelve representative matrices by the method programmed by M. Newman for SEAC have been computed. The same norms will be computed for a typical inversion program on the 704. The matrices are of order 28, the largest that can be handled internally on SEAC. They range from an orthogonal matrix (P-condition) to the Hilbert matrix (P-condition experimentally infinite).

K. Fan completed a study of Existence theorems and extreme solutions for inequalities concerning convex functions or linear transformations. This deals with consistency conditions and extreme solutions for relations of the following two types:

(i) \( f_\nu(x) \leq 0 \) (\( \nu \in I \)), where each \( f_\nu \) is a lower semi-continuous convex function defined on a compact convex set in a topological vector space.

(ii) \( Ax - \lambda x - y_0 \in C \), where \( A \) is a completely continuous linear operator in a Banach space \( X \), \( C \) is a convex set (not necessarily a cone) in \( X \) containing \( 0 \), \( \lambda \neq 0 \) and \( y_0 \in X \) are given.

K. Fan solved the following problem: Given a square matrix \( B = (b_{ij}) \) of order \( n \) with non-negative elements and with \( b_{ii} = 0 \), determine all ordered \( n \)-tuples of positive numbers \( \rho_1^1, \rho_2^1, \ldots, \rho_n^1 \) with the following property: For any square matrix \( A = (a_{ij}) \) of order \( n \) with complex elements and satisfying \( a_{ij} \leq b_{ij} \) (\( i \neq j \)), every eigenvalue of \( A \) lies in at least one of the \( n \) circular disks \( |z - a_{ii}| \leq \rho_{ii} \) (\( 1 \leq i \leq n \)).

A proof given by Alexandroff-Hopf for the Perron-Frobenius theorem is well-known and makes use of the Brouwer fixed point theorem.
K. Fan found that several theorems on matrices with non-negative elements can be proved by using those elementary topological facts which are closely related to the Brouwer fixed point theorem.

M. Newman has derived some new congruences for the coefficients of modular forms. Two consequences of these are the following congruences modulo 13 for the coefficients $c(n)$ of the complete modular invariant $12^3J(\tau)$:

$$c(91n) = 0 \pmod{13}, \quad (n, 7) = 1$$
$$c(143n) = 0 \pmod{13}, \quad (n, 11) = 1.$$

Publications:


(2) Estimation of the frequencies of thin elastic plates with free edges. H. Fujita (University of Tokyo), T. Kato, Y. Nakata (University of Tokyo) and M. Newman. To appear in the Journal of Research, NBS.


STUDY OF DIFFERENTIAL EQUATIONS FOR NERVE EXCITATION
Task 1101-12-5116/56-148

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. Work on a new code of the entire problem for use on IBM 704 has begun. The proposed code will incorporate all decision processes, such as choice of integration interval, search for acceptable parameter values, and computation of initial conditions for each run which previously had to be made off the computer.
TRAINING PROGRAM IN NUMERICAL ANALYSIS
Task 1101-40-5114/57-237

Origin and Sponsor: National Science Foundation
Manager: J. Todd
Full task description: Jan-Mar 1957 issue, p. 5

Status: COMPLETED. The training program was completed as planned.
The following main courses of lectures were presented during this quarter:

Partial differential equations. . . . . . . . . (D. M. Young
(R. D. Richtmeyer
Recursive functions and Turing machines. . . S. C. Kleene
Integral equations. . . . . . . . . . . . . . . H. F. Buckner
Linear programming and related topics . . . C. B. Tompkins
Algebraic equations. . . . . . . . . . . . . U. Hochstrasser
Statistical computations . . . . . . . . . . . M. Zelen, J.M. Cameron
Discrete variable problems . . . . . . . . . M. Hall, M. Newman, O. T. Todd
Advanced topics . . . . . . . . . . . . . . . . . . . H. Cohn, P. Lax, S. M. Ulam
Sources of problems . . . . . . . . . . . . . . F. L. Alt

An introduction to programming for the IBM 704 was given by M. Newman.
In addition, the courses in supporting mathematics were continued as follows:

H. A. Antosiewicz and K. Fan continued the series on Functional
Analysis begun by H. F. Weinberger.
M. Marcus and K. Fan carried on in the series on Bounds for
Eigenvalues of Matrices begun by O. Taussky-Todd.
P. Davis and J. Todd presented a series of talks on Approximation
Theory.
M. R. Hestenes presented special lecture, and L. W. Cohen devoted
an hour to answering questions raised by the program. S. N. Alexander
spoke of the activities of the Data Processing Systems Division. G. Porter
(Chief, Personnel Division, NBS) spoke about the needs of NBS for scientists
and the opportunities for scientists at NBS.
The question of preparing some record of the lectures is under
consideration. Several speakers have submitted manuscripts.
Among the computations completed by the participants were the following:

D. C. Lewis, Jr.: SEAC code for drawing a unicursal curve through a
topological map given by an incidence matrix.
F. R. Olsen: Table of coefficients for the Bernoulli numbers B(n)
expressed as polynomials in n of degree \nu; the cases n = 13(1)19 were covered.
C. L. Seebeck, Jr.: Various financial tables, using double precision
fixed-point arithmetic.
H. C. Griffith: Double precision codes for elliptic functions. There
is now available a table of values of K(k^2), good to 21D for k^2 = 0(.01)1.00,
and tables of sn(pk,k^2), cn(pk,k^2), dn(pk,k^2) for the same values of k^2
and for p = 0(.01)1.00.
F. Scheid: Monte Carlo calculations of the radial distribution of the center of gravity of $n$ random points on the unit circle. The results for $n = 6(1)24$ have been obtained by J. A. Greenwood and D. Durand. The cases $n = 3, 4, 5$ were obtained on SEAC, to about 3D.

All other participants had completed exploratory calculations on major problems when use of SEAC was discontinued in favor of the IBM 704; it is expected that the problems will be completed on the respective local machines.
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. Checking of the final manuscript continued.

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. Checking of the tables continued.

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: CONTINUED. Calculations for the tables have been completed.
Status of Projects

REVISION OF MATHEMATICAL TABLES
Task 1102-40-1110/52-7

Origin: NBS
Managers: W. F. Cahill, I. Stegun
Full task description: July-Sept 1951 issue, p. 41

Status: INACTIVE. For status to date, see Jan-Mar 1957 issue, p. 9.

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

Origin: NBS
Manager: I. Stegun
Full task description: July-Sept 1951 issue, p. 42

Status: INACTIVE. For status to date, see Jan-Mar 1957 issue, p. 9.

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

Origin: NBS
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
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.
L-SHELL CONVERSION COEFFICIENTS
Task 1102-40-1110/53-52

Origin: Oak Ridge National Laboratory
Manager: W. Hall
Full task description: Apr–June 1953 issue, p. 45

Status: CONTINUED. The finite nucleus computations were completed this quarter for selected portions of the original tables. For $L_1$ and $L_{11}$ shells $z = 55, 65, 75, 85, 95; k = .05, .1, .2, .6, 1.0$. For $K$ shell $z = 55, 65; k = 0.5, .1, .2, .6, 1.0$.

AUTOMATIC CODING
Task 3711-60-1120/55-65

Origin: NBS
Manager: J. Wegstein
Full task description: July–Sept 1954 issue, p. 11

Status: CONTINUED. The CORBIE tape system for using the IBM 704 as described in the Jan–Mar 1957 issue, p. 10, was placed in operation. Considerable debugging was required before it functioned as intended. It is now working satisfactorily and appears to be used in more than half of the codes being run on the 704. The assumption that codes can be checked out using symbolic notation entirely has been found to be valid. Statistics on the performance of the CORBIE system are being obtained.

A routine was written and checked out by F. L. Alt and W. F. Cahill which permits the 704 to simulate the SEAC. Some SEAC codes have been run on the 704 using this simulator.

Sections 1, 2, 3, 4, 14, 15, 16, and 18 of a programmer's guide for the 704 were prepared by J. Wegstein. These include an introduction to the 704, the tape library, the CORBIE system, and the BCS (Binary Card System) for the 704.

MATHEMATICAL SUBROUTINES
Task 3711-60-0009/56-160

Origin: NBS
Managers: Staff
Full task description: July–Sept 1955 issue, p. 13

Status: CONTINUED. A subroutine was written which computes the function
\[ w(z) = e^{-\frac{z^2}{2}} (1 + \frac{2i}{\pi} \int_0^z e^{t^2} dt) \]

in floating point arithmetic for any complex \( z \). The same code will be used to provide subroutines for evaluating the Fresnel integrals and the error function for complex arguments. A subroutine for the evaluation of the repeated error integral is in preparation.

A subroutine was written to evaluate the error function

\[ F(x) = \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt \]

using a rational approximation which should give accuracy to \( \pm 3 \) in the seventh place. The argument \( x \) is real and \( 0 \leq x \leq 3.855 \). If \( x > 3.855 \) the value of the error function is set equal to 1.

Tests were made on the matrix subroutines for the addition, subtraction and multiplication of real matrices. The determinant and inverse of a Hilbert matrix (order 6) were also evaluated. The results were accurate to one significant digit in the determinant and inverse of this matrix.

A subroutine was written to multiply matrix \( A \) by the transpose of matrix \( B \), where \( A \) and \( B \) are real and stored row-wise. A subroutine was also written to multiply the transpose of matrix \( A \) by matrix \( B \) where \( A \) and \( B \) are real and stored row-wise. Both of these subroutines may be used when matrix \( B \) is the same as matrix \( A \) and here only matrix \( A \) need be stored.
stated on the tabular page.

The chapter on Powers, Real and Complex Roots will contain the following tables:

Table 3.1: $2, 3, 4, 10, 17, 24$

Prime factors, or $\log_{10} x$ if $x$ prime, $x = 1(1)1000, 108$.

$1/2, 1/3, 1/4, 1/5$

Table 3.2: $\sqrt{1 + x^2}, \sqrt{1 - x^2}$, $x = 0(.01)1, 10D.$

Table 3.3: $(1 + iy)^{1/n}$, $n = 2(1)5$, $y = 0(.01)1, 10D.$

The chapter on Struve functions will contain the following tables:

Table 12.1:

$$
\begin{align*}
H_0(x), H_1(x), & \quad x = 0(.1)5.0, 7D. \\
\frac{1}{0} \int x H_0(t) \, dt, \\
I_0(x) - L_0(x), I_1(x) - L_1(x), & \quad x = 0(.1)5.0, 6D. \\
\frac{1}{0} \int x [I_0(t) - L_0(t)] \, dt, \\
\frac{2}{\pi} \int x \frac{H_0(t)}{t} \, dt.
\end{align*}
$$

Table 12.2:

$$
\begin{align*}
H_0(x) - Y_0(x), H_1(x) - Y_1(x), \\
f_0 = \int_0^x [H_0(t) - Y_0(t)] \, dt - \frac{2}{\pi} \ln x, \\
I_0(x) - L_0(x), I_1(x) - L_1(x), & \quad 1/x = 0(.01).20, 6D. \\
g_0 = \int_0^x [I_1(t) - L_0(t)] \, dt - \frac{2}{\pi} \ln x, \\
\int_x^\infty [H_0(t) - Y_0(t)] \, \frac{dt}{t},
\end{align*}
$$
Chapter 27 on Binary Tables will contain the following:

Table 27.1: \(2^x, x = .001(.001).009(.01).9(.1).9, 10S\)

27.2: \(2^x, x = 0(1)50, \text{ exact}\)

27.3: Addition and Multiplication Tables for Octal System

27.4: \(\log_2 x, x = 0(.001)1.2, 2(1)100(10)1000(100)10,000, 8D\)

27.5: Mathematical Constants in Octal Notation
3. **PROBABILITY AND MATHEMATICAL STATISTICS**

**BIBLIOGRAPHY AND GUIDE TO STATISTICAL LITERATURE**
Task 1103-12-1107/49-1a

Origin: NBS
Manager: L. S. Deming
Full task description: Apr-June 1949 issue, p. 75

Status: TERMINATED. For status to date, see Jan-Mar 1957 issue, page 14. Beginning next quarter work on this task will be reported under task 1103-12-1107/51-2, "Miscellaneous Studies in Probability and Statistics."

**TABLES TO FACILITATE DRAWING RANDOM SAMPLES**
Task 1103-12-1107/51-1

Origin: NBS
Managers: C. Eisenhart, L. S. Deming
Full task description: July-Sept 1950 issue, p. 57

Status: TERMINATED. For status to date, see July-Sept 1952 issue, page 64. Beginning next quarter work on this task will be reported under task 1103-12-1107/51-2, "Miscellaneous Studies in Probability and Statistics."

**MISCELLANEOUS STUDIES IN PROBABILITY AND STATISTICS**
Task 1103-12-1107/51-2

Origin: NBS
Manager: C. Eisenhart
Full task description: July-Sept 1950 issue, p. 58

Status: CONTINUED. C. Eisenhart, N. C. Severo, and V. Martinez continued the study of the effects of data transformations on correlation analysis.

N. C. Severo prepared a short paper on "The non-central chi-square as a test statistic," to be submitted to a technical journal.
M. Zelen has prepared a manuscript entitled "Linear estimation and related topics," which summarizes his lectures presented at the NBS in May 1957 as part of the National Bureau of Standards-National Science Foundation Training Program in Numerical Analysis. This report discusses (i) the Gauss-Markov theorem and extensions, (ii) distribution of quadratic forms, and (iii) likelihood ratio tests of the general linear hypothesis.

Publication:
(1) The weighted compounding of two probabilities from independent significance tests. M. Zelen and L. Joel. Submitted to a technical journal.

STUDIES IN THE MATHEMATICS OF EXPERIMENT DESIGN
Task 1103-12-1107/53-1

Origin: NBS
Manager: W. S. Connor
Full task description: Oct-Dec 1952 issue, p. 60

Status: CONTINUED. W. S. Connor studied a problem concerning the triangular association scheme. The triangular association scheme is an array of n rows and n columns with the following properties: (1) The positions in the principal diagonal are blank. (2) The n(n-1)/2 positions above the principal diagonal are filled by the numbers 1,2,...,n(n-1)/2 corresponding to treatments. (3) The array is symmetric about the principal diagonal. (4) The first associates of any treatment θ are the treatments which lie in the same row and column as θ, and the remaining treatments are second associates of θ. As is well known, from this definition it follows that (a) the number of treatments which are first associates of any treatment θ is 2n-4, and (b) with respect to any two treatments θ₁ and θ₂ which are i-th associates (i=1,2) of each other, there are 2(n-4)-i(n-6) other treatments which are first associates of both θ₁ and θ₂. The problem studied was whether the conditions (a) and (b) can be satisfied by an association scheme different from the triangular association scheme. It was proved for n ≥ 9 that this is impossible. This work is contained in a paper referenced below.

J. M. Cameron continued his investigation of weighing designs for use in calibration work (see the Jan-Mar 1957 issue, p. 16). A number of these designs have been constructed which are such that with respect to any two objects θ₁ and θ₂, there are λ₁ weighings which have θ₁ in the same pan, and λ₂ weighings which have θ₁ and θ₂ in opposite pans.
Publications:

STUDY OF NON-PARAMETRIC STATISTICAL TECHNIQUES
Task 1103-12-1107/56-170

Origin: NBS
Manager: Joan R. Rosenblatt
Authorization: 12/15/55

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

Status: INACTIVE. For status to date, see July-Sept 1956 issue, page 15.

Publication:
(1) Table of the first moment of ranked extremes. J. Lieblein and H. E. Salzer. To appear in the Journal of Research, NBS.
MEASUREMENT OF RELIABILITY
Task 1103-12-1130/56-182


J. R. Rosenblatt and J. M. Smith are calculating additional numerical examples to illustrate the effect of interdependence of components on system performance.

H. Gumbel (Naval Air Missile Test Center, Point Mugu, California) addressed Reliability Seminar V on the subject, "What is a failure?" on April 15.

Publications:
(2) On some aspects of prediction in the study of complex systems.

CATALOG OF FRACTIONAL REPLICATION DESIGNS
Task 1103-12-5147/57-213

Origin and Sponsor: Bureau of Ships
Managers: W. S. Connor, M. Zelen

Status: COMPLETED. The catalog of fractional replication designs for the 3rd series has been completed and transmitted to the sponsor. It is also being readied for publication in the NBS Applied Mathematics Series. The catalog contains designs for the fractions 1/3, 1/9, 1/27, 1/81, 1/243 for n ranging from 4 to 10 factors. These experiment plans have been constructed with the treatment combinations grouped in blocks of equal size so that the experimenter may take advantage of any homogeneous grouping of the experimental material to increase the precision of comparisons among the various factors.
4. MATHEMATICAL PHYSICS

RESEARCH IN MATHEMATICAL PHYSICS AND RELATED FIELDS
Task 1104-12-1115/55-57

Origin: NBS
Manager: R. F. Dressler
Full task description: July-Sept 1954 issue, p. 27

Status: CONTINUED. W. Pell has developed iterative methods for the graphical integration of certain types of ordinary differential equations, both linear and non-linear. Among these are the important equations

\[ g_2(y) \dot{y} + g_1(y) \dot{y} + y = f(x), \quad (y = \text{dy/dx}) \]

\[ f_2(x) \dot{y} + f_1(x) \dot{y} + y = f(x). \]

To illustrate the procedure and accuracy of these methods they were applied to certain special cases, and it appears that one iteration of the procedure will give results sufficiently accurate for engineering purposes for integrals of x of reasonable length. In one period both amplitude and period of the solution of \( \ddot{y} + y = 0, \ y(0) = 0, \ \dot{y}(0) = 1 \), are accurate to within 0.5%. Such accuracy, of course, may not obtain in other cases. A report was begun which will incorporate some examples with an exposition of the methods used.

A. Ghaffari continued a study concerning the analytic properties of the solution of compressible flow past a wedge. It is shown that the solution for the stream function around the wedge as well as its first derivative are both continuous in the main stream. It is also found that the solution for the stream function is bounded when the compressible flow velocity around the wedge reaches its maximum.

Publications:
(3) The quotient-difference algorithm. P. Henrici. To appear in NBS Applied Mathematics Series 49, "Further contributions to the solution of simultaneous linear equations and the determination of eigenvalues."


RESEARCH IN CONTINUUM MECHANICS  
(formerly Mathematical Elasticity)  
Task 1104-12-5160/55-85

Origin: NBS  
Sponsor: Office of Scientific Research, ARDC, USAF  
Manager: R. F. Dressler  
Full task description: Oct-Dec 1954 issue, p. 30

Status: CONTINUED. The problem of the flow about a ring wing in the presence of an axially symmetric body is still under consideration. As a first phase of the problem it was deemed advisable to investigate the mutual interference effects of the simplest cases of this problem viz., the ring vortex in the presence of a doublet and the ring vortex in the presence of a sphere lying on its axis of symmetry. These simple cases are under study.

R. F. Dressler is investigating the edge effect on bent plates for non-zero correction at the edge, and the analogous problem for generalized plane stress. He plans to attend the NATO-AGARD Wind Tunnel Panel at Schweringen, Holland. Also he will serve as a temporary consultant for the European Office of the Air Research Development Command.

Publications:


FOURIER TRANSFORMS OF PROBABILITY DISTRIBUTION FUNCTIONS
Task 1104-12-5160/56-154

Origin: NBS
Sponsor: Office of Naval Research
Manager: F. Oberhettinger
Full task description: July-Sept 1955 issue, p. 20

Status: CONTINUED. The tables of formulas have been prepared for publication. An introduction is being written.

RESEARCH IN FLUID DYNAMICS OF TWO-PHASE FLOWS
Task 1104-12-5160/56-155

Origin and Sponsor: Office of Naval Research
Manager: R. F. Dressler
Full task description: July-Sept 1955 issue, p. 21

Status: CONTINUED. In order to study the condensation process in a mixing chamber, J. M. Burgers and A. Ghaffari studied the growth of a water droplet surrounded by condensing steam. The condensation upon a plane surface and upon spherical drops of given radius was investigated. The amount of heat to be taken up by the water in both cases was found and compared. The equations of motion for a mixture of steam and water droplets were given as affording an idea about what happens in the mixing process and as a means for finding out something about the shape to be given to the mixing chamber. A number of examples were studied using specific values for entrance needs and temperatures of water and steam and for exit pressure.

The results were written up in an NBS report, "On the application of steam-driven water jets for the propulsion of an underwater vessel."

Publication:

RESEARCH IN RADIATION THEORY
Task 1104-12-5160/56-175

Origin: NBS
Sponsor: Office of Naval Research
Manager: F. Oberhettinger
Full task description: Oct-Dec 1955 issue, p. 18

Status: COMPLETED.
5. MATHEMATICAL AND COMPUTATIONAL SERVICES

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. The problem is being studied from the standpoint of adapting it for solution with existing IBM 704 codes.

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. About 16 calculations for d-spacings for tetragonal, hexagonal, orthorhombic and monoclinic crystals were performed. Also redetermination of unit cell constants by least squares fitting to a measured d-spacing were carried out for about 16 crystals.
Work is in progress for writing a general d-spacing code for the 704.

1102-40-5126/53-51 RADIATION DIFFUSION, III
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: Completed.

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. Three procurement contracts were awarded during this quarter.
Test runs on the 704 with a transportation code furnished by the IBM Corporation were started. This work is being done in order to become familiar with the 704 code and with a view toward standardizing procedures for handling all future contract award problems on the 704.
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: Inactive. For status to date, see Jan-Mar 1956 issue, p. 19.

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. Preparation of new spectrum analysis programs for the IBM 704 have been started. The program for computing vacuum wave-numbers from wave-lengths has been written and has been used to compute 2000 new wave-numbers of iodine II. Further programs to evaluate and compute differences between known energy levels, to search for line pairs with these differences, to predict new levels, and to check for reoccurrence of predicted levels and evaluate the predictions, have been partially written, and code checking is proceeding.

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.

3711-60-0009/55-68 CRYSTAL STRUCTURE CALCULATIONS
Origin: NBS, Division 9
Manager: P. O'Hara, S. Block (9.7)
Full task description: Jan-Mar 1955 issue, p. 18
Status: Continued. Existing codes have been modified for solution of the problem on the 704, and code checking is in progress.

3711-60-0009/55-75 PARAMETER OF THE DISPERSION EQUATION FOR OPTICAL GLASS
Origin: NBS, Section 2.2
Manager: R. Zucker
Full task description: Jan-Mar 1955 issue, p. 20
Status: Inactive.

3711-60-0009/55-82 THERMOMETER CALIBRATIONS
Origin: NBS, Section 3.1
Manager: S. Prusch
Full task description: Jan-Mar 1955 issue, p. 20
Status: Continued. Preparation of a code for the calculations to be performed on the IBM 704 computer was started.
### Status of Projects

**1102-40-5126/55-88**  
**STRESSES IN A WALL FOUNDATION**  
**Origin and Sponsor:** NBS, Section 10.1  
**Manager:** I. Stegun  
**Full task description:** Jan-Mar 1955 issue, p. 22  
**Status:** Inactive.

**1102-40-5126/55-113**  
**REACTOR DESIGN**  
**Origin:** Westinghouse Atomic Power Division  
**Sponsor:** Atomic Energy Commission  
**Manager:** U. Hochstrasser  
**Full task description:** Jan-Mar 1955 issue, p. 28  
**Status:** Completed. Results have been transmitted to the sponsor.

**1102-40-5126/55-117**  
**ATTENUATION OF PRESSURE PULSES OF FINITE AMPLITUDE**  
**Origin:** NBS, Section 3.2  
**Sponsor:** Bureau of Aeronautics, U. S. Navy  
**Manager:** M. Paulsen  
**Full task description:** Apr-June 1955 issue, p. 18  
**Status:** Inactive.

**1102-40-5126/55-121**  
**ELECTRON PENETRATION**  
**Origin:** NBS, Section 4.8  
**Sponsor:** Atomic Energy Commission  
**Manager:** S. Peavy  
**Full task description:** Apr-June 1955 issue, p. 19  
**Status:** Continued. The problem has been recoded for the IBM 704 machine. The routine for calculation of the moments has been completed and checked out. The remainder of the program is in the process of being checked out.

**1102-40-5126/55-127**  
**VIBRATIONS OF CIRCULAR DISC**  
**Origin and Sponsor:** Evans Signal Laboratory  
**Manager:** U. Hochstrasser  
**Full task description:** July-Sept. 1955 issue, p. 32  
**Status:** Completed. The results have been transmitted to the sponsor.

**1102-40-5126/56-136**  
**CALCULATION OF WAVE FUNCTIONS BY HARTREE METHOD**  
**Origin and Sponsor:** Naval Research Laboratory  
**Manager:** S. Peavy  
**Full task description:** July-Sept 1955 issue, p. 34  
**Status:** Inactive.
Status of Projects

1102-40-5126/56-140  MULTIPLE CORRELATION ROUTINES
Origin and Sponsor: Agricultural Economics Division, Department of Agriculture
Managers: H. Bremer, M. Paulsen
Full task description: Oct-Dec 1955 issue, p. 26
Status: Completed. Seven problems were run during the quarter. A final report on the problem has been prepared.

1102-40-5126/56-162  STRESSES IN A WALL RESTING ON A FOOTING
Origin and Sponsor: NBS, Section 10.1
Manager: I. Stegun
Full task description: Jan-Mar 1956 issue, p. 26
Status: Inactive.

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. A code for the solution of the Coulomb wave equation is being prepared for the IBM 704 computer.

1102-40-5126/56-166  SCF-LCAO SOLUTION OF SOME HYDRIDES
Origin and Sponsor: NBS, Section 5.9
Manager: E. Haynsworth
Full task description: Jan-Mar 1956 issue, p. 27
Status: Continued. Several additional cases were computed.

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: Inactive.

1102-40-5126/56-172  NUMERICAL EVALUATION OF SPECIAL INTEGRAL EXPRESSIONS
Origin and Sponsor: Diamond Ordnance Fuze Laboratories, Department of the Army
Manager: L. Joel
Full task description: Jan-Mar 1956 issue, p. 29
Status: Inactive.
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Status of Projects

1102-40-5126/56-179  NORMAL PROPAGATION CONSTANT
Origin and Sponsor:  NBS, Section 82.10
Manager:  H. H. Howe (82.10)
Full task description:  Apr-June 1956 issue, p. 30
Status:  Continued.  Very extensive computations were made during this quarter.  These involved several different formulas as follows:  (1) The basic formula (1) given in the Apr-June 1956 issue, page 30, extending to much higher values of G (ground resistivity) and to different values of K (dielectric constant of ground).  (2) The same ionospheric model, but including the first spherical correction described on page 31 of the report for Apr-June 1956.  (3) The same model, but a third spherical correction, namely one in which the right side of equation (2) on page 31 is multiplied by $\sqrt{c^2/(1.01 c^2 - .01)}$.  (4) The two-layered model described in the Jan-Mar 1957 issue, page 30, for the basic formula.  (5) The two-layered model, with the first spherical correction included.

Some additional curves showing $\text{Im}(n)$ in the c-plane were computed for use in a projected report.

1102-40-5126/56-184  GAIN CALCULATIONS OF AN ITERATED TRANSISTOR AMPLIFIER
Origin and Sponsor:  Diamond Ordnance Fuze Laboratories, Department of the Army
Manager:  E. Haynsworth
Full task description:  Apr-June 1956 issue, p. 32
Status:  Inactive.  For status to date, see July-Sept 1956 issue, p. 32.

1102-40-5126/56-186  MECHANICAL MEASUREMENTS OF GAGE BLOCKS
Origin and Sponsor:  NBS, Section 2.5
Manager:  S. Prusch
Full task description:  July-Sept 1956 issue, p. 33
Status:  Inactive.

1102-40-5126/56-192  NOISE MEASUREMENT
Origin and Sponsor:  NBS, Section 6.1
Manager:  W. F. Cahill
Full task description:  Oct-Dec 1956 issue, p. 28
Status:  Completed.  All results have been transmitted to the sponsor.

1102-40-5126/57-209  TRAFFIC DISTRIBUTION
Origin and Sponsor:  Bureau of Public Roads
Manager:  S. T. Peavy
Full task description:  Jan-Mar 1957 issue, p. 32
Status:  Continued.  The program has been completed and checked out on the IBM 705 (at the Treasury Department).
Status of Projects

3711-60-0009/57-210  SOUND VELOCITY

Origin:  NBS, Section 3.2
Manager:  U. Hochstrasser
Full task description:  July-Sept 1956 issue, p. 34
Status:  Inactive.  For status to date, see Jan-Mar 1957 issue, p. 32.

1102-40-5126/57-211  METEOROLOGICAL DATA

Origin and Sponsor:  Diamond Ordnance Fuze Laboratories, Department of the Army
Manager:  P. O'Hara
Full task description:  Oct-Dec 1956 issue, p. 30
Status:  Inactive.

1102-40-5126/57-215  COMPUTATION OF INTEGRALS INVOLVING BESSEL FUNCTIONS

Origin and Sponsor:  NBS, Section 6.1
Manager:  U. Hochstrasser
Full task description:  July-Sept 1956 issue, p. 35
Status:  Completed.  The results have been transmitted to the sponsor.

1102-40-5126/57-219  THERMAL PROPERTIES

Origin and Sponsor:  NBS, Section 3.2
Managers:  J. Cooper, D. Sumida
Full task description:  Oct-Dec 1956 issue, p. 30
Status:  Continued.  Coding of the problem for the IBM 704 computer is in progress.

1102-40-5126/57-221  BESSEL FUNCTIONS FOR COMPLEX ARGUMENTS

Origin and Sponsor:  Diamond Ordnance Fuze Laboratories, Department of the Army
Manager:  R. Zucker
Full task description:  Oct-Dec 1956 issue, p. 31
Status:  Continued.  Several cases were run on SEAC to evaluate the Bessel and Hankel functions for given complex arguments up to the order n specified.  The functions X_n, Y_n and Z_n were also evaluated.  The results were submitted to the sponsor.

1102-40-5126/57-222  ROOTS OF POLYNOMIALS

Origin and Sponsor:  Naval Research Laboratory
Manager:  U. Hochstrasser
Full task description:  Oct-Dec 1956 issue, p. 32
Status:  Inactive.
3711-60-0009/57-223  SELF-CONSISTENT FIELDS

Origin:  NBS, Section 3.2
Manager:  E. V. Haynsworth

Objective:  To prepare a very generalized form of the original code for the 704 for solving self-consistent field problems. The new code will incorporate a number of additional calculations as well as a master program and a control program to make it as flexible as possible. It is intended that this code should operate with efficiency for any given combination of core, drum, and tape storage, as it is to be used at several different installations.

Background:  The original code was prepared in connection with task 1102-40-5126/56-139 (see July-Sept 1955 issue, p. 36). The decision to rewrite the code in a generalized form resulted from consultations with R. A. Nesbet of Boston University, Cambridge, Mass. B. J. Ransil (32) transmitted the request.

Status:  New.

1102-40-5126/57-224  TRACK-WHILE-SCAN RADAR PROBLEM

Origin and Sponsor:  Diamond Ordnance Fuze Laboratories, Department of the Army
Managers:  E. Haynsworth, P. J. Walsh

Full task description:  Oct-Dec 1956 issue, p. 32

Status:  Continued. Modifications were made in several of the factors to be computed. The code has been rewritten for the 704 computer, and code checking is now in progress.

1102-40-5126/57-225  DAMAGE ASSESSMENT PROBLEM, II

Origin and Sponsor:  Corps of Engineers, U. S. Army
Managers:  H. Bremer, W. G. Hall, L. S. Joel

Full task description:  Oct-Dec 1956 issue, p. 33

Status:  Inactive.

1102-40-5126/57-228  MICROWAVE PROPERTIES OF FERRITES

Origin and Sponsor:  Diamond Ordnance Fuze Laboratories, Department of the Army
Manager:  B. Walter

Full task description:  Jan-Mar 1957 issue, p. 35

Status:  Completed. The results were transmitted to the sponsor.

The calculations of $F(H)$ under the assumption of Bloch-Bloembergen damping showed no significant differences from previous calculations assuming Landau-Lifschitz damping. The same general results occurred.
3711-60-0009/57-229 APPLICATION OF ELECTRONIC DATA PROCESSING MACHINERY TO PAYROLL OPERATIONS

Origin: NBS, Section 40.0
Managers: H. Bremer, P. R. McClenon, M. Paulsen, J. B. Tallerico

Full task description: Jan-Mar 1957 issue, p. 36

Status: Continued. During the past quarter item layouts, card layouts and print layouts were drawn up and agreed upon. Two sets of flow charts were drawn up indicating the logical flow of data and the flow of the calculations of individual pay and summarization of this pay.

The problem has been broken up into many small sections to make it possible to assign a section to each member of the Accounting Division for actual coding. It is hoped that in this manner the Accounting Division will be able to eventually handle all of the coding for its own work. One section which concerns breaking the input data into separate items has been coded and is being code checked now.

1102-40-5126/57-234 PERSONNEL SURVEY

Origin and Sponsor: Diamond Ordnance Fuze Laboratories, Department of the Army
Manager: P. O'Hara

Full task description: Jan-Mar 1957 issue, p. 37

Status: Inactive.

3711-60-0009/57-232 POLYNOMIAL EVALUATION

Origin: NBS, Section 3.1
Manager: R. Durrah

Objective: To evaluate

\[ x_n^k(J) = \sum_{j=0}^{k} \frac{\sum_{m=0}^{k} p_m(x_j) e^{-\mu_j^j}}{\sum_{m=0}^{k} p_m(x_j) e^{m \theta}} \]

for \( k = 3,4,5, \)

\( J = .01, 0.1, 1,3,10, \)

\( n = 0,1,2,3,...,k, \ (n \leq k), \)

\( \theta = 1. \)

The \( p_n(x) \) are Gottlier polynomials (see Amer. J. Math. 60, 455(1937)). The \( \mu_j \) are the roots of the equation: \( P_{r+1} (\mu) = 0. \)

Background: The problem arises in the application of the theory of stochastic processes to chemical kinetics and deals particularly with the calculation of the rate of dissociation of diatomic molecules at high temperatures such as are found in shock waves. The problem was transmitted by K. E. Shuler (3.1).
Status: New. The code was written for the 704 and is in the process of being checked out.

3711-60-0009/57-235  TRIPLE INTEGRALS--ENTROPY CALCULATIONS
Origin: NBS, Section 3.2
Managers: W. Gautschi, A. Beam
Objective: To evaluate integrals of the form
\[ I = \int_R f(x) f(y) f(z) \, dx \, dy \, dz \]

with the region R defined by the inequalities \( x+y-z \geq 0, y+z-x \geq 0, z+x-y \geq 0, x \geq 0, y \geq 0, z \geq 0 \). For various values of the parameter \( \lambda \), the functions \( f(x) \) are given in tabular form for \( x \geq 1 \) and are defined by \( f(x) = -x \) for \( 0 < x < 1 \). They have a discontinuity at \( x = 1 \).

Background: The integral arises in the computation of entropy densities for monotonic gases. The problem was communicated by R. E. Nettleton of Section 3.2.

Status: New. By taking into account all the symmetries of the problem, we found that
\[ I = 4 \int_0^\infty f(x)dx \int_{x/2}^x f(y)dy \int_{x-y}^y f(z)dz. \]

The last integral was computed by numerical quadrature, after splitting apart the integral over the unit cube. A code was written for the IBM 704 and is in the process of being checked.

3711-60-0009/57-236  SELF-CONSISTENT FIELD—EIGENVALUES
Origin: NBS, Section 3.6
Manager: E. V. Haynsworth
Objective: To solve a self-consistent field problem using a code already written for previous similar problems. It is necessary to adjust the code for the present problem which is more complicated.

Background: This problem is similar to those described in tasks 1102-40-5126/56-139 (see July-Sept 1955 issue, p. 36) and 1102-40-5126/56-166 (see Jan-Mar 1956 issue, p. 27). It is requested by M. Boyd (3.6).

Status: Completed (New). Results have been submitted to the sponsor.
Status of Projects

3711-60-0009/57-238 MODIFIED LANDAU FUNCTION

Origin: NBS, Section 4.8
Manager: S. Peavy, R. Allsbrook

Objective: To evaluate

\[ L_B(\lambda) = \frac{1}{2\pi} \int_0^\infty \exp \left\{ i\lambda y + iy \ln y - \frac{\pi}{2} y + i\frac{\pi}{2}B + B \ln y \right\} dy \]

\[ + \frac{1}{2\pi} \int_0^\infty \exp \left\{ -i\lambda y - iy \ln y - \frac{\pi}{2} y - i\frac{\pi}{2}B + B \ln y \right\} dy \]

for \( \lambda = -6(\cdot2)10 \) and \( B = -15(\cdot2)4 \).

Background: The modified Landau function arises in the problem of electron range straggling. Its importance is as a weight function for range distributions. It describes the small energy loss distribution with very little modification. This distribution includes effects due to radiative as well as non-radiative interactions.

The problem was submitted by L. Spencer (4.8).

Status: New.

3711-60-0009/57-241 HEAT TRANSFER

Origin: NBS, Section 11.2
Managers: M. Abramowitz, W. F. Cahill

Objective: To solve for various values of \( \lambda \) the partial differential equation

\[ (1-r^2) \frac{\partial^2 \theta}{\partial \xi^2} = \frac{\partial^2 \theta}{\partial r^2} + \frac{1}{r} \frac{\partial \theta}{\partial r} + \frac{1}{\lambda^2} \frac{\partial^2 \theta}{\partial \xi^2} \]

under the boundary conditions

\[ \theta = \theta_0 \quad \text{for} \quad \xi = 0, \]
\[ \theta \text{ finite for} \quad \xi = \infty, \]
\[ \theta = \theta_1 \quad \text{for} \quad r = 1. \]

Background: The above differential equation describes the heat transfer in a tube of infinite extent due to a fluid moving with parabolic velocity distribution.

Status: New. Assuming a solution in the form

\[ \frac{\theta - \theta_1}{\theta_0 - \theta_1} = \sum_{n=1}^{\infty} A_n e^{z_n^\xi} \cdot y(r, z_n), \]

there exists for each value of \( \lambda \) a set of eigenfunctions \( y(r, z_n) \) and corresponding eigenvalues \( z_n^\xi \) which satisfy the differential system.
Status of Projects

\[ y'' + \frac{1}{r} y' + \frac{z^2}{\lambda^2} - z_n (1 - r^2) \] \ y = 0,

\[ y(r,z_n) = 0 \text{ for } r = 1. \]

The code to compute these eigenvalues and eigenfunctions on the 704 was written and checked out.

3711-60-0009/57-247 MECHANICAL IMPEDANCE

Origin: NBS, Section 6.1
Manager: J. P. Menard

Objective: (I) To compute calibration constants \( K(f) \), equal to the complex conjugate of \( K(f) \), for 23 values of the frequency \( f \) ranging from 40 to 10,000.

\[
\bar{K}(f) = \frac{1}{N} \sum_{n=1}^{N} \left[ \frac{F_n}{D_n} - \frac{F_0}{D_0} \right] \left[ \frac{1}{M_n} (2\pi f)^2 \right]
\]

(II) To compute the complex impedance \( Z \) from measured values \( F_x \) and \( D_x \) of forces and displacements, for the frequencies and corresponding values of \( K(f) \) from (I).

\[
Z_x = \left[ \frac{1}{i (2\pi f)} K(f) \right] \left[ \frac{F_x}{D_x} - \frac{F_0}{D_0} \right]
\]

(III) Given \( Z \) from (II), to calculate by approximate methods parameters for the following equation:

\[
Z_x = R_x + iX \ x = i(2\pi f)n + \left[ \frac{R + i(2\pi f)M}{R + r} \right] \left[ \frac{r - ik/(2\pi f)}{R + r} \right] + i \left[ \frac{(2\pi f)M - k/(2\pi f)}{R + r} \right]
\]

The following parameters are to be obtained:

1) \( k = \frac{1}{N_1} \sum_{f} \left[ - (2\pi f)X \ x \right], \ 400 \leq f \leq 750; \)

\( N_1 \) is the number of frequency points in the range between 400 and 750.

2) \( r = \frac{1}{N_2} \sum_{f} R_x, \ 400 \leq f \leq 4000; \)

\( N_2 \) is the number of frequency points in the range between 400 and 4000.

3) \( m = \frac{1}{N_3} \sum_{f} \left( \frac{X \ x}{2\pi f} + \frac{k}{(2\pi f)^2} \right), \ 1500 \leq f \leq 4000; \)
Status of Projects

$N_n$ is the number of frequency points in the range between 1500 and 4000.

4) $Q = \frac{f(\text{zero})}{f(\text{min}) - f(\text{max})}$, $f < 250$.

$f(\text{zero})$ is the frequency at which $X$ is nearest zero.

5) $M = \frac{k}{[2\pi f(\text{zero})]^2 (1 + 1/Q^2)}$

6) $R = -r + \sqrt{r^2 + 4 \left[2\pi f(\text{zero})]\right]^2 M^2 / Q^2$

**Background:** A method has been developed for determining the resistive and reactive components of the impedance of the human head and mastoid, or of other high mechanical impedances, using a special direct-recording measuring system that records both force and motion. (See E.L.R. Corliss, W. Koidan, J. Accoust. Soc. Amer. 27, 1164 (1955)).

For a given frequency $f$ one or more known masses are used for calibration, and the voltages (expressed in complex form) from the force pickup and displacement measuring device are recorded. At certain frequencies measurements are also made with no load for correction purposes. In the above expressions,

- $M_n$ is the value of the individual mass,
- $N$ is the number of masses,
- $F$ and $D$ are measured values of force and displacement expressed in a complex form,
- $Z_x$ is the complex impedance of the human head or mastoid,

  - the subscript $n$ refers to a mass $M_n$,
  - the subscript 0 designates no load,
  - the subscript $x$ refers to the head or mastoid.

The problem was requested by M. D. Burkhard (6.1)

**Status:** New.
3711-60-0009/57-248  THE EVALUATION OF A TRIPLE INTEGRAL FOR THE
SOLUTION OF NEGATIVE ION DETACHMENT

Origin:  NBS, Section 4.6
Manager:  S. Peavy

Objective: The following quantity is to be computed:

\[ \sigma = \frac{4}{\pi} t^2 N_o^2 [I_1(t^2) + I_1'(t^2) - I_2(t^2)] \]

where

\[ I_1(t^2) = \int_0^1 \int_{-1}^1 \int_{-1}^1 \frac{d\alpha}{(1+q^2-2q\alpha)^2} \frac{d\beta}{K^2} \frac{H^2(K)}{K^2} \]

\[ I_1'(t^2) = \int_0^1 \int_{-1}^1 \int_{-1}^1 \frac{d\alpha}{(1+s^2-2s\alpha)^2} \frac{d\beta}{(K')^2} \frac{H^2(K')}{K'^2} \]

\[ I_2(t^2) = \int_0^1 \int_{-1}^1 \int_{-1}^1 \frac{d\alpha}{1+q-2q\alpha} \frac{d\beta}{K^2} \frac{H^2(K)}{K^2} T \]

for

\[ T = \left[ (1-s^2)^2 + 4s^2 \left( \beta - \frac{1}{s} \frac{(1-q^2)}{(1+q^2-2q\alpha)^2} \right) \left( \beta - \frac{1}{s} \frac{(1-q^2)}{(1+q^2-2q\alpha)^2} \right) \right]^{-\frac{1}{2}} \]

\[ K^2 = 2 \frac{k_o^2}{t^2} \left[ 1 - \frac{t^2}{2} - q\alpha - s\beta (1+q^2-2q\alpha)^{\frac{1}{2}} \right] \]

\[ (K')^2 = 2 \frac{k_o^2}{t^2} \left[ 1 - \frac{t^2}{2} - s\alpha - q\beta (1+s^2-2s\alpha)^{\frac{1}{2}} \right] \]

\[ H(K) = \int_0^\infty dr \ r \ \eta_0(r) \sin Kr; \ \eta_0(r) = \begin{cases} \frac{\beta - r}{1-r} & \text{for } r < r_0 \\ \frac{A_o}{r} e^{-k_o^2/r} & \text{for } r \geq r_0 \end{cases} \]

\[ s^2 + q^2 + 1-t^2, \ s \text{ and } q \geq 0 \]

The results are needed for the following values of \( t^2 \):

\[ .5, .25, .15, .10, .075, .05, .025, .015, .0125, .01, .0075, .005 \]

\[ .004, .003, .002; \]

and for the following two sets of constants:

Case 1: \( k_o^2 = .05512, b_o = 1.057, A_o = .5186, r_o = 1.882, N_o^2 = 2.292 \)

Case 2: \( k_o^2 = .02825, b_o = .5060, A_o = -1.840, r_o = 8.778, N_o^2 = .4164 \)
Status of Projects

Background: The problem arises in the process of an electron striking a negative ion and detaching one of its bounded electrons. The computations were requested by S. Geltman (4.6).

Status: New.
6. STATISTICAL ENGINEERING SERVICES

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

Origin: NBS
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. Plastic panels: A fractional replication of a $4^3 \times 5$ design was constructed for use in an interlaboratory study of the properties of panels used in the maritime industry, for F. W. Reinhart, Section 7.7.

2. Transistor aging study: Analysis of extensive data on the behavior of transistors with time was begun for G. Conrad, Section 1.6.

3. Spectrographic analysis: An analysis of data from an interlaboratory study of the within-day, between-day and between-laboratory variation in a proposed standard method for spectrographic analysis of metal alloys was carried out for R. Alvarez, Section 5.10.

The two-semester in-hours course on "Selected Techniques of Statistical Analysis" was completed. Drs. Connor, Eisenhart, Rosenblatt and Zelen served as instructors.

Work was begun on the preparation of a battery of programs for statistical analysis of data on the new computer.

Publications:


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

Origin and Sponsor: Ship Structure Committee, NRC
Manager: W. J. Youden

Authorized 12/1/51

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

Status: CONTINUED. A brief report was prepared, summarizing the lengthy statistical analysis of 9 properties on 12 plates and giving recommendations for sampling future heats.

Analysis of data on 6 plates from each of 2 new steels 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,
Department of Interior
Managers: C. Eisenhart, W. J. Youden

Authorized 10/9/53

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

Status: CONTINUED. Comments of C. Eisenhart, W. J. Youden, M. Zelen and others on a manuscript entitled "The meaning and importance of 'semi-quantitative' analysis," by E. M. Shoemaker (U.S.G.S., Colorado Plateau District, Grand Junction) were transmitted to the author.

Full details of the multiple regression analysis of the dependence of the size of uranium ore deposits on chemical composition of the ore (see Jan-Mar 1957 issue, p. 40) were transmitted to A. T. Miesch (Northwestern University) and E. M. Shoemaker (U.S.G.S., Colorado Plateau District, Grand Junction) in a memorandum by J. M. Cameron and W. S. Connor, with additional comments by C. Eisenhart.

C. Eisenhart and W. S. Connor completed a preliminary study of whether and to what extent success in locating ore and mineralized deposits by indicator plants depends on the depth of the deposits below the ground surface. Data provided by H. L. Cannon (Geochemical Exploration Section, Denver) was used. The results were transmitted to Mrs. Cannon in memorandum form.

On April 30th, J. M. Cameron, C. Eisenhart, M. G. Natrela and J. R. Rosenblatt participated in a Washington meeting of the Committee on Statistics in Geology, of the Geologic Division, U.S.G.S. W. L. Newman (Colorado Plateau District, Grand Junction) commented on the difficulties met thus far by the Denver and Grand Junction groups in their attempts to gain acceptance of their geologic work involving 'semi-quantitative' spectrochemical analysis. C. Wahshaftig (U.S.G.S. Center, Menlo Park, California) discussed some of the statistical problems arising in the work of the Menlo Park Center.
Status of Projects

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

Origin and Sponsor: Office of Ordnance Research
Manager: C. Eisenhart
Full task description: Oct-Dec 1954 issue, p. 28

Authorized 12/29/54

Status: CONTINUED. The planned contents of the Manual is as follows:

Preface
Introduction
Some Basic Statistical Concepts
Part I. Some Standard Techniques for Quantitative Data
   1. Performance of an item
   2. Statistical tests concerning averages and dispersions
   3. Description, prediction and correlation
Part II. Some Standard Techniques for Qualitative Data
   1. Proportions and percentages
   2. Sensitivity testing
Part III. The Planning and Analysis of Comparative Experiments
   1. General considerations
   2. Comparing the performance of several items, products or processes
   3. Experiments in which several factors are studied simultaneously (factorial experiments)
   4. Experiments to determine optimum conditions or levels
Part IV. Miscellaneous
   1. Rejection of observations
Tables

A revised draft of Part I, sections 1 and 2 (Estimation and Tests) is in the process of being reproduced for circulation. The current draft was prepared with consideration to the coordinated report of comments received on a previous draft, 16 August 1956. Major additions in the new version include some short-cut tests and distribution-free tests.

Part I, section 3 (Regression) is essentially complete, except for the addition of some figures and examples. It is planned to circulate the test of this portion for comment.

Parts II, III, and IV, have been drafted, but examples have to be added. The selection and preparation of tables is completed.
APPLICATION OF ELECTRONIC COMPUTERS

During this quarter the installation in the Computation Laboratory of a new IBM type 704 electronic computer was completed, thus modernizing the Bureau's computing facilities by making available one of the newest and fastest machines. Problems previously solved on the SEAC are being recoded for solution on the 704. After this quarter SEAC will no longer be regularly maintained as a Bureau service facility. It will be used by the Data Processing Systems Division as an applications research facility and an engineering tool for studies of components and systems.

The record of SEAC operations for tasks of the Applied Mathematics Division for the period April 1 through June 30 is as follows:

<table>
<thead>
<tr>
<th>Task No.</th>
<th>Title</th>
<th>Code Checking</th>
<th>Productive Operation</th>
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<tr>
<td>1104/55-55</td>
<td>Research in numerical analysis</td>
<td>2</td>
<td></td>
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<tr>
<td>5114/57-237</td>
<td>Numerical analysis training program</td>
<td>8</td>
<td>55</td>
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<tr>
<td>5116/56-148</td>
<td>Study of differential equations for nerve fiber excitation</td>
<td>2</td>
<td></td>
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<tr>
<td>1110/53-52</td>
<td>L-shell conversion coefficients</td>
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<td>74</td>
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<tr>
<td>1110/51-8</td>
<td>Tables of power points of analysis-of-variance tests</td>
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<td>18</td>
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<td>1110/52-37</td>
<td>Spheroidal wave functions</td>
<td>1</td>
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<tr>
<td>5126/52-44</td>
<td>Calculations for d-spacings</td>
<td>4</td>
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<tr>
<td>5126/54-30</td>
<td>Spectrometer analysis</td>
<td></td>
<td>43</td>
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<tr>
<td>5126/55-68</td>
<td>Crystal structure calculations</td>
<td>2</td>
<td>6</td>
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<tr>
<td>5126/55-97</td>
<td>High temperature properties of air</td>
<td>15</td>
<td></td>
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<tr>
<td>5126/55-121</td>
<td>Electron penetration</td>
<td>3</td>
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<tr>
<td>0009/56-160</td>
<td>Mathematical subroutines</td>
<td>7</td>
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<tr>
<td>5126/56-162</td>
<td>Stresses in a wall resting on a footing</td>
<td>4</td>
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<tr>
<td>5126/56-166</td>
<td>SCF-LCAO Solution of some hydrides</td>
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<td>5126/56-179</td>
<td>Normal propagation constant</td>
<td>35</td>
<td>73</td>
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<td>5126/56-192</td>
<td>Noise measurement</td>
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<td>Thermal properties</td>
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<td>5126/57-223</td>
<td>Self-consistent fields</td>
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<td>0009/57-236</td>
<td>Self-consistent field--eigenvalues</td>
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<td>0002/51-1</td>
<td>Statistical engineering</td>
<td>2</td>
<td>12</td>
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<tr>
<td>1115/55-57</td>
<td>Research in mathematical physics and related fields</td>
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<tr>
<td>Miscellaneous items</td>
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Totals: 86 458
OTHER:

5113/57-216 Handbook of mathematical functions  3  14
5126/54-13 Award of procurement contracts by linear programming  10
5126/55-113 Reactor design  10
5126/55-127 Vibration of a circular disc  9
5126/56-140 Multiple correlation routines  2
5126/56-163 Nuclear scattering  8
5126/56-184 Transistor amplifier  11
5126/57-224 Track-while-scan radar problem  4  143
Classified tasks  16  106

Totals:  23  311

The record of the use of the IBM 704 for the period May 14 through June 30 is as follows:

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<th>Task No.</th>
<th>Title</th>
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<th>Production (MINUTES)</th>
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<tr>
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<td>Research in mathematical topics applicable to numerical analysis</td>
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<tr>
<td>5170/56-159</td>
<td>Research in theories of discrete structures</td>
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<td>Numerical analysis training program</td>
<td>42</td>
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<tr>
<td>5116/56-148</td>
<td>Nerve fiber excitation</td>
<td>19</td>
<td>73</td>
<td>30</td>
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<td>5113/57-216</td>
<td>Handbook of mathematical tables</td>
<td>43</td>
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<td>Automatic coding</td>
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<td>0009/56-160</td>
<td>Staff subroutines</td>
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<tr>
<td>5126/52-44</td>
<td>Calculations of d-spacings</td>
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<td>5126/54-30</td>
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<td>High temperature properties of air</td>
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<td>0009/57-229</td>
<td>Payroll operations</td>
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<td>Polynomial evaluation</td>
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<td>0009/57-235</td>
<td>Triple integrals</td>
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<td>0009/57-238</td>
<td>Modified Landau functions</td>
<td>23</td>
<td>120</td>
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<td>Heat transfer</td>
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<td>Weather Bureau</td>
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<td>Nuclear Physics Section</td>
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<td>Statistical engineering</td>
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<td>*5710/--</td>
<td>Data Processing--Post Office Problem</td>
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</table>

**Totals:** 859 7926 1886

*Managed by the requesting agency.*
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.

Applied Mathematics Colloquium Series


Applied Statistics Seminar


Statistical Theory Seminar


Mathematical Physics Section Seminar

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


TAUSSKY-TODD, O. Commutativity in finite matrices. Presented before the Mathematics Department, Ohio State University, Columbus, Ohio, May 16.


YOUDEN, W. J. (1) Dice, data and deductions. Presented at a meeting of the Detroit Section of the American Chemical Society, held at the University of Michigan, Ann Arbor, Mich., May 21; also presented at the University of Notre Dame, Notre Dame, Indiana, May 24. (2) Problems of the experimenter. Presented at a meeting of the American Association of Physics Teachers, Washington, D. C., April 6; also presented at a Seminar at the E. I. duPont de Nemours Co., Newburgh, N.Y., April 17. (3) Interpretation of chemical data. Presented at a meeting of the Toledo Section of the American Chemical Society, held at Bowling Green University, Bowling Green, Ohio, May 20; also presented before the Michigan State University Section of the American Chemical Society, East Lansing, Mich., May 23. (4) Control of experimental data by
statistical design. Presented at the University of Michigan, Ann Arbor, Mich., May 22.


* * * * * *

Papers presented at the meeting of the American Mathematical Society held at New York University, New York, N. Y., April 5-6:

GHAFFARI, A. On the solution of compressible flow past a wedge.

MARCUS, M. On subdeterminants of doubly stochastic matrices.

NEWMAN, M. Some theorems about $p_r(n)$.
Publication Activities

1. PUBLICATIONS THAT APPEARED DURING THE QUARTER

1.2 Manuals, Bibliographies, and Indices


1.3 Technical Papers


1.4 Reviews and Notes


2. MANUSCRIPTS IN THE PROCESS OF PUBLICATION JUNE 30, 1957

2.1 Mathematical Tables

(1) Tables of the bivariate normal distribution function and related functions. To appear as NBS Applied Mathematics Series 50.

(2) Table of the first moment of ranked extremes. J. Lieblein and H. E. Salzer. To appear in the Journal of Research, NBS.

2.2 Manuals, Bibliographies, and Indices


2.3 Technical Papers


Publication Activities


(20) Mechanized computation of thermodynamics tables at the National Bureau of Standards. J. Hilsenrath (NBS Thermodynamics Section) and J. Wegstein. To appear in the Proceedings of the Joint Conference on Thermodynamic Transport Properties of Fluids,


(22) Estimation of the frequencies of thin elastic plates with free edges. T. Kato, H. Fujita, Y. Nakata (University of Tokyo); and M. Newman. To appear in the Journal of Research, NBS.


(33) Generation of Bessel functions on high speed computers. I. Stegun and M. Abramowitz. Submitted to a technical journal.


(37) A determinantal inequality of H. P. Robertson, I. O. Taussky. Submitted to a technical journal.

(38) Some computational problems concerning integral matrices. O. Taussky. To appear in the 1956 Meeting of the Italian Society for the Advancement of Science, held in Sicily.


Publication Activities


(50) The analysis of incomplete block designs for asymmetrical factorial arrangements. M. Zelen. Submitted to a technical journal.


2.4 Reviews and Notes


(2) The probability of a saddle point. A. J. Goldman. Submitted to a technical journal.


2.5 Miscellaneous

(1) Further contributions to the solution of simultaneous linear equations and the determination of eigenvalues. To appear as Applied Mathematics Series 49.

COMM-DC-49,041
The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major field laboratories in Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant reports and publications, appears on the inside front cover of this report.

WASHINGTON, D. C.


- Office of Basic Instrumentation
- Office of Weights and Measures

BOULDER, COLORADO


