

**NATIONAL BUREAU OF STANDARDS REPORT**

4801

PROJECTS and PUBLICATIONS  
of the  
APPLIED MATHEMATICS DIVISION

A Quarterly Report  
April through June 1956



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

U. S. DEPARTMENT OF COMMERCE

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NATIONAL BUREAU OF STANDARDS

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**Optics and Metrology.** Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

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

**Mechanics.** Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

**Organic and Fibrous Materials.** Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Organic Plastics. Dental Research.

**Metallurgy.** Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion.

**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

# NATIONAL BUREAU OF STANDARDS REPORT

**NBS PROJECT**

**NBS REPORT**

11.0

4801

## PROJECTS and PUBLICATIONS of the APPLIED MATHEMATICS DIVISION

April through June 1956



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

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April 1 through June 30, 1956

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\*Only unclassified projects are included in this report.



# Status of Projects

June 30, 1956

## 1. NUMERICAL ANALYSIS

### RESEARCH IN THEORIES OF DISCRETE STRUCTURES

Task 1100-11-5170/56-159

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 found a new brief proof of the theorem of L. J. Mordell that a quadratic form with rational integral elements is a sum of four squares of linear forms with rational integral coefficients if and only if the determinant of the forms is a sum of three squares. M. Newman found a further abbreviation of this proof.

O. Taussky continued earlier work on a correspondence between classes of matrices  $S^{-1}AS$  with rational integral elements and ideal classes in a certain algebraic number field. The matrices  $S$  are assumed unimodular and the characteristic polynomial of  $A$  irreducible. The ideal class which corresponds to the matrix class  $S^{-1}A'S$  is characterized. For the case of quadratic fields it is the inverse class. The case when the class definition for  $|S| = \pm 1$  coincides with the one for  $|S| = 1$  is characterized. A manuscript was prepared.

O. Taussky prepared a manuscript of her lecture on "Commutativity in finite matrices", given at the meeting of the American Mathematical Association held at Annapolis, Maryland, May 25 (see publication (12) below).

K. Goldberg and M. Newman have extended their previous manuscript on certain pairs of rational integral unimodular matrices of order two which generate a free group.

K. Goldberg has proved that two rational integral unimodular matrices of order two commute if and only if they are powers (within sign) of the same matrix.

K. Goldberg and E. C. Dade have continued their investigation of linear associative algebras with a basis of incidence matrices.

K. Goldberg has continued his investigation of iterated convolutions, emphasizing relations between different convolutions.

## Publications:

- (1) The formal power series for  $\log(e^x e^y)$ . K. Goldberg. Appeared: Duke Math. J. 23, 13-22 (1956).
- (2) The number of absolute points of a correlation. A. Hoffman, M. Newman, E. Strauss, O. Taussky. To appear in the Pacific Journal of Mathematics.
- (3) Some computation problems in algebraic number theory. O. Taussky. Appeared: Proceedings of the Sixth Symposium in Applied Mathematics of the American Mathematical Society, held at Santa Monica City College, August 26-28, 1953, pp. 187-193 (McGraw-Hill Book Co., Inc., New York, 1956).
- (4) Bounds and asymptotic behavior of the coefficients in the series  $\log(e^x e^y)$ . K. Goldberg. In manuscript.
- (5) 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.
- (6) Generation and testing of pseudo-random numbers. O. Taussky and J. Todd. Appeared: Proceedings of a Symposium on Monte Carlo Methods, held at Gainesville, Florida, 1954, pp. 15-28 (John Wiley & Sons, Inc., New York, N. Y., 1956).
- (7) On the Hilbert matrix. T. Kato. To appear in the Proceedings of the American Mathematical Society.
- (8) Some free subgroups of the modular group. K. Goldberg and M. Newman. In manuscript.
- (9) Classes of positive definite unimodular circulants. M. Newman and O. Taussky. To appear in the Canadian Journal of Mathematics.
- (10) Unimodular matrices of order two which commute. K. Goldberg. In manuscript.
- (11) Incidence algebras. E. C. Dade and K. Goldberg. In manuscript.
- (12) Commutativity in finite matrices. O. Taussky. In manuscript.
- (13) Classes of matrices. 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 completed his work on the survey of stability criteria for solutions of systems of ordinary differential equations. All criteria included in this survey are based upon certain gauge functions, known in the literature as Lyapunov functions, and are independent of consideration of variational equations and the like. A manuscript has been prepared (see publication (8) below).

Exploratory calculations in connection with the tabulation of the Cauchy parameters described in the previous quarterly report (Jan-Mar 1956) have been started by J. Gager.

R. Moore has prepared, as a training project, codes for the evaluation of  $\mathcal{T}(n)$ .



J. Todd continued his work on a direct approach to stability problems in connection with partial differential equations (see publication (3) below). Some difficulties of an algebraic nature have been isolated.

J. Todd and O. Taussky have continued work in certain problems about the eigenvalues of the Hilbert matrix and related matrices.

H. Cohn has begun to compute class numbers in cubic fields using a formula of Dedekind.

Publications:

- (1) Stable systems of differential equations with integrable perturbation term. H. A. Antosiewicz. Appeared: J. London Math. Soc. 31, 208-212 (1956).
- (2) On the Lerch zeta function. F. Oberhettinger. To appear in the Pacific Journal of Mathematics.
- (3) 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.
- (4) Some Monte Carlo experiments for computing multiple integrals. P. Davis and P. Rabinowitz. Appeared: MTAC 10, 1-7 (1956).
- (5) Complete sequences and approximations in normed linear spaces. P. Davis and K. Fan. Submitted to a technical journal.
- (6) A matrix with real characteristic roots. K. Goldberg. Appeared: J. Res. NBS 56, 87 (1956), RP2652.
- (7) Note on bounds for determinants. E. V. Haynesworth. In manuscript.
- (8) A survey of Lyapunov's second method. H. A. Antosiewicz. To appear in Annals of Mathematics Studies.
- (9) Obituary notice on A. M. Turing. O. Taussky and John Todd. To appear in Mathematical Tables and Other Aids to Computation.

RESEARCH IN MATHEMATICAL TOPICS APPLICABLE TO  
NUMERICAL ANALYSIS

Task 1101-10-5116/55-56

Origin: NBS

Authorized 8/13/54

Sponsor: Office of Naval Research

Revised 8/29/54

Managers: J. Todd, M. Newman

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

Status: CONTINUED. Motivated by extremum problems in analysis, Ky Fan has been studying families of  $n+1$  closed convex sets

$$\{C_1, C_2, \dots, C_{n+1}\}$$

in the Euclidean  $n$ -space  $E^n$  with the following two properties: (a) Every  $n$  of the sets  $C$  have a non-empty intersection, (b)  $\bigcap_{i=1}^{n+1} C_i$  is empty. The following results were obtained: (1) In order that  $n+1$  closed convex sets  $C_i$  in  $E^n$  satisfy both conditions (a) and (b), it is necessary and

sufficient that  $E^n - \bigcup_{i=1}^{n+1} C_i$  have a bounded component. (2) Let  $C_i$  be  $n+1$  closed convex sets in  $E^n$  satisfying (a) and (b); Let  $\Phi_i$  be  $n+1$  gauge functions defined on  $E^n$ ; Let

$$\delta = \min_{x \in E^n} \max_{1 \leq i \leq n+1} d_i(x, C_i),$$

where

$$d_i(x, C_i) = \min_{y \in C_i} \Phi_i(x-y).$$

Then there exists a point  $x_0$  in the bounded component  $U$  of  $E^n - \bigcup_{i=1}^{n+1} C_i$  such that

$$d_i(x_0, C_i) = \delta, \quad (1 \leq i \leq n+1).$$

Furthermore, we have

$$\min_{x \in E^n} \max_{1 \leq i \leq n+1} d_i(x, C_i) = \max_{x \in U} \min_{1 \leq i \leq n+1} d_i(x, C_i).$$

The second result includes as a special case Collatz-Wielandt's min-max and max-min characterization of the largest eigenvalue of a matrix with positive elements. Study of related geometrical problems and applications to extremum problems in analysis are to be continued.

M. Newman has completed a manuscript entitled "Some theorems on  $P_r(n)$ ". A general congruence for the coefficients of  $\prod_{n=1}^{\infty} (1-x^n)^r$  is

proved, from which the Ramanujan congruences for partitions modulo 5, 7, 11 may be derived as a corollary. Other identities and theorems are given as well.

A class of entire modular functions on the subgroup  $\Gamma_0(pq)$  of the modular group ( $p, q$  primes exceeding 3) has been constructed, and it is shown that for  $p=5, q=7$ ;  $p=5, q=11$ ; and  $p=7, q=11$  certain linear combinations of these functions form a polynomial basis for  $\Gamma_0(pq)$ . It is probable that this is true for any  $p, q$ .

A routine to put an integral matrix into Hermite normal form (using the internal memory) has been prepared by M. Newman. Such a routine may be used to determine the rank of a matrix and its determinant. It may also be used to determine the exact solution of a system of equations with integer terms to solve diophantine equations in many variables, etc. The order of the matrix must not exceed 29. The routine is very rapid, an  $18 \times 18$  matrix requiring about one minute of computation time.

#### Publications:

- (1) Generalizations of identities for coefficients of certain modular forms. M. Newman. Appeared: J. London Math. Soc. 31, 205-208 (1956).
- (2) Compactification of completely regular spaces. Ky Fan and F. Wagner (University of Notre Dame). In manuscript.

- (3) On dominant eigenvalues of positive matrices. T. Kato. In manuscript.
- (4) Error bounds for eigenvalues of symmetric integral equations. H. Wielandt. Appeared: Proceedings of the Sixth Symposium in Applied Mathematics of the American Mathematical Society, held at Santa Monica City College, August 26-28, 1953, pp. 261-282 (McGraw-Hill Book Co., Inc., New York, 1956).
- (5) On systems of distinct representatives. A. J. Hoffman and H. W. Kuhn (Bryn Mawr College). To appear in Annals of Mathematics Study 38.
- (6) Systems of linear inequalities. Ky Fan. To appear in Annals of Mathematics Study 38.
- (7) Systems of distinct representatives and linear programming. A. J. Hoffman and H. W. Kuhn (Bryn Mawr College). To appear in the American Mathematical Monthly.
- (8) Dilworth's theorem on partially ordered sets. G. B. Dantzig (RAND Corporation) and A. J. Hoffman. To appear in Annals of Mathematics Study 38.
- (9) On the minimization of concave and convex functionals. G. B. Dantzig (RAND Corporation), A. J. Hoffman, W. Hirsch (New York University). In manuscript.
- (10) 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.
- (11) An inclusion theorem for modular subgroups. M. Newman. Submitted to a technical journal.
- (12) 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.
- (13) On the existence of identities for the coefficients of certain modular forms. M. Newman. To appear in the Journal of the London Mathematical Society.
- (14) Integral boundary points of convex polyhedra. A. J. Hoffman and J. B. Kruskal (Princeton University). To appear in the Annals of Mathematics Study 38.
- (15) Linear Programming. A. J. Hoffman. Appeared: App. Mech. Rev. 9, 185-187 (May 1956).
- (16) Systems of inequalities involving convex functions. Ky Fan (University of Notre Dame), I. Glicksberg (RAND Corporation), and A. J. Hoffman. In manuscript.
- (17) Generalization of a theorem of Konig. A. J. Hoffman. To appear in the Journal of the Washington Academy of Sciences.
- (18) Some theorems on  $P_r(n)$ . M. Newman. Submitted to a technical journal.

## 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. About 20 cases, mostly for temperature  $18.5^{\circ}\text{C}$ , were run during this quarter and were submitted to the sponsor.

The search for values of the parameter  $k$ , for which the solutions of the basic system of differential equations have a prescribed behavior, has cut down the length of the interval of admissible values of  $k$  to less than  $10^{-9}$ . At most five cases for temperature  $18.5^{\circ}\text{C}$  remain to be run.

NUMERICAL EXPERIMENTS ON POTENTIAL THEORY  
USING THE NEHARI ESTIMATES  
Task 1101-10-5116/56-189

Origin: NBS

Authorized 7/10/56

Sponsor: Air Research and Development Command, USAF

Managers: P. Davis, U. Hochstrasser

Objective: To conduct numerical experiments using orthonormal harmonic functions; and, in particular, to obtain numerically the harmonic measures of the sides of a skew pentagon by this means.

Background: Z. Nehari has given an estimate of error when the Dirichlet Problem is solved by expanding the Dirichlet data into a Fourier series of orthonormal harmonic functions (Z. Nehari, "On the numerical solution of the Dirichlet problem," an unpublished report, Carnegie Institute of Technology, Pittsburgh, Pa.). This estimate now makes possible a more precise discussion of the numerical treatment of certain problems in potential theory. The present investigation is a sequel to a study that was summarized by P. Davis and P. Rabinowitz ("Numerical experiments in potential theory using orthonormal functions," J. Wash. Acad. Sci. 46, 12-17 (1956)).

Status: NEW.

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. Typing of the final manuscript for publication 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. A table of  $F_0(\eta, \rho)$  and  $F'_0(\eta, \rho)$  for  $\eta = .5(.5)25$ ,  $\rho = 0(.5)40$  is in process of computation. Values for  $\eta = 3(.5)22$  have already been obtained.

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: INACTIVE. For status to date, see Jan-Mar 1956 issue, p. 6.

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.

## 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 were carried out for the following:

K shell:

Z = 75, k = 1.0

Z = 35, k = .05

Z = 95, k = .4, .6, .8.

L<sub>III</sub> shell:

Z = 25, k = .05, .1, .15, .20,

Z = 35, k = .05, .1,

Z = 95, k = .05, .1, .15, .2.

## 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. The subroutine for floating point addition, subtraction, and multiplication of matrices, and determinant evaluation have been incorporated in a matrix interpretation routine. To cause one of these subroutines to be executed it is only necessary to write a pseudo instruction (four addresses and one operation) which treats matrices as a regular instruction treats numbers. For example, to multiply the matrix beginning in cell  $\alpha$  by the matrix beginning in cell  $\beta$  and store the result beginning in cell  $\gamma$ , then pick up the next pseudo instruction at  $\delta$ , one would write  $\alpha \beta \gamma \delta 8 -$ . The 8- indicates matrix multiplication, and all such operations refer to a standard location for a dimension word that gives the dimensions of the matrices concerned. This system is kept as a 1024 word record on magnetic wire called Base 02.

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 matrix subroutines to add and multiply matrices, to raise a matrix to a given power, to compute the value of a determinant, and to orthonormalize a set of vectors have been written and checked out. A subroutine to rewrite an  $n \times n$  matrix with complex elements as a  $2n \times 2n$  matrix with real elements where the element  $a+bi$  is replaced by the  $2 \times 2$  submatrix  $\begin{pmatrix} a & b \\ -b & a \end{pmatrix}$  has also been completed. With the completion of this subroutine, the same operations can be performed with complex matrices as with real matrices. All of these subroutines utilize floating decimal point numbers and they are being adapted to the SEAC matrix interpretation system (see Automatic Coding, task 1102-40-1120/55-65).



### 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.

#### 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 1956 issue, page 12.

#### Publication:

A note on the normal distribution. S. Geisser. To appear in the Annals of Mathematical Statistics.

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. Bose (affiliated with the Statistical Engineering Laboratory for the summer) delivered 13 lectures on the application of finite geometries to the construction of factorial designs. R. C. Burton provided necessary and sufficient conditions for the construction of an identity relationship for which the words are specified with respect to the numbers of letters to each power. He showed that when such an identity relationship exists it is unique, and provided a method of construction. Professor Bose formalized the argument.

M. Zelen has revised his paper "The analysis of covariance for incomplete block designs" (formerly, "On the analysis of covariance").

Publications:

- (1) Contributions on partially balanced incomplete block designs with two associate classes. W. H. Clatworthy. To appear as NBS Applied Mathematics Series 47.
- (2) Fractional factorial experiment designs for factors at two levels. To appear as NBS Applied Mathematics Series 48.
- (3) 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, Washington, D. C., October 1955.
- (4) 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, Washington, D. C., October 1955.
- (5) The analysis of covariance for incomplete block design. M. Zelen. Submitted to a technical journal. (Formerly listed as "The analysis of covariance.")
- (6) Exact tests of significance for combining inter- and intra-block information. M. Zelen. Submitted to a technical journal.

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 A. F. Sarhan of the

University of North Carolina regarding editorship and planning a proposed monograph on order statistics for the use of practicing and theoretical statisticians.

Publication:

- (1) Geological application of extreme-value methods to interpretation of cobbles and boulders in gravel deposits. W. C. Krumbein (Northwestern University) and J. Lieblein. To appear in the Transactions of the Geophysical Union.

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 "On the power of some rank order two-sample tests" was presented by J. R. Rosenblatt at the Eastern Regional Meeting of the Institute of Mathematical Statistics, Princeton, N. J., April 20.

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) On the independence of tests of randomness and other hypotheses. I. R. Savage. To appear in the Journal of the American Statistical Association.

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

Origin: NBS

Authorized: 3/23/56

Manager: M. Zelen

Full task description: Jan-Mar 1956 issue, p. 13

Status: CONTINUED. Joint activities of M. Zelen, J. Lieblein, and J. R. Rosenblatt included visits to various NBS laboratories to confer with scientists about possible applications of statistical techniques in problems related to reliability prediction and improvement, a visit to the Reliability Research Department of Aeronautical Radio, Inc., and a visit to the Allentown Laboratory of Bell Telephone Laboratories to participate in seminars on statistical problems related to reliability considerations.

M. Zelen has developed a technique for making an optimum

selection among possible additions of redundant components when the number of redundant components to be added is constrained by (for example) restrictions on total equipment weight.

J. R. Rosenblatt has done further work on the properties of methods for obtaining confidence intervals for the product of binomial parameters.

J. Lieblein has worked on a rule-of-thumb relationship that makes it possible to deduce the effect of conditions of use on reliability and performance of equipment.

M. Zelen has started an investigation to determine how one can make effective use in practice of the relation between the distribution of failures and the conditional distribution of failures. For example, if the conditional probability of failure varies directly with usage time, then the square of the failure time will follow an exponential distribution. (This situation typifies "wear-out" failures.)

Review of literature was continued.

A sequence of three seminars has been planned, to be presented in July.

#### 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. P. Chiarulli and F. M. Chilton, Jr., have initiated a study on the possibilities of the development of a Cartesian Diver balance as a weighing instrument. Previous work on such balances has been studied and a more general analysis of the theory of such a balance has been made which precisely indicates the approximations implicit in the work of the previous investigators.

##### Publications:

- (1) Entropy changes in rarefaction waves. R. F. Dressler. Submitted to a technical journal.
- (2) 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.
- (3) On the representation of a certain integral involving Bessel functions of hypergeometric series. P. Henrici. Submitted to a technical journal.
- (4) On the domain of regularity of generalized axially symmetric potentials. P. Henrici. To appear in the Proceedings of the American Mathematical Society.
- (5) 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. Oberhettlinger

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 corrugated diaphragm work is being continued through an analysis of a sequence of diaphragms with a fixed shape and for a range of thicknesses. The case of a very thin diaphragm is at present under consideration. In this case the presently obtained homogeneous solutions of the differential equations lead to the appearance of ill-conditioned matrices and a careful analysis is being made to determine more suitable homogeneous solutions.

With respect to the vibrating triangular wing project, W. F. Cahill has written and checked out a set of nine codes which compute the coefficients and sets up the 78x78 finite difference matrix as a function of Poisson's ratio and the aspect ratio of the triangular plate. The lowest eigenvalue and eigenvector is to be computed for various combinations of three values of Poisson's ratio and three values of the aspect ratio of the wing. These results will be compared with corresponding experimental results.

The approximate numerical solution of the elastic torsion problem for the hollow square has been completed on SEAC by J. L. Synge and W. F. Cahill, and a paper on this work has been prepared.

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. To appear in the Proceedings of the Eighth Symposium in Applied Mathematics of the American Mathematical Society, held at Chicago, Ill., April 1956.
- (3) Elastic waves in anisotropic media. J. L. Synge. Submitted to a technical journal.
- (4) The torsion of a hollow square. J. L. Synge and W. F. Cahill. Submitted to a technical journal.

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. It has been decided to expand the previous compilation of Fourier transforms of distribution functions. A large number of new additions to the existing collection have been made.

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

Origin: Office of Naval Research  
Sponsor: " " Authorized 9/30/55  
Manager: R. F. Dressler  
Full task description: July-Sept 1955 issue, p. 21

Status: CONTINUED. The model, previously considered, of an interface separating two phases of a moving fluid in which phase transition is brought about by heat removal and/or cold liquid addition at the interface has been amplified to include the case of a momentum sink at the interface (corresponding to friction losses along channel walls) and cold liquid injection through the initial section itself. Based on this more general model a new example has been computed and a previous example has been recomputed using the more recent and more extensive tables of thermodynamic properties of water by W. Koch [VDI-Wasserdampf-tafeln, Third Edition, R. Oldenbourg, Munich, 1952]. These new results have been included in the previously prepared paper on condensation interfaces.

Publications:

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

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

Origin: The American University  
Sponsor: Office of Naval Research  
Manager: R. Stoneley  
Full task description: July-Sept 1955 issue, p. 21 Authorized 9/30/55

Status: CONTINUED. R. Stoneley and U. Hochstrasser have prepared a paper on the variation with depth of the amplitude of Rayleigh waves in a continent with a double surface layer.

Dispersion curves obtained in the propagation of Rayleigh waves across an ocean floor in which there are two rocky layers have been considered for twelve models of oceanic structure by R. Stoneley and U. Hochstrasser with the aid of SEAC. A paper containing these results is in preparation as Part II of a previous paper (publication (1) below).

A preliminary investigation of the equations governing the

deformation of the Earth by gravitational forces has been made and a program for SEAC is now being prepared to obtain the deformation derived from spherical harmonics of the third and higher degrees.

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) The attenuation of Rayleigh waves with depth in a medium with two surface layers. R. Stoneley and U. Hochstrasser. To appear in the Geophysical Supplement, Monthly Notices, Royal Astronomical Society.
- (4) Lectures - Surface waves in an elastic media. R. Stoneley. A Monograph.

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. The so-called Mehler inversion formula (Mehler Transform)

$$g(y) = \int_0^{\infty} P_{-\frac{1}{2}+ix}(y) f(x) dx,$$

$$f(x) = x \tanh(\pi x) \int_1^{\infty} P_{-\frac{1}{2}+ix}(y) g(y) dy,$$

where  $P_{\nu}(y)$  is the Legendre function of the first kind, is of great importance for boundary value problems involving a conical structure. The compilation of a collection of such Mehler Transforms has been started.

Investigations concerning the diffraction and reflection of pulses on wedges have been started and are in progress.



## 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: Completed. Results have been transmitted to the sponsor.

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. Structure factors and phase angles were computed for an artificial crystal belonging to space group P. This information will be used to check the validity of various phase determination formulae. This computation of structure factors and phase angles was carried out on the SEAC using a routine written by R. Prosen of Division 9.

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 9 orthorhombic, 4 tetragonal and 22 hexagonal crystals. Also determination of unit cell constants was carried out by least square fittings to measured d-spacings for 7 tetragonal, 14 hexagonal and 7 orthorhombic crystals.

The orthorhombic case was again extended to include additional sets of h,k,l, for d-spacing calculations.

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: Inactive.

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: Continued. Data on the spatial and angular distributions of photons emitted either monodirectionally or isotropically near the interface of two homogeneous media of different densities have been obtained. A sample of approximately 12,000 photons was generated.

A code has been designed to evaluate the formula for singly scattered x-radiation, that is, the angular distribution of photons which have suffered a single collision since emission from the source.

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. Bid evaluation continued to be run off on the "Transportation Code" as the problems were submitted by the Sponsor.

By now these problems are routine and it is possible to submit the answers to the sponsors two to three days after a problem has been submitted. Most of the time goes into preparation of data and checking the answers. The actual running time for most problems on SEAC is ten minutes per run and about three runs per problem; this is for a cost matrix whose average size is 15x20.

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. Six new cases were run and transmitted to 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: 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: Inactive.

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 4.5

Manager: W. G. Hall

Full task description: Apr-June 1955 issue, p. 12

Status: Completed.

Publication: "Electron physics tables," by L. Marton, C. Marton (Electron Physics Section), and W. G. Hall; NBS Circular 571, March 30, 1956.

Available from the U. S. Government Printing Office, 50 cents.

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

Origin and Sponsor: NBS, Section 82.1

Manager: B. G. Urban

Full task description: Jan-Mar 1955 issue, p. 17

Status: Completed. The problem has been coded by H. H. Howe (82.1) for computation on a punched card machine at the NBS Boulder Laboratories.

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

Origin and Sponsor: Naval Research Laboratory

Manager: I. Stegun

Full task description: Oct-Dec 1954 issue, p. 18

Status: 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 30

Manager: H. Bremer

Full task description: July-Sept 1954 issue, p. 18

Status: Inactive. For status to date, see Oct-Dec 1954 issue, p. 19.

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

Origin: NBS, Division 9

Manager: R. Prosen (Div. 9)

Full task description: Jan-Mar 1955 issue, p. 18

Status: Continued. The general structure factor routine has been checked out and was used (see task 1102-40-5126/51-37, p.19 ). Code checking for the general Fourier routine to calculate three-dimensional electron density maps is progressing satisfactorily.

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

Origin and Sponsor: Naval Medical Research Institute

Manager: S. Prusch

Full task description: Jan-Mar 1955 issue, p. 19

Status: Continued. Intermediate results were listed and furnished to the sponsor for further study.

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. For status to date, see Jan-Mar 1956 issue, p. 20.

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

Origin: NBS, Section 11.3

Manager: L. S. Joel

Full task description: Oct-Dec 1954 issue, p. 23

Status: Continued. Scattered values are being computed to finish the computation.

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.  $\alpha$ ,  $\beta$ , and  $\delta$  constants were computed for approximately 52 thermometers. Calibration tables were computed on approximately 35 thermometers under test.

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

Origin and Sponsor: NBS, Section 10.1

Managers: E. Marden, G. H. Urban

Full task description: Jan-Mar 1955 issue, p. 22

Status: Continued. Using 60 new coefficients, stresses for a wall whose length equals its width were computed and transmitted to the sponsor.

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

Origin and Sponsor: Missouri River Division, Corps of Engineers, U.S.Army

Manager: H. Bremer

Full task description: Jan-Mar 1955 issue, p. 26

Status: Continued. Additional problems were solved on the UNIVAC at the Army Map Service.

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

Origin and Sponsor: NBS, Section 82.1

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

Full task description: Jan-Mar 1955 issue, p. 26

Status: Completed. Results have been submitted to the sponsor.

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: Continued. Some of the results were transmitted and discussed with the originator. It was decided to change the code such that the eigenvalue appears in the source term, since the other formulation causes mathematical difficulties. A special test case, a base reactor consisting of only one region, is being set up in order to compare the approximate solutions obtained by difference methods with the exact solutions.

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: Continued. Fifty-five values of the attenuation of expansion pulses as a function of the cross section area of the attenuator and of the amplitude of the expansion pulse were calculated and submitted to the originator.

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

Origin and Sponsor: NBS, Section 3.1

Manager: B. G. Urban

Full task description: Apr-June 1955 issue, p. 18

Status: Inactive. For status to date, see Jan-Mar 1956 issue, p. 22.

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. A code has been completed and checked out for the computation of spatial moments in the plane isotropic case for high

and low electron source energies. Another code which computes the distribution of the moments has also been checked out. One more program remains to be completed, that is, the computation of the moments in the point isotropic case.

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

Origin: Advisory Committee on Weather Control

Sponsor: U. S. Weather Bureau

Manager: M. Newman

Full task description: Apr-June 1955 issue, p. 20

Status: Inactive.

1102-40-5126/55-123 TEMPERATURE DISTRIBUTION

Origin: NBS, Section 6.4

Sponsor: NBS, Section 6.4

Manager: W. G. Hall

Full task description: Apr-June 1955 issue, p. 19

Status: Inactive. For status to date, see Oct-Dec 1955 issue, p. 24.

1102-40-5126/55-126 AERODYNAMIC HEATING

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

Managers: B. Walter, R. Capuano

Full task description: July-Sept 1955 issue, p. 31

Status: Continued. Tables of  $T_w$  were calculated for various values of

B: B=7.05, 5.4, 3.2, 1.69, 1.28 for the four trajectories. Intersections of  $T_w$  were then obtained for the various values of B.

Tables of  $T_w$  were recalculated from modified expressions for

Bh  $\Delta t$  and  $T_{AW}$ . Accordingly

$$\overline{B'h' \Delta t'} = 1.016 \left( \frac{\bar{V}}{\bar{V}'} \right)^{0.2} B\bar{h} \Delta t$$

and

$$\Delta T_{aw} = 0.150 (10^{-3}) (\bar{V}) (\bar{V}' - \bar{V}) (3.281)^2,$$

so that

$$\overline{T_{AW'}} = T_{AW} + \Delta T_{AW}.$$

Work was begun on the heat transfer for a laminar boundary layer, which is based on the following formulae:

$$T_{AW} = (1 + 0.2M_0^2) T_0,$$

$$h = 0.763 (\alpha V_0 \rho_2)^{\frac{1}{2}} A.$$

## 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: Continued. Further solutions for values of the parameter have been obtained. A new supervisory routine that obtains better initial guesses for the solutions has been devised and checked out.

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

Origin: NBS, Section 2.2

Manager: E. Marden

Full task description: July-Sept 1955 issue, p. 33

Status: Inactive.

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

Origin: Moore School of Engineering

Sponsor: Office of Naval Research

Manager: I. Stegun

Full task description: July-Sept 1955 issue, p. 33

Status: Inactive.

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

Origin: NBS, Section 82.1

Sponsor: NBS, Section 82.1

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

Full task description: July-Sept 1955 issue, p. 34

Status: Completed. Results have been submitted to the sponsor.

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

Origin: Naval Research Laboratory

Sponsor: " " "

Manager: S. Peavy

Full task description: July-Sept 1955 issue, p. 34

Status: Continued. More runs with the latest code were made on request from the sponsor. Then the code was changed to include the original equations of  $V(r)$  as written in the July-Sept 1955 issue, p. 34.

One test run was made with this change.

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

Origin and Sponsor: National Advisory Committee on Aeronautics

Manager: R. Zucker

Full task description: July-Sept 1955 issue, p. 35

Status: Inactive. For status to date, see Jan-Mar 1956 issue, p. 24.

1102-40-5126/56-139 STUDY OF INTERNUCLEAR POTENTIAL FOR H<sub>3</sub>

Origin and Sponsor: NBS, Section 3.2

Manager: E. Haynsworth

Full task description: July-Sept 1955 issue, p. 36

Status: Continued. Several variations on the original code have been written and for one of these variations all the computations desired by the sponsor have been computed. The other variations are in the process of being checked.

## 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: Continued. Forty multiple correlation problems have been completed and submitted to the sponsor. The smallest problem had four variables covering a period of 12 years, the largest had seven variables covering a period of 25 years. There are at least ten more problems that have been prepared by the sponsor's staff and are ready to be computed on SEAC. The time per problem varies with the size--from 20 to 30 minutes. When the high speed punch is available the time is cut down by about one-third.

## 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 sponsor provided 189 additional sets of initial conditions and their trajectories are being computed with the NORC.

## 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: Completed. Results have been submitted to the sponsor.

## 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. Results are being periodically delivered to sponsor.



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. Urban

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

Status: Terminated. Because sufficient UNIVAC time was not available  
for the project, it was decided to discontinue it.

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. The required codes have been written and are being  
checked out.

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: Completed.

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. For status to date, see Jan-Mar 1956 issue, p. 26.

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. Initial conditions have been varied and various  
test cases are being run.

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. A new formula was given to evaluate the expression I  
(see Oct-Dec 1955 issue, p. 33) where  $\tan \delta_n$  is now expressed only  
in terms of spherical Bessel and Neuman functions.

$$\tan \delta_n = - \frac{J'_n(\xi^{\frac{1}{2}})}{N_n(\xi^{\frac{1}{2}})} \cdot \frac{(\xi+p)^{\frac{1}{2}} \frac{J'_n(\xi+p)^{\frac{1}{2}}}{J_n(\xi+p)^{\frac{1}{2}}} - \xi^{\frac{1}{2}} \frac{J'_n(\xi^{\frac{1}{2}})}{J_n(\xi^{\frac{1}{2}})}}{(\xi+p)^{\frac{1}{2}} \frac{J'_n(\xi+p)^{\frac{1}{2}}}{J_n(\xi+p)^{\frac{1}{2}}} - \xi^{\frac{1}{2}} \frac{N'_n(\xi^{\frac{1}{2}})}{N_n(\xi^{\frac{1}{2}})}}$$

and

$$I_{\text{LIMIT}} = \frac{8\xi}{p^2} \cdot \frac{1}{\ln(4 \cdot 1.781 \xi^{\frac{1}{2}} - 1)}$$

for  $\xi \gg p$ ,  $\xi \gg 1$ .

The code was checked out and sample cases were run.

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. The code has been checked out in full, and a number of problems have been run.

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

Origin and Sponsor: NBS, Division 3

Manager: I. Stegun

Full task description: Jan-Mar 1956 issue, p. 28

Status: Inactive. For status to date, see Jan-Mar 1956 issue, p. 28.

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. 1. The coding necessary to compute the collision integrals mentioned in the full task description was completed and code checking is being done. An expression was derived to account for the singularity occurring for some values of  $g$  and  $b$  due to "orbiting" which causes the angle of deflection to become infinite. Means were provided for finding points at which this singularity occurs and for replacing the integral in that range by an algebraic approximation. 2. A combining code was written to compute thermodynamic functions from collision integrals and concentrations for various gas mixtures. This code obtained the solution of the following two sets of equations:

$$(a) \sum_{j=1}^n L_{ij} v_j = 1$$

where

$$L_{ij} = \frac{32n_o}{15C} \frac{m_i}{m_j} \sum_{e=1}^n \frac{C_e m_e}{(m_i + m_e)^2} \left\{ 5m_j (\delta_{ij} - \delta_{ej}) \Omega_{ie}^{1,1} + \frac{3}{2} m_e \Omega_{i,e}^{2,2} (\delta_{ij} + \delta_{ej}) \right\},$$

Here  $C_i$  = the relative concentrations of species  $i$ ,

$m_i$  = the molecular weight of species  $i$ ,

$$C = \sum_{i=1}^n C_i,$$

$n_o$  = number of molecules in one cc. of perfect gas at N.T.P.

$$(b) \sum_{j=1}^n W_{ij} h_j = 1,$$

$$W_{ij} = \frac{32n_o}{5} \left( \frac{m_i}{m_j} \right)^2 \sum_k C_k \left( \frac{m_k}{m_i + m_k} \right)^3 \left\{ \left[ \Omega_{ik}^{1,3} - 5\Omega_{ik}^{1,2} \right. \right. \\ \left. \left. + \frac{5}{4} \Omega_{ik}^{1,1} \left( 5 + 6 \frac{m_j^2}{m_k} \right) \right] (\delta_{ij} - \delta_{jk}) + \frac{2m_j}{m_k} (\delta_{ij} + \delta_{jk}) \Omega_{ik}^{2,2} \right\}$$

The  $\Omega_{ij}^{1,1}$ ,  $\Omega_{ij}^{1,2}$ ,  $\Omega_{ij}^{1,3}$ ,  $\Omega_{ij}^{2,2}$  and the  $C_i$ 's are functions of  $T$ , and together with the  $m_i$ 's they comprise input data for the problem.

Solutions are found for both sets of equations by evaluating  $n+1$  determinants and using Cramer's rule. Once solutions are found for a given set of data at a given temperature the results are combined according to the relations:

$$n = n_o KT \sum_{j=1}^n \frac{C_j v_j}{C}$$

$$K = \frac{15R^2 T}{v_o} \sum_{j=1}^n \frac{C_i}{m_j} h_j$$

Use was made in the coding of the fact that  $\Omega_{i,e}$  are symmetric. The code has been checked out and can handle mixtures of gases containing up to eight different components.

1102-40-5126/56-172 NUMERICAL EVALUATION OF SPECIAL INTEGRAL EXPRESSIONS  
Origin and Sponsor: Diamond Ordnance Fuze Laboratory, Department of the  
Army

Manager: L. Joel

Full task description: Jan-Mar 1956 issue, p. 29

Status: Continued. Code is being checked.

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

Origin and Sponsor: Public Health ServiceManager: S. PruschFull task description: Jan-Mar 1956 issue, p. 29Status: Terminated. Inability at the present time to transfer data from cards to wire caused a delay which would have outdated the survey data.

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

Origin and Sponsor: NBS, Section 12.5Manager: G. H. UrbanFull task description: Jan-Mar 1956 issue, p. 30Status: Continued. Coding of the NBS payroll on UNIVAC was continued for the first month of the quarter. It was then decided to continue the study of a model Government payroll on a high speed computer by assisting the National Security Agency in the application of their payroll to a punched card machine. Preliminary planning and flow charting of their payroll had been done by the NSA prior to this time. Detailed flow charting was then begun for file maintenance, leave records, gross and net pay calculations, and reports. Ninety percent of the flow charting has been completed and coding has begun.

## 1102-40-5126/56-179 NORMAL PROPAGATION CONSTANT

Origin and Sponsor: NBS, Section 82.10Manager: H. H. Howe (82.10)Objective: To compute the intensity and phase of a low-frequency radio wave propagating to great distance. The ionosphere is assumed to be sharply bounded.

The ionosphere and earth are considered as a wave-guide, and all significant modes are to be calculated. Five parameters are involved namely,

H, the height of the ionosphere in wave lengths,

K, the dielectric constant of the ground, relative to that of free space,

G, the ratio of the displacement current in air to the conduction currents in the ground,

$$L = \frac{(\text{collision frequency in ionosphere}) \times (\text{angular frequency of wave})}{(\text{plasma frequency in ionosphere})^2}$$

n, the node number.

$R_g$ , the reflection coefficient at the ground, is to be found from the  $R_g$  formula;

$$R_g = \frac{(KG-i) c - \sqrt{KG^2 - iG - G^2 + c^2 G^2}}{(KG-i) c + \sqrt{KG^2 - iG - G^2 + c^2 G^2}} \quad (1)$$

$R_s$ , the reflection coefficient at the ionosphere, is to be found from

the same formula, only replacing K by l and G by L. In the flat earth approximation, c, "cosine of the reflection angle," is found by iteration from the following formula:

$$c = \frac{n}{2H} - i \frac{\log R R_s g}{4\pi H} \quad (2)$$

where some fixed rule is adopted regarding which value of the log is used, and where n takes on various integral values. When a value of c is found satisfying these equations, the propagation constant s is found from:

$$s = \sqrt{1 - c^2} \quad (3)$$

Two different spherical corrections are used. In the first, the right side of (2) is multiplied by  $c^2/(c^2 - .005)$ . In the second, it is multiplied by  $\sqrt{c^2/(.99 c^2 + .01)}$ .

Background: In order to study the behavior of ratio atmospherics and other low-frequency radiation, it is convenient to represent the field as the sum of modes. At very low frequencies, only the mode of order zero is significant, since the higher-order modes are rapidly attenuated, as shown by a large negative coefficient of the imaginary part of s.

Status: New. In the first part, flat-earth computations were made for  $H = .05, .1, .2, .5, 1, 2, 3$ ;  $n = 1, 2, 3, 4$ ;  $G = 0, .001, .1$ ;  $L = .1, .2, .5, 1, 2, 5, 10$ ;  $K = 15$ .

The code was then revised so that the parameters were G/H and L/H instead of G and L, these being suited for study of results at varying frequencies. Flat-earth computations were made for  $H = .05, .2, .5, 1(1)12$ ;  $G/H = 0, .00001, .0001$ ;  $L/H = .01, .02, .05, .1, .2, .5, 1$ ; n from 1 to 11, unless the imaginary part of s became less than -0.1. In addition, computations were made for the same values of H and n, for  $G/H = .0001, L/H = .05$  only, for  $K = 1$ ; and also for  $K = 15$  with the two spherical-earth formulas.

This phase of the work is considered complete except for studying certain anomalies which arose: (1) The arbitrary rule about which value of the Log to use apparently lost the zero mode. (2) For high H and G, the values for  $n = 1$  came out as  $c = 0$ , which seems to be an error, as it shows a discontinuity from neighboring values.

#### 1102-40-5126/56-181 COULOMB WAVE FUNCTIONS

Origin: Yale University

Sponsor: Atomic Energy Commission

Manager: M. Abramowitz

Objective: To compute the Coulomb wave functions  $F_L, F'_L, G_L, G'_L$ , for specified values of  $\rho, \eta, L$ .

Background: These functions arise for the values requested in problems of interaction of charged nuclear particles in connection with a project underway by G. Breit at Yale University. The SEAC program for computing tables of the functions is to be employed (see task 1102-40-1110/47-2,

p. 7).

Status: Completed (New). Tables were computed for

$\eta = 8.127,$	$L = 0,1,$	$\rho = 4.9(.2)21.5;$
$\eta = 8.004,$	$L = 0(1)8,$	$\rho = 5.6(.2)23;$
$\eta = 6.999,$	$L = 0(1)15,$	$\rho = 6.4(.2)28;$
$\eta = 6.153,$	$L = 0(1)20,$	$\rho = 7.2(.2)32;$
$\eta = 5.772,$	$L = 0(1)21,$	$\rho = 7.8(.2)32;$
$\eta = 5.7048,$	$L = 0,1,$	$\rho = 5(.25)20;$
$\eta = 5.5133,$	$L = 0,1,$	$\rho = 5.1737(.25868)20.6946;$
$\eta = 4.1762,$	$L = 0,1,$	$\rho = 5.4822(.27411)21.9826.$

The results were transmitted to Professor Breit.

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

Objective: To analyze the voltage gain of the first stage of an n-stage transistor amplifier. The voltage gain is to be calculated as a function of various parameters, including the number of stages following the first stage, the loading between the stages, the frequency input, and different equivalent circuits for the transistor.

Background: The problem was designed by C. W. Durieux of the Diamond Ordnance Fuze Laboratories as an experiment in the use of the electronic computer for the solution of electrical network problems by matrix methods.

Status: New. Since SEAC does only real calculations, each 2x2 complex matrix was transformed into a real 4x4 matrix where the complex element  $a+bi$  is represented by a 2x2 submatrix:

$$\begin{pmatrix} a & b \\ -b & a \end{pmatrix}.$$

The subroutine which effects the transformation and those involving the necessary matrix calculations were written for general  $n \times n$  matrices.

It was found that the solution could be stated concisely in terms of matrix algebra, but that the numerical calculations involved are very cumbersome. In general, it may be said that the performance of transistors in various types of circuits can be determined in this manner. As a specific problem video amplifiers were analyzed.

The results of the first problem were transmitted to the sponsor.

## 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) Flame spread along interior finishes: analysis of factorial experiments, use of logarithmic transformation, for D. Gross, Fire Protection Section.

(2) Standard samples for alloys: analysis of a number of data from chain block design, analysis of homogeneity data, for R. E. Michaelis, Spectrochemistry Section.

(3) Strength of glass: analysis of data, for M. J. Kerper, Refractories Section.

(4) Temperature compensation of watches: analysis of data, for H. A. Bowman, Mechanical Instruments Section.

(5) Measurement of sugar color: analysis of rankings, for V. R. Deitz, Surface Chemistry Section.

(6) Acceptance tests for computers: properties of sequential tests for binomial parameters when incorrectly applied, for R. D. Elbourn, Application Engineering of Data Processing Systems.

(7) Heat of combustion of fuels: method of production of heat of combustion from other properties, for G. T. Armstrong and R. S. Jessup, Thermodynamics Section.

(8) Calibration of mirrors: estimation of parameters from non-orthogonal data, for W. S. Sanders, Engineering Electronics Section.

(9) Opacity of paper: revision of testing procedures, for H.K. Hammond, Photometry and Colorimetry Section.

(10) Reading errors arising in use of balances: devised method for estimating, for L. B. Macurdy, Mass and Scale Section.

(11) Stress of paper: application of extreme-value theory to analysis of data for specimens of different length, for T. Lashoff, Paper Section, and J. Mandel, Testing and Specifications Section.

(12) Prediction of octane number from cetane number: determination of best fitting equation, for F. L. Howard, Engine Fuels Section.

Statistical analyses were made on SEAC for E. K. Plyler and H. C. Allen, Radiometry Section; for M. D. Burkland, Sound Section; for R. S. Jessup, Thermodynamics Section; for R. W. Johnston, Radiation Instruments Branch; for R. S. Marvin, Rubber Section; and for P. Hidnert,

## Length Section.

W. S. Connor, C. Eisenhart, and Joan R. Rosenblatt visited the NBS Boulder Laboratories, May 14-16. Conferences were held with (1) E. L. Crowe (Statistician in the Director's Office), on his statistical advisory and consultation services at NBS Boulder; (2) R. E. McGavin (Tropospheric Propagation Research Section), on the effect of propagation path and grazing angle on reflection coefficients of radio propagation over irregular terrain; (3) H. A. Thomas and W. F. Snyder (Radio Standards Division), on the scope and program of the new Calibration Center, and on the measurement and specification of the reliability of electronic equipment; (4) R. S. Kirby (Tropospheric Propagation Research Section), on the new analysis of the radio ground conductivity data, and on radio field strength measurement surveys; (5) K. A. Norton (Radio Propagation Engineering Division), on a mathematical model of atmospheric turbulence with respect to refractive index at radio frequencies; (6) R. Silberstein (Upper Atmosphere Research Section), on application of power-spectrum and autocorrelation techniques to radio propagation high-frequency measurements; and (7) A. H. Shapley, J. V. Lincoln, and others of the Upper Atmosphere Research Section, on statistical problems involved in forecasting radio weather. The visitors also gave the following talks: (1) C. Eisenhart, "Randomization in experimentation," May 14; (2) Joan R. Rosenblatt, "Unassuming statistical techniques," May 15; (3) W. S. Connor, "Experiments with many factors," May 16.

W. S. Connor also spoke on "Experiments with many factors" at the Atomic and Radiation Physics Division Staff Meeting, June 15.

## Publications:

- (1) National physical standards and design of experiments. W. J. Youden. To appear in *Revue de l'Institut International de Statistique* (The Hague).
- (2) More scientists. W. J. Youden. Submitted to a technical journal.
- (3) A simplified calibration of platinum versus platinum-rhodium thermocouples. B. E. Squire (NBS Temperature Measurements Section) 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 statistically selected sub-sample was taken from ship steel plates chosen from current production for use in a number of physical tests. The determination of the transition temperature by the Charpy v-notch test commonly requires several specimens run at a number of different temperatures. In this study 36 specimens (four



specimens for each of nine temperatures) were required and their location on the steel plate extended from the edge to the center of the plate. A balanced incomplete block design with three specimens per block was employed to eliminate trends across the plate in case such heterogeneity exists in the plate.

Extensive analyses were made of the results of a number of such tests, with special attention focused on the details of the measurement process.

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: COMPLETED. A report giving a collection of formulas for computing probabilities from common statistics was submitted to the sponsor.

A table of a function related to problems of diffusion in the atmosphere was computed on SEAC. A code for combining effects from several sources using this function was prepared.

Publication.

- (1) 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, Washington, D. C., October 1955.

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. W. S. Connor, C. Eisenhart, and Joan R. Rosenblatt visited the Colorado Plateau District offices of the U. S. Geological Survey during the period May 17-22, to confer with T. Botinelly, W. L. Newman, A. T. Miesch, and E. M. Shoemaker on statistical problems

connected with the Distribution of Elements project. The discussion centered on the geologic uses and usefulness of so-called "semi-quantitative" spectrographic methods of analysis for chemical constituents of rocks. Particular attention was given to the dissimilarity of the methods of reporting results of such analyses employed by the Denver and Washington laboratories of the USGS, and to the recent proposal from Washington for achieving uniformity in reporting. Other topics considered were (a) the statistical analysis of data from singly and doubly truncated bivariate distributions, and (b) the application of multiple and partial correlation techniques in studying relationships between chemical composition and size of uranium deposits. Discussions were held also (a) with F. G. Poole, on the recording procedures and methods of analysis of directional data on cross-bedding dip in various formations of Colorado Plateau and neighboring regions; and (b) with W. Thordarson and J. H. Stewart on the collection and contingency-table analysis of pebble samples. Messrs. Poole and Thordarson demonstrated their field sampling techniques on a near-by Burro Canyon outcrop.

While at Grand Junction, the visitors gave the following talks: (1) Joan R. Rosenblatt, "Unassuming statistical techniques," May 18; (2) C. Eisenhart, "Some canons on sound experimentation," May 21; and (3) W. S. Connor, "Components of variance," May 21. Dr. Connor and Dr. Eisenhart devoted May 19 to a most instructive field trip under the guidance of E. M. Shoemaker, down the Unaweep Canyon to Gateway, up the Dolores and Sam Miguel River Valleys to Uravan, and over Club Mesa to Paradox Valley, visiting a number of uranium mines and deposits en route.

Dr. Connor and Dr. Eisenhart participated in the Clinic on Statistical Problems in Geology sponsored by the Committee on Statistics in Geology, Geologic Division, USGS, at the Denver Federal Center, May 22. Advice was given on the following: (1) A multi-factor field experiment having to do with chemical content of rocks in Hawaii, presented by F. Lotspeich, Geochemical Exploration Branch; (2) comparison and evaluation of 20 field methods of chemical analysis used in geochemical exploration, presented by J. H. McCarthy, Geochemical Exploration Branch; (3) design of experiment on uranium content as a function of stratigraphic positions and distance from known ore bodies, presented by L. Huff, F. Lesure, and A. J. Froelich, Geo-chemical Exploration Branch; (4) evaluation of correlation coefficients between chemical constituents of rock when "0" (absent) and "Tr" (trace) values are involved, presented by R. C. Kepferle, Fuels Branch; and (5) a similar problem presented by R. Jones, Geochemistry and Petrology Branch. Following the Clinic, Dr. Eisenhart and Dr. Connor addressed the Denver Pick and Hammer Club on "Some canons of sound experimentation" and "Components of variance," respectively.

W. S. Connor, C. Eisenhart, M. G. Natrella, and J. R. Rosenblatt took part in the Clinic on Statistical Problems in Geology, Geologic Division, USGS, at the GSA Building, Washington, D. C., on May 24. Suggestions were offered on the following: (1) Optimum designs of two-stage sampling procedure for minerals allowing for differential costs, presented by D. Carroll, Geochemistry and Petrology Branch; (2) study of rare elements in coal ash, presented by T. Stadnichenko, Geochemistry and Petrology Branch; (3) probability distribution of radioactivity count data, presented by M. Ruben, Geology and Petrology Branch; and (4) design of

sampling grid for contour mapping of regional variation of permeability of rocks, presented by D. Jobin, Mineral Deposits Branch.

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. A draft of the section, "Description, Prediction, and Correlation," has been completed. Drafts of the following sections of Part II, "Some Statistical Techniques for Quantitative Data," have been completed: "Estimating True Proportion or Percentages," "Statistical Tests Concerning Proportions," "Tests of Relationships and Associations."

A tentative final draft of the Introduction, and the first portion of Part I, "Some Statistical Techniques for Quantitative Data," is being reproduced for circulation to various readers for criticism and comment.

APPLICATION  
OF  
NATIONAL BUREAU OF STANDARDS AUTOMATIC COMPUTER (SEAC)

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

<u>Task No.</u>	<u>Title</u>	<u>Code Checking</u>	<u>Productive Operation</u>
NBS:			
1104/55-55	Research in numerical analysis	4	
5116/55-56	Research in mathematical topics applicable to numerical analysis		1
5116/56-148	Study of differential equations for nerve fiber excitation	4	43
1110/47-2	Tables of Coulomb wave functions	7	18
1110/53-51	Radiation diffusion	17	104
5126/52-44	Calculations for d-spacings	2	11
5126/53-29	Dynamic behavior of aircraft structures	3	5
5126/53-52	L-Shell conversion coefficients		27
5126/54-4	High temperature properties of water	5	33
0009/54-17	Depolymerization		19
5126/54-30	Spectrometer analysis	2	
5126/55-53	Electronic functions	9	34
0009/55-65	Automatic coding	5	
5126/55-68	Crystal structure calculations	31	3
5126/55-81	Combining tests for significance	3	5
5126/55-88	Stresses in a wall foundation		5
5126/55-97	High temperature properties of air	4	58
5126/55-118	Thermometer calibrations	2	
5126/55-121	Electron penetration	5	3
5126/55-123	Temperature distribution	2	
5126/55-127	Vibration of a circular disc	4	4
0009/56-131	Ray tracing, II	6	46
5126/56-139	Internuclear potential for H <sub>3</sub>	6	18
5126/56-142	Matrix codes	1	
5126/56-144	Auto correlation	2	1
5126/56-150	Mathematical expression	6	
0009/56-160	Mathematical subroutines	3	
5126/56-166	SCF-LCAO solution of some hydrides	12	2
5126/56-167	Multiple regression	2	
5126/56-171	Collision integrals used in transport theory	15	6
5126/56-179	Normal propagation constant	2	
5126/56-185	Matrix multiplication	16	
5126/56-192	Noise measurement		1
5126/56-194	Standard deviation	1	
5160/55-85	Research in mathematical elasticity	14	65

<u>Task No.</u>	<u>Title</u>	<u>Code</u> <u>Checking</u>	<u>Productive</u> <u>Operation</u>
<u>NBS:</u>			
5160/56-156	Research in mathematical geophysics	18	8
0002/52-1	Statistical aspects of administrative operations	3	13
Misc.	Training	8	2
<u>OTHER:</u>			
5126/51-37	Molecular structure	2	6
5126/53-45	Application of game theory		9
5126/54-13	Award of procurement contracts for linear programming	3	16
5126/55-104	"Fuse" problem		89
5126/55-119	Field rocket problem		1
5126/55-113	Reactor design		2
5126/56-130	Aircraft responses	5	1
5126/56-136	Calculation of wave functions	1	14
5126/56-138	Crystal counter efficiency	1	
5126/56-140	Multiple correlation routines		22
5126/56-151	Cross section measurements		76
5126/56-165	Integral for scattering functions	6	48
5126/56-163	Nuclear scattering	11	5
5126/56-173	Job satisfaction inventory	7	1
5126/56-181	AEC Coulomb wave computations		43
5126/56-184	Transistor amplifier	17	6
5126/56-191	High order polynomials		4
5126/56-193	Continued fraction	1	1

## 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

- MONTROLL, E. W. (University of Maryland and NBS). Applications of the theory of stochastic processes:
1. History, aims and scope of stochastic processes. April 12.
  2. Discrete random processes. April 19.
  3. Continuous stochastic processes. May 10.
  4. Non-linear processes. May 17.
  5. Birth-death processes and renewal theory. May 31.
  6. Queuing and waiting time processes. June 14.

### Applied Mathematics Division Seminar

- BOSE, R. C. (University of North Carolina). (1) A set of incidence matrices arising in a combinatorial problem of experimental design. June 15. (2) A combinatorial problem on matrices with elements from a finite field. June 22.

### Statistical Theory Seminar

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

- COX, D. R. (Cambridge University). Mathematical techniques in queuing theory. April 11.
- SATTERTHWAITE, F. (Rath and Strong, Inc., Boston). A method for planning experiments with a large number of factors. April 25.

### Applied Statistics Seminar

- COX, D. R. (Cambridge University). Quick tests of significance. April 12.

Algebra Seminar

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

- JOEL, L. S. Indefinite quadratic forms. I. April 11; II. April 18.
- MARSH, R. W. (Department of Defense). N-ary quadratic forms. I. April 25; II. May 2.
- HAYNSWORTH, E. Quadratic forms with unimodular circulant matrices. May 9.
- REINER, I. (Institute for Advanced Study, Princeton). Integral matrix solutions of polynomial equations. May 16.
- KREISEL, G. (Institute for Advanced Study, Princeton). A theorem of Artin. May 23.

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

- ALT, F. L. The development of electronic computing equipment. Presented at the Second Institute on Electronics in Management, held by The American University, Washington, D. C., May 14-18.
- CONNOR, W. S. (1) Experiments with many factors. Presented to the staff of the NBS Boulder Laboratories, Boulder, Colo., May 16, and also at an NBS Atomic and Radiation Physics Staff Meeting, June 15. (2) Components of variance. Presented to the staff of the Colorado Plateau District, U. S. Geological Survey, Grand Junction, Colo., May 21, and also to the Denver Pick and Hammer Club, U. S. Geological Survey, Denver Federal Center, Denver, Colo., May 22.
- COOPER, J. W. Adaptation of a problem in thermodynamics to computation by SEAC. Presented at an NBS Thermodynamics Colloquium, May 28.
- EISENHART, C. (1) Randomization in experimentation. Given at a Colloquium of the Department of Mathematics, Carnegie Institute of Technology, Pittsburgh, Pa., May 3. Also presented to the staff of the NBS Boulder Laboratories, Boulder, Colo., May 14. (2) Some canons of sound experimentation. Presented to the staff of the Colorado Plateau District, U. S. Geological Survey, Grand Junction, Colo., May 17, and also to the Denver Pick and Hammer Club, U. S. Geological Survey, Denver Federal

Center, May 22.

- GOLDBERG, K., and M. NEWMAN. Some free groups generated by matrices of order two. Presented by title at the meeting of the American Mathematical Society, New York, N. Y., April 20-21.
- HAYNSWORTH, E. Characteristic roots of matrices. Presented at a meeting of the Mathematics Department of the University of North Carolina, Chapel Hill, N. C., April 3.
- HOFFMAN, A. J. Application of a computer to a particular task. Presented as one of a series of "Eight Lectures on Computers and Automation," sponsored by five professional societies, Washington, D. C., April 4.
- RHODES, I. Machine programming and coding. Presented as one of a series of "Eight Lectures on Computers and Automation," sponsored by five professional societies, Washington, D. C., April 11.
- ROSENBLATT, J. R. (1) On the power of some rank-order two-sample tests. Presented at the Eastern Regional Meeting, Institute of Mathematical Statistics, Princeton, N. J., April 20. (2) Unassuming statistical techniques. Presented to the staff of the NBS Boulder Laboratories, Boulder, Colo., May 15, and also presented to the staff of the Colorado Plateau District, U. S. Geological Survey, Grand Junction, Colo., May 18.
- STONELEY, R. (1) The thickness of the continents: Waves in crystalline media. Presented at a meeting of the Department of Seismology, University of California, Berkeley, Calif., April 2-4. (2) The interior of the earth. Presented at a meeting of the Chemical Society, Washington, D. C., April 12. (3) The thickness of the continents. Presented before the Department of Geology, Princeton University, Princeton, N. J., April 19. Also presented before the Department of Geology, Harvard University, Cambridge, Mass., May 10. (4) The propagation of elastic waves over the surface of a cubic crystal. Presented before the Department of Geology, Massachusetts Institute of Technology, Cambridge, Mass., May 11. (5) On turbidity currents. Presented before the Department of Geology and Geophysics, University of Michigan, Ann Arbor, Mich., May 16.
- SYNGE, J. L. Stationary principles for forced vibrations in elasticity and electromagnetism. Presented at the Eighth Symposium in Applied Mathematics of the American Mathematical Society, Chicago, Ill., April 1956.
- TAUSSKY-TODD, O. Commutativity of finite matrices. Presented at a meeting of the Mathematical Association of America, held at the U.S. Naval Academy, Annapolis, Md., May 5.



- TODD, J. Mathematicians and computers. Presented before the Sigma Xi Chapter, Washington, D. C., April 9.
- WEGSTEIN, J. H. Automatic coding principles. Presented at a Symposium on Advanced Programming Methods for Digital Computers, held by the Office of Naval Research, Washington, D. C., June 28.
- YOU DEN, W. J. (1) Statistical evaluation of analytical data. Presented in the Passaic Valley Lecture Series, Nutley, N. J., April 18. (2) Dice, data, and deductions. Presented to the Rochester Section, Optical Society of America, Rochester, N. Y., May 8. (3) Statistical design and statistical analysis in engineering research programs. Presented at the National Academy of Sciences-National Research Council, Division of Engineering and Industrial Research Meeting, Washington, D. C., May 28. (4) Statistics and engineering research programs. Presented at a joint meeting under the auspices of the National Science Foundation and the American Society for Engineering, University of Michigan, Ann Arbor, Mich., June 21.
- ZEL EN, M. Combining independent tests of significance for incomplete block designs. Presented at a joint meeting of the Biometrics Society and the Institute of Mathematical Statistics, Princeton, N. J., April 21.

# Publication Activities

## 1. PUBLICATIONS THAT APPEARED DURING THE QUARTER

### 1.1 Mathematical Tables

- (1) Electron physics tables. L. Marton and C. Marton (NBS Electron Physics Section), and W. G. Hall. NBS Circular 571 (March 30, 1956). Available from the Government Printing Office, Washington 25, D. C., 50 cents. (Supersedes Part II of NBS Mathematical Table 17, Miscellaneous Physical Tables.)

### 1.3 Technical Papers

- (1) Stable systems of differential equations with integrable forcing term. H. A. Antosiewicz. J. London Math. Soc. 31, 208-212 (1956).
- (2) Some Monte Carlo experiments in computing multiple integrals. P. Davis and P. Rabinowitz. MTAC 10, 1-7 (Jan. 1956).
- (3) A matrix with real characteristic roots. K. Goldberg. J. Res. NBS 56, 87 (Feb. 1956), RP2652.
- (4) The formal power series for  $\log e^x e^y$ . K. Goldberg. Duke Math. J. 23, 13-22 (Mar. 1956).
- (5) Generalizations of identities for the coefficients of certain modular forms. M. Newman. J. London Math. Soc. 31, 205-208 (1956).
- (6) Generation and testing of pseudo-random numbers. O. Taussky and J. Todd. Proceedings of a Symposium on Monte Carlo Methods, held at Gainesville, Fla., 1954, pp. 15-28 (John Wiley & Sons, Inc., New York, 1956).

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The following papers appeared in the Proceedings of the Sixth Symposium in Applied Mathematics of the American Mathematical Society, held at Santa Monica City College, Santa Monica, California, August 26-28, 1953 (McGraw-Hill Book Co., New York, N. Y., 1956):

- (7) The assignment problem. T. S. Motzkin. pp. 109-125.
- (8) Some computational problems in algebraic number theory. O. Taussky. pp. 187-193.
- (9) Machine attacks on problems whose variables are permutations. C. B. Tompkins. pp. 195-211.
- (10) Best approximation polynomials of given degree. J. Walsh. pp. 213-218.

- (11) On the asymptotic transformation of certain distributions into the normal distribution. W. Wasow. pp. 251-259.
- (12) Error bounds for the eigenvalues of symmetric integral equations. H. Wielandt. pp. 261-282.

#### 1.4 Notes

- (1) Linear programming. A. J. Hoffman. (An expository article). App. Mech. Rev. 9, 185-187 (May 1956).

#### 1.5 Miscellaneous items

- (1) Development of automatic computers. F. L. Alt. Appeared in "Electronics in Management," L. H. Hattery and G. P. Bush, editors (The University Press of Washington, D. C., Washington 9, D. C., 1956), pp. 15-21.

### 2. MANUSCRIPTS IN THE PROCESS OF PUBLICATION JUNE 30, 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. To appear as NBS Applied Mathematics Series 48.

#### 2.3 Technical Papers

- (1) A survey of Lyapunov's second method. H. Antosiewicz. To appear in Annals of Mathematics Studies.
- (2) 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.
- (3) Some examples of the use of high speed computers in statistics. J. Cameron. To appear in the Proceedings of the 1955 Conference on the Design, Development, and Testing, Washington, D. C., October 1955.
- (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) A discussion of "Design of corrugated diaphragms" by J. A. Haringx. R. F. Dressler. To appear in the Transactions of the American Society of Mechanical Engineers.
- (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, I. Glicksburg (University of Notre Dame), and A. J. Hoffman. Submitted to a technical journal.
- (11) A note on the normal distribution. S. Geisser. To appear in Annals of Mathematical Statistics.
- (12) On the domain of regularity of generalized axially symmetric potentials. P. Henrici. To appear in the Proceedings of the American Mathematical Society.
- (13) On the representation of a certain integral involving Bessel functions by hypergeometric series. P. Henrici. Submitted to a technical journal.
- (14) Generalization of a theorem of Konig. A. J. Hoffman. To appear in the Journal of the Washington Academy of Sciences.
- (15) Integral boundary points of convex polyhedra. A. J. Hoffman and J. B. Kruskal (Princeton University). To appear in Annals of Mathematics Study 38, "Papers on linear inequalities and related systems."
- (16) On systems of distinct representatives. A. J. Hoffman and H. W. Kuhn (Bryn Mawr College). To appear in Annals of Mathematics Study 38, "Papers on linear inequalities and related systems."
- (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. To appear in the Proceedings of the American Mathematical Society.
- (20) Geological application of extreme-value methods to interpretation of cobbles and boulders in gravel deposits. W. C. Krumbein (Northwestern University) and J. Lieblein. To appear in the Transactions of the Geophysical Union.
- (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) On the existence of identities for the coefficients of certain modular forms. M. Newman. To appear in the Journal of the London Mathematical Society.
- (24) Some theorems about  $P_r(n)$ . M. Newman. Submitted to a technical journal.
- (25) Classes of positive definite unimodular circulants. M. Newman, and O. Taussky. To appear in the Canadian Journal of Mathematics.
- (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) Pitfalls in computation. I. A. Stegun and M. Abramowitz. Submitted to a technical journal.
- (32) The transmission of Rayleigh waves across an ocean floor with two surface layers. R. Stoneley. To appear in the Bulletin of the Seismological Society of America.
- (33) The attenuation of Rayleigh waves with depth in a medium with two surface layers. R. Stoneley and U. Hochstrasser. To appear in

the Geophysical Supplement, Monthly Notices, Royal Astronomical Society.

- (34) 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.
- (35) Elastic waves in anisotropic media. J. L. Synge. Submitted to a technical journal.
- (36) Stationary principles for forced vibrations in elasticity and electromagnetism. J. L. Synge. To appear in the Proceedings of the Eighth Symposium in Applied Mathematics held by the American Mathematical Society, Chicago, Ill., April 1956.
- (37) The torsion of a hollow square. J. L. Synge and W. F. Cahill. Submitted to a technical journal.
- (38) 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.
- (39) Investigations of the properties of corrugated diaphragms. W. A. Wildhack (NBS Office of Basic Instrumentation), R.F. Dressler, and E. C. Lloyd (NBS Mechanics Division). To appear in the Transactions of the American Society of Mechanical Engineers.
- (40) Design of experiments in research and development. W. J. Youden. To appear in the Proceedings of the Office of Ordnance Research Conference on Design and Experiments in Army Research, Development, and Testing, Washington, D. C., October 1955.
- (41) National physical standards and design of experiment. W. J. Youden. To appear in Revue de L'Institut International de Statistique (The Hague).
- (42) Exact tests of significance for combining intra- and inter-block information. M. Zelen. Submitted to a technical journal.
- (43) The analysis of covariance for incomplete block designs. M. Zelen. Submitted to a technical journal.

## 2.5 Miscellaneous items

- (1) Contributions on partially balanced incomplete block designs with two associate classes. W. H. Clatworthy. To appear as NBS Applied Mathematics Series 47.
- (2) Further contributions to the solution of simultaneous linear equations and the determination of eigenvalues. To appear as

Applied Mathematics Series 49.

(3) More scientists. W. J. Youden. Submitted to a technical journal.

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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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