**NATIONAL BUREAU OF STANDARDS REPORT**

8529

# PROJECTS and PUBLICATIONS

# of the

# APPLIED MATHEMATICS DIVISION

A Semiannual Report

January through June 1964


U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

# THE NATIONAL BUREAU OF STANDARDS

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** Located at Boulder, Colorado.

# NATIONAL BUREAU OF STANDARDS REPORT

**NBS PROJECT**
205.0

**NBS REPORT**
8529

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# APPLIED MATHEMATICS DIVISION

## A Semiannual Report

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U.S. DEPARTMENT OF COMMERCE

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# APPLIED MATHEMATICS DIVISION

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** Postdoctoral Resident Research Associate
°° Temporary appointment
***Guest worker
°°°Student trainee

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° Only unclassified material is included in this report.

# Status of Projects

## 1. NUMERICAL ANALYSIS

### RESEARCH IN NUMERICAL ANALYSIS AND RELATED FIELDS
Task 1101-12-11110/55-55

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

Status: CONTINUED. A proof of the fact that a bounded automorphic form of dimension zero is constant has been given by M. Knopp, J. Lehner and M. Newman. An elementary proof for the case of a function was also given.

The 2-dimensional representations of the Hecke groups are being studied by J. Lehner and M. Newman. In particular all 2-dimensional representations of the modular group have been determined.

M. Knopp and M. Newman are studying groups defined by the vanishing of an additive character. For example they show that if $G$ is a subgroup of a free abelian group $F$ of finite rank such that $F/G$ has no elements of finite order, then $G$ can be defined by the vanishing of a suitable additive character on $F$.

K. Goldberg has collected copies of all of the original papers dealing with Hadamard matrices, their construction, generalizations, and applications.

K. Goldberg has investigated the determination of conditions for "associativity" in certain combinatorial operations, i.e. $f(f(x,y), z) = f(x, f(y,z))$ with $f$ a homogeneous polynomial summed over partitions of its degree, and $x$, $y$, $z$ vectors of variables.

S. Haber continued numerical experiments on a modified Monte-Carlo quadrature procedure he had proposed, and obtained results generally conforming to his theoretical estimates. He also worked together with F. Gross on problems relating to fix-points of entire functions.

R. Miech spent the period experimenting with sieves and found proofs of the following assertions: 1) if $f(x)$ and $g(x)$ are polynomials with integral coefficients and $N$ is a positive integer then there is a number $Q$ which depends on the degree of $f(x)g(x)$ such that the number of positive integers $m$ for which $N - g(m) > 0$ and $f(m)$ $n - g(m)$ has at most $Q$ prime factors approaches infinity as $N$ approaches infinity; 2) the number of positive integers $N \leq x$ for which $g(x) - N$ is irreducible is asymptotic to $x$.

F. Gross has completed the following papers: 1) Entire solutions of the functional equation $h(f(z)) = g(z)$ ; 2) On simple sets of polynomials (with E. G. Straus); 3) On compositions of entire functions; 4) Functional equations and fix-points.

F. W. J. Olver is continuing his work in asymptotic expansions under Task 1101-11-11421/63.

Publications:


(1) Weierstrass points of $\Gamma_0(n)$. J. Lehner and M. Newman. Annals of Mathematics, 79, 360-368 (1964).
(2) A complete description of the normal subgroups of genus one of the modular group. M. Newman. American Journal of Mathematics, 86, 17-24 (1964).
(3) Free subgroups and normal subgroups of the modular group. M. Newman. Illinois Journal of Mathematics, 8, 262-265 (1964).
(4) Normal subgroups of the modular group which are not congruence subgroups. M. Newman. To appear in Proc. American Mathematical Society.
(5) Congruence subgroups of positive genus of the modular group. M. Knopp, M. Newman. To appear in Illinois Journal of Mathematics.

(6) Symplectic modular groups. M. Newman and J. R. Smart. To appear in Acta Arithmetica.
(7) Note on the partition function. M. Newman. To appear in American Mathematical Monthly.
(8) Hadamard matrices of order cube plus one. K. Goldberg. Accepted for publication in the Proceedings of the American Mathematical Society.
(9) A note on some quadrature formulas for the interval $(-\infty, \infty)$. S. Haber. Mathematics of Computation, vol. 18, 313-314.
(10) Almost primes generated by a polynomial. R. Miech. To appear in Acta Arithmetica.
(11) Entire functions all of whose derivatives are integral at the origin. F. Gross. To appear in the Duke Mathematical Journal.

## RESEARCH IN MATHEMATICAL TOPICS APPLICABLE TO NUMERICAL ANALYSIS
Task 1101-12-11421/55-56

Origin: NBS Authorized 8/13/54
Sponsor: Office of Naval Research
Manager: Morris Newman
Full Task description: July-September 1954 issue, p. 5

Status: INACTIVE. All manuscripts which had not been published when this project was rendered inactive have been transferred to Task 1101-12-11110/55-55.

## ASYMPTOTIC EXPANSIONS
Task 1101-11-11421/63

Origin: NBS Authorized 9/10/63
Sponsor: U. S. Army Research Office, Durham, N. C.
Manager: F. W. J. Olver
Full task description: July-December 1963 issue, p. 2

Status: CONTINUED. F. W. J. Olver and F. Stenger have completed their investigation of the asymptotic solution of ordinary second-order differential equations in a domain containing an irregular singularity and have evolved a fully satisfactory theory of error bounds. Applications have been made to Bessel functions and confluent hypergeometric functions. An extension of the theory to systems of $n$ first-order equations is now being studied by F. Stenger.

F. W. J. Olver is investigating the application of the theory of error bounds to the development of a rigorous basis for phase-integral methods for second-order differential equations.

Publications:

(1) Error bounds for asymptotic expansions with an application to cylinder functions of large argument. F. W. J. Olver. Proceedings of a Symposium on Asymptotic Solutions of Differential Equations and their Applications (Madison, Wisconsin, 1964). New York: John Wiley (1964).

(2) On the asymptotic solutions of second-order differential equations having an irregular singularity of rank one. F. W. J. Olver. Submitted to a technical journal.

(3) Whittaker functions of large argument. F. W. J. Olver. Submitted to a technical journal.

(4) Error bounds for asymptotic expansions in turning-point problems. F. W. J. Olver. Journal of the Society for Industrial and Applied Mathematics, Vol. 12, No. 1, March 1964, 200-214.

(5) Error analysis of Miller's recurrence algorithm. F. W. J. Olver. Mathematics of Computation, Vol. 18, No. 85, January 1964, 65-74.

## 2. MATHEMATICAL TABLES AND PROGRAMMING RESEARCH

### HANDBOOK OF MATHEMATICAL FUNCTIONS
Task 1102-40-11121/57-216

Origin and Sponsor: National Science Foundation — Authorized 12/27/56
Manager: Irene A. Stegun
Full task description: October-December 1956 issue, p. 10

Status: COMPLETED. The Handbook of Mathematical Functions has been released as Applied Mathematics Series 55 and is available from the U.S. Government Printing Office.

### CURRENT RESEARCH IN THE COMPUTATION LABORATORY
Task 1102-12-11122/63-1999

Origin and Sponsor: NBS, Section 11.2 — Authorized 8/18/63
Manager: Don I. Mittleman
Full task description: July-December 1963 issue, p. 3

Status: CONTINUED. The theory of universal covering surfaces was successfully applied when the number of singularities did not exceed three.

### AUTOMATIC CODING
Task 1102-12-11120/55-0065

Origin: NBS — Authorized 9/29/54
Manager: P. Walsh
Full task description: July-September 1954 issue, p. 11

Status: CONTINUED. Some members of the staff visited several installations throughout the country to observe time shared computing systems in action and to obtain ideas from people experienced in time sharing systems. Further thought was given to the applicability of remote terminals to NBS needs. Some ideas on the quality of service desired from remote terminals were developed. Thought was also given to the type of system which should be developed to maintain the quality of service desired.

## 3. PROBABILITY AND MATHEMATICAL STATISTICS

### RESEARCH IN PROBABILITY AND MATHEMATICAL STATISTICS
Task 1103-12-11131/63-1259

Origin: NBS Authorized 10/1/62
Manager: Joan Raup Rosenblatt
Full task description: July - December 1962

Status: CONTINUED. Roy H. Wampler is continuing the study initiated by Churchill Eisenhart, with the collaboration of Ann D. Smith and John Van Dyke, on the distribution of tolerance interval coverages in sampling from a normal distribution. The tolerance intervals have the form $(\bar{x} - ks, \bar{x} + ks)$, where $\bar{x}$ and s denote the sample mean and standard deviation. Sample size is denoted by n. The following tables have been computed:

(1) Expected values of the coverage P(k,n) where the factors k (computed by Bowker, 1947) are such that with probability $\gamma$ the coverage is at least p. Arguments covered are $\gamma = .75, .90, .95, .99$; $p = .75, .90, .95, .99, .999$; $n = 2(1)10, 12, 15, 20, 30, 61$.

(2) Approximate probability points $P_\alpha(k,n)$ of the coverage of tolerance intervals whose expected coverage is preassigned to be $p_0$ (Wilks, 1941), for $p_0 = .50, .95$; $\alpha = .005, .01, .025, .05, .10, .20, .25, .50, .75, .80, .90, .95, .975, .99, .995$; $n = 2(1)10, 12, 15, 20, 30, 60$.

(3) Approximate probability points and expected values of the coverage of tolerance intervals for certain values of k, $\alpha$, n, namely: $k_1 = .6745$, $k_2 = t_{.50}$, $k_3 = t_{.50}\sqrt{\frac{n+1}{n}}$, $k_4 = 2$, $k_5 = 3$; $\alpha = .005, .50, .995$; $n = 2, 5, 10, 20, 30, 60$; when $t_{.50}$ is the 50% two-tailed percentage point of the t-distribution for n-1 degrees of freedom.

Graphs of the (approximate) cumulative distribution functions and probability density functions of coverages of the Wilks type have been obtained for $p_0 = .50, .95$; $n = 4, 10, 30, 60$.

A study of the behavior of some estimates for the mean and the variance from very small samples (n = 3,4) when one of the sample values is from a contaminating distribution was begun by T. Willke. In 1952 Lieblein derived the distributions of several estimates, such as the mean of the best two out of three, for non-contaminated samples. Since this kind of estimate is used only when some contamination is suspected, this study is meant to find out how well they work for contaminated samples. Both Monte Carlo and analytical methods will be used.

John Van Dyke's paper on "Fitting $y = \beta x$ when the variance depends on x" has been completed. Properties of various weighted least squares estimators for $\beta$ are studied. Estimation of the variance of an estimator of $\beta$, and the effect of the choice of x values are also investigated.

Janace Speckman's paper "Determinations based on duplication of readings" reports the properties of a measuring procedure in which observations are made until two identical values have been obtained, this duplicated value serving as estimate of the mean. The underlying distribution is taken to be normal, with extreme tails truncated. Unless the rounding lattice is very coarse and happens to be advantageously placed, a better estimate of the mean will be obtained from the average of two observations. The study was motivated by the use of the duplication procedure in a test method proposed by the American Society for Testing and Materials.

Thomas A. Willke has completed a paper developing generalized applications of Youden's rank sum test for outliers. The paper has been published together with a table of one-sided percentage points for the test.

H. H. Ku is preparing two chapters for a handbook on Industrial Metrology, sponsored by the American Society of Tool and Manufacturing Engineers. Chapter IC, Statistical Concepts of a Measurement Process, leads up to a discussion of precision and accuracy. A basic kit of tools for the comparison and manipulation of variances is given in Chapter ID, Statistical Analysis of Measurement Data. The use of control chart techniques for monitoring stability is emphasized. Examples are given using calibration data obtained in NBS laboratories.

Publications:

(1) On an extreme rank sum test for outliers. W. A. Thompson, Jr., and T. A. Willke. Biometrika 50, 375-383, December 1963.

(2) A note on a generalized elliptic integral. George H. Weiss. J. Res. NBS-B. (Math. and Math. Phys.) 68B, 1-2, Jan.-Mar. 1964.

(3) Calculation of certain multiple generating functions. George H. Weiss. J. Res. NBS-B. (Math. and Math. Phys.) 68B, 13-15, Jan.-Mar. 1964.

(4) Effects of a distribution of gap acceptance functions on pedestrian queues. George H. Weiss. J. Res. NBS-B. (Math. and Math. Phys.) 68B, 31-33, Jan.-Mar. 1964.

(5) Miscellaneous studies in probability and statistics: distribution theory, small-sample problems, and occasional tables. Statistical Engineering Laboratory. NBS Technical Note No. 238, April 24, 1964.

(6) Determinations based on duplication of readings. Janace A. Speckman. J. Res. NBS-B. (Mathematics and Mathematical Physics) 68B, 49-53, Apr.-June 1964.

(7) Fitting $y = \beta x$ when the variance depends on x. John Van Dyke. J. Res. NBS-B. (Math. and Math. Phys.) 68B, 67-72, Apr.-June 1964.

(8) General application of Youden's rank sum test for outliers and tables of one-sided percentage points. Thomas A. Willke. J. Res. NBS-B. (Math. and Math. Phys.) 68B, 55-58, Apr.-June 1964.

(9) La revolucion Fisheriana en los metodos de experimentacion. W. J. Youden. Estadistica, Journal of the Inter-American Statistical Institute, September 1963. (Translation of "The Fisherian revolution in methods of experimentation", J. Amer. Statist. Assoc. 46, 47-50, 1951.)

(10) Use of general purpose coding systems for statistical calculations. J. M. Cameron and J. Hilsenrath (NBS Equation of State Section). To appear in Proceedings of IBM Symposium on Scientific Computing.

(11) A simple method for calculating orthogonal bases for a vector space and its complement. J. M. Cameron. Submitted to a technical journal.

(12) Estimation for a one-parameter exponential model. Janace A. Speckman and Richard G. Cornell (Florida State Univ.). Submitted to a technical journal.

## MEASUREMENT OF RELIABILITY
Task 1103-12-11130/56-182

Origin: NBS Authorized 3/23/56
Manager: Joan R. Rosenblatt
Full task description: January-March 1956 issue, p. 13

Status: INACTIVE.

## RESEARCH IN MATHEMATICAL PHYSICS AND RELATED FIELDS

Task 1104-12-11141/55-57

Origin: NBS Authorized 9/1/54
Manager: W.H. Pell
Full task description: July-September 1954 issue, p. 27

Status: CONTINUED. The theoretical and experimental study of constitutive relations for continua with non-linear response to applied forces carried on by Dr. B. Bernstein together with E.A. Kearsley and L. Zapas, of Sec. 6.05, has been continued.

As mentioned in July-Dec. 1963 P and P the problem of calculating the response of a material to a given strain history using the Bernstein-Kearsley-Zepas constitutive relation has been considered. Dr. Hansjörg Oser has set up a program for fitting the data from which the response is to be calculated.

Dr. Bernstein and his co-workers have recently concerned themselves with the thermodynamical aspects of visco-elasticity. A thermodynamics has been incorporated into the BKZ theory which includes the isothermal concepts of the elastic fluid but is applicable to non-equilibrium conditions and includes thermal as well as mechanical phenomena. To develop such a thermodynamics, equilibrium is defined as a state free of shear stress. To the usual state variables of thermostatics is adjoined a quantity with dimensions of entropy which depends on the deformation history. This formulation makes possible the precise mathematical description of a material which behaves like an elastic material if investigated on a very short time scale but whose "stored energy" relaxes in time to show fluid-like behavior in the long time limit. The formulation gives a specific calculation of entropy in either equilibrium or non-equilibrium, and shows a monotonic increase of entropy as the material relaxes towards an equilibrium state. It specifically predicts that the temperature will rise if work is done on the material under isochoric and adiabatic conditions and will fall if the material does work under the same conditions. A relation between time and temperature effects is introduced in a general fashion including the case where temperature is a function of time.

There has been time, so far, to check only a few of the characteristics shown by this formulation. All of those checked so far give results in agreement with experience and persuade us that we have here the start of a very general and powerful tool with which to analyze material behavior in a fundamental and useful fashion.

Dr. John Lagnese has conducted an investigation concerning the fundamental solution and Huygens' principle for linear combinations of linear differential operators of second order. A manuscript on this subject has been prepared.

In connection with the question of Huygens' principle, Dr. Lagnese has proved that Hadamard's conjecture is true in a certain extended sense for the class of operators of the form

$Lu = u_{tt} - \sum_{i=1}^{n} u_{x_i x_i} + c(t)u$. A manuscript concerning this result is in preparation.

Drs. J.H. Bramble and L.E. Payne completed their study of a priori pointwise bounds for the problem of the elastic plate with mixed boundary conditions. The plate boundary was supposed to consist of disjoint arcs $\Sigma_1$ and $\Sigma_2$, and the plate to be simply connected. Three problems were considered:

a) $u$, $\partial u/\partial n$ given on $\Sigma_1$; $u$, $M(u)$ on $\Sigma_2$

b) $u$, $\partial u/\partial n$ given on $\Sigma_1$; $M(u)$, $V(u)$ on $\Sigma_2$

c) $u$, $M(u)$ given on $\Sigma_1$; $M(u)$, $V(u)$ on $\Sigma_2$

where $M(u)$ and $V(u)$ are essentially the edge bending moment and shear, respectively.

Study is currently under way on the properties of Green's functions, with the aim of obtaining explicit bounds for the Green's function and its normal derivative for the Dirichlet problem for general second order elliptic equations and various domains.

Dr. Payne presented to the May colloquium of Div. 6 a survey of the methods he and Dr. Bramble have developed for the establishment of a priori bounds for the solution of boundary value problems of mechanics.

Dr. W.H. Pell has been collaborating with Mr. A. Kirstein, of Sec. 6.04, on a comparison of the theory of deflection of elastic plates supported and loaded by point loads with experimental results obtained by Mr. Kirstein. In the cases thus far considered, theory and experiment are in excellent agreement.

Publications:

(1) Thermodynamics of perfect elastic fluids. B. Bernstein, E.A. Kearsley, and L.J. Zapas. Submitted to Journal of Research, Section B, Math. and Math. Physics.

(2) A new differential operator of the pure wave type. J.E. Lagnese. To appear in Contributions to Differential Equations.

(3) On Rayleigh's non-linear vibration equation. A. Ghaffari. Proceedings of the International Symposium on Non-Linear Vibration, Kiev, USSR, September 12-18, 1961, Vol. II, pp. 130-133.

(4) Inequalities for solutions of mixed boundary value problems for elastic plates. J.H. Bramble and L.E. Payne. Journal of Research NBS, 68B, pp. 77-92, 1964.

(5) The effect of error in measurement of elastic constants on the solutions of problems in classical elasticity. J.H. Bramble and L.E. Payne. Journal of Research Section B, Math. Math. Physics, Vol. 67, pp. 157-168, July-Sept. 1963.

(6) Pointwise bounds in the first biharmonic boundary value problem. J.H. Bramble and L.E. Payne. Journal of Mathematics and Physics, Vol. 42, No. 4, pp. 278-286, 1963.

## PLASMA RESEARCH
## Task 1104-12-11140/59-422

Origin: NBS Authorized 6/30/59
Manager: C.M. Tchen
Full task description: April-June 1959 issue, p. 15

Status: CONTINUED. Principal activity has been along the lines of research problems reported on in July-Dec. 1963 P and P, i.e., work has been principally in the two areas indicated below.

(1) Stochastic theory of diffusion in a plasma across a magnetic field. A stochastic theory was used to investigate the diffusion across a constant magnetic field for the following cases: (a) diffusion by collision, (b) diffusion by collective oscillations, and (c) diffusion by turbulence. For the cases (a) and (b) a general formula was obtained, which by suitable degeneration could be brought to agree with existing special theories. Such diffusion was found to decrease with the

magnetic field. For the case (c), the diffusion was found to increase in magnitude with the turbulent fluctuations. As the magnetic field plays the role of an external supply of turbulent energy, it broadens the turbulent spectrum and increases the diffusion, contrary to the situation in cases (a) and (b). A paper with the above title was presented at the International Symposium on Plasma Diffusion, Munich, Germany, June 1964.

(2) Spectrum of magnetohydrodynamic turbulence. Consider a plasma with incompressible, isotropic, and homogeneous turbulence in a uniform magnetic field. The magnetohydrodynamic equations for the velocity and the magnetic field were used, and proceeding therefrom, the equations for the spectra of velocity and magnetic field were derived. The Heisenberg hypothesis was introduced for the formulation of the non-linear terms which were responsible for the transfer of energy in the cascade of modes. The non-linear equations were solved for the inertial and dissipative ranges of spectra. A report on this work is in preparation.

## DYNAMICS OF PLASMAS

### Task 1104-12-11417/62-1157

Origin: NBS
Manager: C.M. Tchen
Full task description: April-June 1959 issue, p. 15

Status: CONTINUED. The investigations of Dr. C.M. Tchen's group on the kinetics of plasmas have continued. Emphasis in this period has been on the numerical aspects of problems, with Dr. K. Hain, Institut für Plasma Physik, Garching, Germany and Dr. W.L. Sadowski aiding Dr. Tchen in this work. Work was concentrated on two areas:

(1) Non-linear damping of waves in a plasma.

This is a continuation of work initiated by Drs. Sadowski and Tchen, and noted in Jan.-July 1963 P and P. The non-linear damping governed by the Vlasov equation is under study. Stability difficulties have been encountered in the numerical integration, but it now appears that these have been overcome.

(2) One-dimensional problems of the interaction of a plasma with a magnetic field.

Two problems were investigated: a) the unsteady and non-linear expansion of a plasma into a vacuum, with a constant magnetic field initially present in the plasma; b) a semi-infinite plasma driven at one end by a time-varying magnetic field. The evolution of the interaction in time was investigated numerically by including transport coefficients. A report on this is in preparation by Drs. Tchen and Hain.

The reports a), b) and c) listed in Jan.-July 1963 P and P are in the process of revision. They are:

a) The Kinetic Equation for Rapidly Varying Plasma,

b) Diffusion of the Correlation Function in a Plasma,

c) Plasma Oscillations with Collective Correlations

## THEORY OF SATELLITE ORBITS

Task 1104-12-11441/62-1166

Origin: NBS — Authorized 1/9/62
Sponsor: National Aeronautics and Space Administration
Manager: J.P. Vinti
Full task description: January-March 1962 issue, p. 12

Status: CONTINUED. Dr. Vinti has derived the connections between the orbital elements in spherical coordinates and in parabolic coordinates for the Kepler problem. This is in preparation for calculating the effect of a uniform gravitational field on an elliptic orbit, which in turn has applications to the effect of radiation pressure on the orbit of an artificial satellite. He is currently working out this problem by perturbational methods, using parabolic coordinates. The problem is the classical analogue of the Stark effect for a hydrogen atom, for which spherical coordinates fail, but for which parabolic coordinates succeed.

Publication:

(1) The spheroidal method in the theory of the orbit of an artificial satellite. J.P. Vinti. To appear in the Proceedings of the Symposium on Celestial Mechanics, held March 1964, at the Mathematisches Forschungsinstitut at Oberwolfach, West Germany.

## HYPERVELOCITY IMPACT

Task 1104-12-11418/63-1373

Origin and Sponsor: Applied Physics Laboratory
Johns Hopkins University — Authorized 4/22/63

Manager: Barry Bernstein

Status: TERMINATED. A formulation of the problem presented by the sponsor has been made which is based on what appears to be a reasonable model of the physical phenomenon under consideration. Only numerical solution of the problem seems feasible, and the work required for this formidable. A careful evaluation of the time required for a machine solution indicated the monetary expenditure with available computers would be orders of magnitude greater than anticipated by the sponsor when the project was initiated. It has therefore been terminated.

## 5. OPERATIONS RESEARCH

### OPERATIONS RESEARCH

Task 1105-12-11115/61-546

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

Status: CONTINUED. The following investigations in various fields of operations research were carried out by members of the staff:

(1) P. Meyers continued research on remetrizing a space so as to make the Banach Contraction Theorem applicable; his results extend and unify those of Janos and Edelstein. A.J. Goldman generalized an inequality due to B.C. Rennie, and subsequently (with J.B. Diaz and F.T. Metcalf, U. of Maryland) showed that the Rennie inequality and its generalization were respectively equivalent to the Diaz-Metcalf inequalities complementing those of Cauchy-Schwarz and of Hölder. A.J. Goldman generalized recursive-function-theoretic results of J. and R.M. Robinson pertaining to the generation of functions, using specified operations, without introducing intermediate functions of unnecessarily many variables. K. Kloss continued his use of the NBS PILOT computer to investigate solutions of the congruences $(p-1)! \equiv -1 \pmod{p^2}$ and $q^{p-1} \equiv 1 \pmod{p^2}$ for primes p and q. He used PILOT to show that for $0 < n \leq 12000$, $8n+3$ is always the sum of a square and twice a prime (thus supporting a conjecture made by Euler). At the suggestion of Dr. G. Howett (NBS Sec. 2.01) he investigated the possibility of generating primes by a formula of the form $f(k) = a_o p_k + a_1 p_{k-1} + \cdots + a_m p_{k-m}$, where $m, a_o, a_1, \ldots, a_m$ are integer constants and $p_i$ denotes the i-th prime.

(2) L.S. Joel and K. Kloss (with G. Stonebreaker and G. McKay of the Institute for Applied Technology) continued work on modelling some aspects of the textile industry; a more specific model based on field interviews was constructed for the production-distribution cycle of a tufted carpet factory. J. Levy began related studies concerning the important parameters of information (cost, value, timeliness, accuracy) at various levels in such an industry. (Reported here for convenience; supported under Project No. 30409.) K. Kloss (with V. DeGutis of the Veterans' Administration) began developing computer procedures for facilitating hospital floor layout, with emphasis on translating architects' assessments, of the relative importance of proximity for different types of functional units, into a specific algorithm. (Reported here for convenience; supported under Project No. 11647).

A.J. Goldman (with B.M. Levin of the Transport Systems Division) is preparing a survey of mathematical and simulation models relevant to transportation research and development. (Reported here for convenience; supported under Project No. 19407). A.J. Goldman, and W. Hall of 11.02, are participating in the Commerce Department's economic analysis of the proposed commercial supersonic transport plane.

(3) C. Witzgall completed a study of mathematical models and concepts relevant to determining that location of a central facility which minimizes the total costs of transportation between it and its customers. One section, excerpted for separate publication, contains a proof that a metric (not necessarily symmetric) defined on a linear space, if convex in each argument separately, must arise from a norm. Dr. Witzgall is now studying a new class of models for efficiently representing urban origin-to-destination travel times.

J. Levy and A.J. Goldman continued investigations of the effects of buffer capacity in a simple mail sorting machine. P. Meyers continued analysis of a stochastic sorting process, and developed a mathematical model for value analysis of a proposed new subsystem of a sorting system. D. Kleinman continued work on the computer simulation of a class of mail sorting devices. A.J. Goldman investigated some mathematical measures of ambiguity for address-coding schemes in mail sorting. (Reported here for convenience; items (3) all supported under Project No. 12450.)

Publications:

(1) A Generalization of Rennie's inequality. A.J. Goldman. Journal of Research NBS, 68B, No. 2, pp. 59-64, 1964.

(2) Examples relating to the simplex method. A.J. Goldman and Daniel Kleinman. Operations Research 12 (Letters to the Editor), No. 1, pp. 159-161, 1964.

(3) Generation and composition of functions. A.J. Goldman. Submitted to a technical journal.

(4) Weak generalized inverses and minimum variance linear unbiased estimation. M. Zelen and A.J. Goldman. Submitted to a technical journal.

(5) On convex metrics. C. Witzgall. Submitted to a technical journal.

(6) Approximating symmetric relations by equivalence relations. C.T. Zahn, Jr. Submitted to a technical journal.

(7) Realization of semi-multipliers as multipliers. Harriet Fell and A.J. Goldman. To appear in Amer. Math. Monthly (Math. Notes).

(8) Barely faithful algebras. Harriet Fell and John Mather. To appear in Amer. Math. Monthly (Math Notes).

## COMMERCIAL REFILE PROBLEM DCA

Task 1105-12-11465/63-1494

Origin and Sponsor: Defense Communication Agency Authorized 6/19/63
Manager: Lambert S. Joel
Full task description: June 19, 1963

Objective: To analyze various instrumentalities of the Defense Communications System and if possible, to determine optimal structure and operational procedures according to appropriately developed cost/ effectiveness/ and feasibility criteria.

Background: The DCS processes a large number of messages to, from, and within the military establishment. It is quite desirable to minimize annual costs while maintaining adequate quality and accuracy of service.

Status: CONTINUED. Two "Integer Program" computer codes were obtained through SHARE (IBM computer users group) and tested with artificially constructed small refile problems (5 candidate, 10 destinations and 6 candidate, 12 destinations). The algorithms failed, running about 10000 iterations without solution and halting after sensing excessive round off error accumulation. A slightly changed formulation of the problems normalizing the equations terminated for the same reason after about 1100 iterations. Three other computer programs were discovered to be in existence but as all are subject to proprietary restrictions they were not obtained for experimentation.

L.S. Joel wrote and tested a Fortran program to determine the feasibility of a particular very simple "hill climbing" or local optimum generating algorithm based on the formulation set up for Integer Programming. The program was refined and expanded using "machine language" (FAP) and is being debugged. Various other approximate methods proposed by C. Witzgall, A.J. Goldman and L.S. Joel were examined and studies leading to computer implementation started.

Joel Levy investigated the relationship between the communication network connecting members of a "team" pursuing a common known objective, and the nature of the feasible policies for the team.

Jack Edmonds investigated extensions of the Shannon "switching game".

## COMBINATORIAL MATHEMATICS

Task 1105-12-11455/62-1205

Origin: NBS Authorized 5/2/62
Sponsor: Army Research Office-Durham
Manager: Jack Edmonds
Full task description: April-June 1962 issue, p. 15

Status: CONTINUED. C. Witzgall continued the preparation, testing, and documentation of computer codes for the maximum matching algorithms.

Edmonds continued the preparation of papers on earlier reported material. He began investigations on the theory of matroids. Matroids embody the "abstract properties of linear dependence". They bear closely on electrical networks, switching functions, matrices, lattices, and projective configurations. One result is that: The columns (elements) of a matrix (matroid) M can be partitioned into as few as k sets each of which is linearly independent, if and only if every subset of the columns (elements) of M has cardinality at most k times its rank.

Publications:

(1) Existence of k-edge connected ordinary graphs with prescribed degrees. Jack Edmonds. Journal of Research NBS, 68B, 1964.

(2) Paths, trees, and flowers. Jack Edmonds. To appear in the Canadian Journal of Mathematics.

(3) On the surface duality of graphs. Jack Edmonds. Submitted to a technical journal.

(4) Maximum matching and a polyhedron with (0,1)-vertices. Jack Edmonds. Submitted to a technical journal.

(5) On matching problems. J. Edmonds, A.J. Goldman, C. Witzgall, and C.T. Zahn, Jr. Presented to the meeting of the Army Research Office Working Group on Computers at NBS, Feb. 5, 1964.

(6) Optimal matchings and degree-constrained subgraphs. A.J. Goldman. Journal of Research NBS, 68B, 1964.

(7) A modification of Edmonds' maximum matching algorithm. C. Witzgall and C.T. Zahn, Jr. Submitted to a technical journal.

1102-40-11645/56-0166 SCF-LCAO SOLUTION OF SOME HYDRIDES
Origin and Sponsor: NBS, Section 5.9 (now Division 15)
Manager: P.J. Walsh
Full task description: January-March 1956 issue, p. 27
Status: TERMINATED.

1102-40-11645/56-0186 MECHANICAL MEASUREMENTS OF GAGE BLOCKS
Origin and Sponsor: NBS, Section 2.5
Manager: B.S. Prusch
Full task description: July-September 1956 issue, p. 33
Status: CONTINUED. Computations were performed to check 42 laboratory sets of gage blocks as requested.

1102-40-11647/58-0266 DEPOLYMERIZATION PROCESSES
Origin and Sponsor: NBS, Section 7.6
Manager: R. Zucker
Full task description: July-September 1957 issue, p. 36
Status: REACTIVATED. Production runs were made and results submitted to sponsor.

1102-40-11645/58-0339 COMPUTATION OF VISCOELASTICITY PROPERTIES OF MATERIALS
Origin and Sponsor: NBS, Section 3.4
Manager: H. Oser
Full task description: January-March 1958 issue, p. 38
Status: CONTINUED. We continued with analysis and computation of various blending laws for creep and stress relaxation of polymer solutions. The program of the Bell Laboratories which computes creep when stress relaxation is given, has been thoroughly tested. In the regions of interest the accuracy is about 1 percent which is better than the experimental accuracy.

1102-40-11645/60-0486 MORSE WAVE FUNCTIONS AND FRANCK-CONDON FACTORS
Origin and Sponsor: NBS, Section 3.0
Manager: Ruth Zucker
Full task description: January-March 1960 issue, p. 28
Status: CONTINUED. Production runs were made and results submitted to sponsor.

1102-40-11645/60-0513 RADIATIVE ENVELOPES OF MODEL STARS
Origin and Sponsor: National Aeronautics and Space Administration
Managers: P.J. Walsh and S. Haber (11.1)
Full task description: July-September 1960 issue, p. 23
Status: INACTIVE.

1102-40-11645/61-0538 SPECTRAL REFLECTANCE
Origin and Sponsor: NBS, Section 9.4
Managers: S. Haber (11.1) and P.J. Walsh
Full task description: October-December 1960 issue, p. 23
Status: INACTIVE.

1102-40-11647/62-1022 CALCULATIONS FOR SPECTRUM OF DIPOLE RADIATION
Origin and Sponsor: Naval Research Laboratory
Manager: R.J. Arms
Full task description: April-June 1958 issue, p. 33
Status: CONTINUED. More results have been submitted to the sponsor.

1102-40-11645/62-1027 NEW SYSTEM
Origin and Sponsor: NBS, Section 11.2
Manager: P.J. Walsh, V. Dantzler, W. Lipton
Full task description: July-September 1961 issue, p. 22
Status: CONTINUED. The ϕMNITAB system was incorporated as a subsystem of the IBM system IBSYS (Version 8). The program written to insert ϕMNITAB under IBSYS should prove to be a useful tool for including similar systems under the IBSYS framework.

Version 10 of IBSYS was released by IBM and will replace the current version sometime in July. Reassembly of the IBSYS supervisor was required and an accounting routine was inserted into this version. The 1410 program, BϕSS, required modifications to be compatible with this version of IBSYS. Some library subroutines, which were written at the University of Chicago, will also be inserted into this IBSYS system.

The number of users of IBSYS at NBS has increased over this period and it is hoped that this increase will continue as newer programming features are made available in current and future versions of the IBSYS system.

The Stanford University Algol Compiler (SUBALCϕM) was obtained and some experimental runs are being set up. This system compiles programs written in SUBALGϕL, Stanford University's algorithmic language. This language is an extension of the Burrough's Algebraic Language, BALGϕL.

1101-12-11416/62-1091 BOUNDS FOR EIGENVALUES
Origin: Wright-Patterson AFB
Manager: H. Oser
Full task description: October-December 1961 issue, p. 4
Status: COMPLETED. The investigations about the relaxation of a Lorentz gas were completed. Eigenvalues and eigenfunctions of the second-order differential operator were determined up to order 10 for 4 different values of the force parameter s in the $r^{-s}$ - force law.

Publication:

(1) On the relaxation of a Lorentz gas under an $r^{-s}$ force law. H. Oser, K.E. Shuler and G.H. Weiss. To appear in J. Chem. Physics.

1102-40-11647/62-1130 FALLOUT SHELTER COMPUTATIONS
Origin and Sponsor: Office of Civil Defense
Manager: W. Hall
Full task description: October-December 1961 issue, p. 25
Status: CONTINUED. Modifications have been made in programs and procedures to enable lowering of the minimum protection factor to 10 rather than the previously used value of 20. Other changes were made in output format and to distinguish between first and second generation data items. Second generation data are being processed.

1102-40-11647/62-1155 MORTGAGE LOAN SURVEY
Origin and Sponsor: Federal Home Loan Bank Board
Manager: Ruth Zucker
Full task description: January-March 1962 issue, p. 24
Status: COMPLETED.

1102-40-11647/62-1178 LOGARITHMIC COEFFICIENTS
Origin and Sponsor: NBS, Section 5.3
Manager: R.J. Arms
Full task description: January-March 1962 issue, p. 27
Status: INACTIVE.

1102-40-11647/62-1179 CATALOGUE INFORMATION
Origin and Sponsor: HDL
Manager: Ruth Varner
Full task description: January-March 1962 issue, p. 27
Status: INACTIVE.

1102-40-11647/62-1189 SEQUENTIAL METHODS TABLES
Origin and Sponsor: Quartermaster Research and Engineering Field Evaluation Agency, U.S. Army
Manager: R.J. Arms
Full task description: April-June 1962 issue, p. 26
Status: CONTINUED. Production runs have been completed up to the amount of available funds. More funds are needed for completion of the project.

1102-40-11647/62-1193 SOLUTION TO SECOND ORDER PARTIAL DIFFERENTIAL ELLIPTIC EQUATIONS
Origin and Sponsor: NBS, Section 3.8
Manager: P.J. Walsh
Full task description: April-June 1962 issue, p. 28
Status: INACTIVE.

1102-40-11647/62-1196 HEAT OF ADSORPTION
Origin and Sponsor: NBS, Section 15.2
Manager: Ruth Varner
Full task description: April-June 1962 issue, p. 29
Status: INACTIVE.

1102-40-11647/62-1203 CYLINDRICAL SHOCK WAVE
Origin and Sponsor: NBS, Section 3.7
Managers: Sally Peavy and S. Haber
Full task description: April-June 1962 issue, p. 30
Status: INACTIVE.

1102-40-11647/62-1212 COLOR DIFFERENCES
Origin and Sponsor: NBS, Section 10.9
Manager: J.D. Waggoner
Full task description: April-June 1962 issue, p. 33
Status: COMPLETED.

1102-40-11647/63-1240 SECRET SERVICE FORGERY PROJECT
Origin and Sponsor: Treasury Department, U.S. Secret Service
Manager: M. Paulsen
Full task description: July-December 1962 issue, p. 33
Status: CONTINUED. A new scheme of output was found to be advisable in matching coded information found in signatures of forged government checks. This involved making many changes in the original output program. Two sets, of about 200 forged checks each, have been submitted and the requested information given to the sponsor.

1102-40-11647/63-1355 STUDY OF ELECTRONIC ENERGY BANDS IN THE RUTILE CRYSTAL
Origin and Sponsor: NBS, Section 13.4
Managers: P.Walsh and A. Gregg
Full task description: January-June 1963 issue, p. 26
Status: TERMINATED. Production runs were made and the results have been submitted to the sponsor. These results will be published.

1102-40-11647/63-1368 HEART DISEASE CONTROL
Origin and Sponsor: Public Health Service
Manager: Sally Peavy
Full task description: January-June 1963 issue, p. 27
Status: COMPLETED. Program given to sponsor.

1102-40-11647/63-1377 WISKER GROWTH IN A VAPOR ATMOSPHERE
Origin and Sponsor: NBS, Section 8.5
Managers: H. Oser and J.A. Simmons (8.5)
Full task description: January-June 1963 issue, p. 28
Status: REACTIVATED. The problem was analyzed again and refined techniques for the iterative solution of the system of integral equations were designed. A computer program was written by Miss Maxine L. Paulsen and Walter Lipton. This program is currently being checked out.

1102-40-11647/64-1410 INTEGRO-DIFFERENTIAL EQUATIONS
Origin and Sponsor: Institute for Defense Analysis
Manager: R.J. Arms
Full task description: July-December 1963 issue, p. 16
Status: INACTIVE.

1102-40-11647/64-1415 SINGLE CRYSTAL DATA
Origin and Sponsor: NBS, Section 5.6
Manager: D.I. Mittleman
Full task description: July-December 1963 issue, p. 16
Status: TERMINATED. The program will be handled directly from the Office of Standard Reference Data.

1102-40-11647/64-1442 COLFACS Authorized 3/30/64
Origin and Sponsor: HEW
Managers: Ruth Zucker and J.D. Waggoner
Objective: To edit and prepare a series of tables relating to status and career orientations of college faculty 1962-63. Two profiles containing numerous fields such as age groups, sex, rank, student level taught most, salary status, type of institute, etc. are to be cross tabulated with other fields with controls on numerous fields. Weighted tallies and percent are to be obtained for the various tabulations. Also median and averages where salary tables are computed.
Background: The need for reliable and current information on college faculty is widely felt throughout the educational field. It is generally recognized that this decade will be a period of rapid expansion in higher education. This survey is an effort to help fill some of the gaps in knowledge about faculty. The survey was conducted by questionnaires to a selected sample of voluntarily participating individuals. 13017 questionnaires were received. The problem was transmitted by Kenneth G. Nelson, HEW.
Status: NEW. Editing and correlation codes were written and checked out. Tables were run and submitted to the sponsor.

1102-40-11647/64-1450 GLASS BEAD DATA Authorized 3/24/64
Origin and Sponsor: NBS, Section 10.7
Manager: R. Zucker
Objective: See January-March 1961 issue, p. 22, PARTICLE SIZE CALCULATIONS. The above task is a continuation of the previous project with slight modifications.
Background: Modifications were introduced to take care of change in the microscope calibration factor.

In order to estimate the effect of certain measurement errors on the calculated distributions and parameters, simulated errors were introduced and the results recomputed for a group of 1000 beads.

There were three individual runs based on the following assumptions.

a) Assume the diameter of each bead was in error by 0.3 micron.
b) Increase the bubble diameter of each bead by 6 %.
c) Eliminate all imperfect beads from a group of data.

The Stoke's law distributions were originally calculated for water, having a density of 1.00 g/ml and air, having a neglible density in comparison with the beads. Computations were also made for Stoke's law distributions in media of different densities.

Several groups of 1000 beads were involved in the above calculations.
Status: REACTIVATED.

1100-12-11404/64-1456 RESEARCH ON A PICTURE LANGUAGE MACHINE Authorized 5-1-61
Origin: NBS
Sponsor: National Science Foundation
Manager: Russell A. Kirsch
Full task description: July-December 1963 issue, p. 17

Status: CONTINUED. The technique of syntax direction for interpreting syntactically described information sources was investigated by R. A. Kirsch. The technique which was developed for natural language sources has been partially extended to include schematic pictures.

W. C. Watt developed a computer algorithm capable of generating and analyzing a large body of English sentences which describe pictorial images.

1100-12-11404/64-1456 RESEARCH ON BIOLOGICAL PATTERN DATA PROCESSING Authorized 1-21-64
Origin: NBS
Sponsor: National Institutes of Health
Manager: Russell A. Kirsch

Objective: To investigate computer techniques for processing biological patterns. Specific attention is to be given to three kinds of techniques: 1. Those for analyzing images to produce quantitative data; 2. Those for synthesizing (schematic and diagrammatic) images for visual consumption; and 3. Those for associating linguistic descriptions with the articulated part of the images they describe. Photomicrographs (of brain tissue) are to be automatically processed with these three kinds of techniques in order to study, by simulation, the specific future machines for implementing such processing.

Status: NEW. A preliminary feasibility study has produced a grammar for a fragment of English including statements, questions, and processing commands pertaining to brain tissue photographs. A picture processing language, PAX, from the University of Illinois has been set up and experimented with on the 7094. Automatically scanned and quantized images of brain tissue have been analyzed in PAX.

1102-40-11647/64-1466 GREENBRIER CLINIC PROJECT Authorized 1/26/64
Origin and Sponsor: HEW
Managers: M. Paulsen and W. Hall
Objective: To take the data from approximately 60,000 cards having many multi-punched columns and convert it into a form that could be used by regular EDP equipment.
Background: This medical examination data was taken at Greenbrier Clinic, White Sulphur Springs, West Virginia. Initially the data was put on porta-punch and mark sense cards but later all this data was transferred to standard type punch cards. There were 3274 patients having at least one and as many as eleven examinations. There were in all 10,146 examinations (6 cards each) and 195 deaths (1 card each) or a total of 61,071 cards involved.
Status: COMPLETED. An elaborate edit routine was written to do a column by column check, certain checks between columns, checks for missing cards within an examination, missing examinations, duplicate cards and various other checks that could be applied. All information that could be converted to a usable form was (a card having a wrong number, that is other than 1 to 6 or death - could not, because there was no way to know which of the 7 different convert-edit routines should be used.) The printed information from the edit portion of the routine indicates any incorrect information found in the converted data. The converted data consists of a 206 word record for each examination (including the death examinations - which just has more filler.)

The 61,071 cards submitted were put on tape and sorted. This tape was used as input to the above mentioned routine. The objective has been accomplished - the edited, converted, expanded data is now on two magnetic tapes in a form that can be used in various medical studies by the HEW Department on regular EDP equipment.

1102-40-11647/64-1479 NUCLEAR QUADRUPOLE Authorized 6/8/64
Origin and Sponsor: NBS, Section 13.4
Manager: P. Walsh
Objective: To determine the solution to the problem of nuclear quadrupole splitting of Zeeman energy levels of a nucleus in the region where perturbation theory does not converge sufficiently rapidly. The program is suitable for all nuclear magnetic resonance studies but is most useful when one principle axis can be determined experimentally, which is the present case of interest. The program is being used currently to fit the spectra observed in potassium azide.

The problem is to find the eigenvalues and eigenvectors of the Hermetian matrix J of order (2I+1) defined below.

1) Diagonal Elements

$$\frac{Aq}{4I(2I-1)} \left(3m^2-I(I+1)\right) - m\,Ah\cos\theta$$

2) One-Above Diagonal

$$\frac{-Ah}{2} \sqrt{I(I+1)-m(m+1)} \sin\theta\, e^{-i\Phi}$$

3) Two-Above Diagonal

$$\frac{Aq\,\eta}{8I(2I-1)} \sqrt{I(I+1)-m(m+1)} \sqrt{I(I+1)-(m+1)(m+2)}$$

4) All other elements are zero.

I, Aq, Ah and $\eta$ are input parameters. m assumes the value I on the first row of the matrix and decreases by 1 for successive rows.

$$\Phi = \Phi_o(\Delta\Phi)\ \Phi_n$$
$$\theta = \theta_o(\Delta\theta)\ \theta_m$$

The differences of the eigenvalues are calculated and plots of these differences against $\theta$ are obtained.
Background: The general solution of the secular equation of the Hamiltonian describing Zeeman and quadrupole interactions has been previously done only for very special values of the parameters. The present experimental work required an exact solution of the secular equation.
Status: NEW. The Hermetian matrix described above was changed to a real symmetric matrix of twice the given order. A program was written to generate the matrix from input parameters, calculate the eigenvalues and eigenvectors, difference the eigenvalues and plot these differences against the range of $\theta$ values. The program has been checked out and production runs were submitted to the sponsor. Production runs are being conducted under the sponsor's direction.

1102-40-11647/64-1488 INTERPLANETARY CALCULATIONS Authorized 1/28/64
Origin and Sponsor: NASA
Manager: J. Arms
Objective: To assist in the development of a program for the simulation of interplanetary trips subject to a family of input parameters. The problem was submitted by Dr. Stanley Ross of NASA.
Background: Plans of interplanetary travel require the investment of large amounts of man years and funds. With the help of a computer trip simulation program it is hoped that some planning costs will be reduced.
Status: NEW. Programming has begun. Parameter looping codes are in the process of checkout. Some trip simulations have been made.

1102-40-11647/64-1501 SPACE INVENTORY Authorized 2/20/64
Origin and Sponsor: NBS, Section 50.0
Managers: P. O'Hara and J. Wilkinson
Objective: To prepare an inventory that shows the location and usage of all rooms at NBS, Washington. Summaries are required by building, division, and usage code.
Background: Part of this task was formerly run by the Accounting Division on standard IBM equipment. In order to prepare additional reports with fewer machine passes it was decided to program the job for the IBM 1410.
Status: NEW. COMPLETED. The 1410 program has been checked out and one production run has been completed. Future runs will be made by the sponsor.

1102-40-11647/64-1511 AUTOMATIC FILING SYSTEM Authorized 3/16/64
Origin and Sponsor: International Commerce
Manager: W. Hall
Objective: To aid BIC in the design of formats and procedures to test the feasibility of producing World Trade Lists from a world trade directory file.
Background: BIC has the responsibility of furnishing U.S. businesses with data concerning potential overseas markets. This has been done via World Trade Lists prepared by foreign service officers in the market area although much of the pertinent information is contained in a world trade directory file.

Japan was chosen as the test country both because it is one of the most active export markets in terms of volume and variety of commodities and because language problems are as difficult as any others expected.

Although EAM equipment is to be used for testing, the system is designed to permit easy transition to a stored program computer with a high I/O capability.
Status: COMPLETED.

1102-40-11647/64-1528 LUMBER STANDARDS Authorized 5/1/64
Origin and Sponsor: NBS, Section 18.0 (R.E. Wilson)
Manager: L. Joseph
Objective: To assist the Statistical Engineering Laboratory (11.3) in the summarization of the results of a questionnaire concerning a revision of SPR 16-53: American Lumber Standards for Softwood Lumber.
Background: The American Lumber Standards Committee submitted a proposal to revise the softwood lumber standard under the voluntary commodity standards program. A questionnaire was circulated to ascertain whether the proposal had wide support in the industry. Because a large response was expected, the Applied Mathematics Division was requested to assist in processing of the data.
Status: NEW. COMPLETED. In conjunction with Mr. Cameron and others of the Statistical Engineering Laboratory (11.3) routines were written to edit and process the data. Production runs were made. A final report has been submitted.

## 7. STATISTICAL ENGINEERING SERVICES

### COLLABORATION ON STATISTICAL ASPECTS OF NBS RESEARCH AND TESTING

Task 3911-61-39951/51-1

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

Status: CONTINUED. Dr. Youden collaborated with the Bureau's Radioactivity Section on studies of the calibration of radiation standards. These studies involved, in addition to the problems of design for the multiple comparisons among the standards and the unknowns, the concomitant investigation of the effect of experimental factors such as position and time trend on the precision and accuracy of the results.

J. M. Cameron and K. Bedeau have developed a computer program for the analysis of weighing designs that has greatly facilitated the development and comparison of special designs needed in the work of the Mass laboratory in its dead weight testing in the 10,000 lb. range. As yet no mathematical method for the construction of an optimum design exists so that new designs for use in this program were selected from a group of the most promising designs. The computer makes it economically possible to intercompare a fairly exhaustive list of possible designs and hence arrive at an optimum (or near optimum) design.

Mrs. M. G. Natrella has taught the second semester of a course in Experimental Statistics using her own book, NBS Handbook 91, as the text. This course was originally scheduled for one semester but was extended because of the demand of the students. The popularity and usefulness of Handbook 91 inside the Bureau is matched by a wide distribution to the public--nearly 6000 copies having been sold since October 1963.

Through the cooperative efforts of T. E. Hockersmith(6.00) and H. H. Ku(11.03), over the past year, a new form of report of calibration has been adopted by the Mechanics Division for the calibration of proving rings. The new report, which replaces the type in use since 1946, includes a table of load values and detailed information on precision and accuracy of the calibration. An expository paper on the "Uncertainties Associated with Proving Ring Calibration" is being prepared for presentation at the October meeting of the Instrument Society of America.

Publications:

(1) Statistics of irreversible termination in homogeneous anionic polymerization. Bernard D. Coleman (Mellon Institute), Fred Gornick (NBS Macromolecules Synthesis and Structure Section), and George Weiss. J. Chemical Physics 39, 3233-3239, December 15, 1963.

(2) Exact conditions for the preservation of a canonical distribution in a Markovian relaxation process. H. C. Andersen, I. Oppenheim, Kurt E. Shuler (Director's Office), George H. Weiss. J. Math. Physics 5, 522-536, April 1964.

(3) Exact Faxen solution for contrifugation when sedimentation depends linearly on concentration. George Weiss and Irwin H. Billick (Macromolecules Synthesis and Structure Section). Nature 201, 912-913, February 29, 1964.

(4) A simple derivation of the Faxen solution to the Lamm equation. George Weiss. J. Mathematical Physics 5 675-676, 1964.

(5) Statistics in its proper place. W. J. Youden. J. Wash. Academy of Sciences 54, 53-57, March 1964.

(6) Mathematical models for personnel promotion. E. L. Crow (Boulder Laboratories) and George Weiss. Submitted to a technical journal.

(7) Relaxation of a Lorentz gas with a repulsive $r^{-s}$ force law. H. Oser, K. Shuler (Director's Office), and G. H. Weiss. Submitted to a technical journal.

(8) Evaluation of exact solutions to the Lamm equation. I. Billick (Macromolecules Synthesis and Structure Section) and G. H. Weiss. Submitted to a technical journal.

(9) Non-equilibrium thermodynamics of canonically invariant relaxation processes. H. Andersen, I. Oppenheim, K. Shuler (Director's Office), and G. H. Weiss. Submitted to a technical journal.

(10) Sampling and statistical design. W. J. Youden. To appear in Proceedings, Symposium on Environmental Measurements, U. S. Public Health Service, 1963.

(11) The evolution of designed experiments. W. J. Youden. To appear in Proceedings, IBM Symposium on Scientific Computing.

## STATISTICAL SERVICES
Task 1103-40-11625/58-346

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

Status: CONTINUED. Dr. Youden assisted the International Atomic Energy Agency in the planning of interlaboratory tests for establishment of standard samples for uranium and for trace elements associated with uranium.

THIS IS A RECORD OF THE USE OF THE IBM 7094 FOR THE PERIOD OF JANUARY 1, THROUGH JUNE 30, 1964.

| TASK NUMBER | | TITLE | ASSEMBLY TIME | CODE CHECKING | PRODUCTION TIME | TOTAL TIME ON COMPUTER |
|---|---|---|---|---|---|---|
| NBS SERVICES | | | ( M I N U T E S ) | | | |
| 51-0002 | 11.03 | STATISTICAL ENGINEERING | 253 | 105 | 229 | 587 |
| 63-0003 | 11.03 | CLASS+++ | 2 | 2 | 5 | 9 |
| 54-0030 | 13.01 | SPECTRUM ANALYSIS++ | 69 | 20 | 522 | 611 |
| 54-0031 | 13.01 | SPECTRUM ANALYSIS++ | 3 | 0 | 26 | 29 |
| 54-0032 | 13.01 | SPECTRUM ANALYSIS++ | 69 | 18 | 168 | 255 |
| 54-0033 | 13.01 | SPECTRUM ANALYSIS++ | 101 | 21 | 937 | 1059 |
| 54-0034 | 13.01 | SPECTRUM ANALYSIS++ | 4 | 1 | 232 | 237 |
| 55-0065 | 11.02 | AUTOMATIC CODING | 26 | 13 | 19 | 58 |
| 55-0082 | 3.01 | THERMOMETER CALIBRATION+ | 0 | 0 | 248 | 248 |
| 56-0166 | 15.00 | SCF-LCAO SOLUTION OF HYDRIDES+ | 36 | 105 | 648 | 789 |
| 57-0219 | 3.02 | THERMAL PROPERTIES+ | 23 | 11 | 99 | 133 |
| 57-0236 | 3.08 | SCF EIGENVALUES+ | 11 | 16 | 134 | 161 |
| 57-0250 | 2.01 | SPECTROPHOTOMETRIC DATA+ | 42 | 8 | 45 | 95 |
| 57-0252 | 4.04 | NEUTRAL MESON EXPERIMENTS++ | 51 | 33 | 92 | 176 |
| 58-0256 | 10.06 | COMPOSITE WALL STUDIES++ | 178 | 113 | 61 | 352 |
| 58-0266 | 7.06 | DEPOLYMERIZATION PROCESSES | 0 | 0 | 25 | 25 |
| 58-0272 | 3.07 | EQUATION OF STATE++ | 4 | 3 | 5 | 12 |
| 58-0314 | 3.07 | APPROXIMATIONS FOR GAS MIXTURES | 1 | 11 | 5 | 17 |
| 58-0339 | 6.05 | VISCOELASTICITY PROPERTIES | 23 | 10 | 11 | 44 |
| 60-0489 | 3.01 | INVERSION OF LINE PROBE DATA+ | 109 | 76 | 48 | 233 |
| 61-0523 | 4.07 | NEUTRON CROSS SECTION STUDIES++ | 11 | 0 | 0 | 11 |
| 61-0538 | 9.04 | SPECTRAL REFLECTANCE DATA | 0 | 0 | 29 | 29 |
| 61-0559 | 3.01 | THERMOCOUPLE CALIBRATION+ | 7 | 57 | 32 | 96 |
| 61-0562 | 7.06 | CUBIC LATTICES+ | 0 | 0 | 47 | 47 |
| 62-1000 | 12.05 | POST OFFICE OPERATIONS STUDY++ | 32 | 14 | 7 | 53 |
| 62-1003 | 15.04 | MOLECULAR SPECTROSCOPY+ | 1 | 0 | 104 | 105 |
| 62-1005 | 4.03 | RADIATION INTERACTION++ | 279 | 150 | 165 | 594 |
| 62-1006 | 4.03 | RADIATION INTERACTION++ | 408 | 511 | 663 | 1582 |
| 62-1011 | 13.05 | DISPERSION INTEGRALS++ | 7 | 3 | 31 | 41 |
| 62-1015 | 15.01 | THERMAL FUNCTIONS++ | 24 | 22 | 17 | 63 |
| 62-1019 | 41.00 | NBS PERSONNEL REPORT++ | 5 | 28 | 153 | 186 |
| 62-1027 | 11.02 | NEW SYSTEM | 194 | 80 | 182 | 456 |
| 62-1029 | 9.07 | D-SPACING CALCULATIONS+ | 0 | 0 | 8 | 8 |
| 62-1033 | 9.07 | CRYSTAL STRUCTURE CALIBRATION++ | 83 | 117 | 334 | 534 |
| 62-1034 | 30.00 | PHOTOIONIZATION CROSS SECTION++ | 24 | 2 | 71 | 97 |

CURRENT APPLICATIONS OF AUTOMATIC COMPUTER

| TASK NUMBER | | TITLE | ASSEMBLY TIME | CODE CHECKING | PRODUCTION TIME | TOTAL TIME ON COMPUTER |
|---|---|---|---|---|---|---|
| NBS SERVICES | | | ( M | I N U T E | S ) | |
| 62-1035 | 7.07 | CREEP DATA ANALYSIS++ | 29 | 4 | 3 | 36 |
| 62-1036 | 7.07 | FILM THICKNESS++ | 1 | 0 | 43 | 44 |
| 62-1038 | 7.05 | STANDARDIZATION ANALYSES++ | 0 | 14 | 1 | 15 |
| 62-1052 | 2.00 | BLACK BOX COMPUTER SERVICE+ | 0 | 0 | 2 | 2 |
| 62-1055 | 8.04 | ELLIPSOIDAL COMPUTATION++ | 0 | 0 | 1 | 1 |
| 62-1064 | 2.04 | GAGE BLOCK STUDIES++ | 1 | 0 | 22 | 23 |
| 62-1066 | 1.02 | STANDARD CELLS++ | 0 | 0 | 12 | 12 |
| 62-1080 | 9.02 | BLACK BOX COMPUTER SERVICE+ | 0 | 0 | 90 | 90 |
| 62-1081 | 9.01 | BLACK BOX COMPUTER SERVICE+ | 0 | 0 | 16 | 16 |
| 62-1089 | 9.06 | ELASTIC CONSTANTS++ | 0 | 0 | 81 | 81 |
| 62-1107 | 6.05 | OSCILLATING SPHERE++ | 4 | 0 | 14 | 18 |
| 62-1125 | 9.05 | MATRIX COMPUTATIONS | 160 | 44 | 140 | 344 |
| 62-1157 | 11.04 | PLASMA RESEARCH++ | 90 | 40 | 11 | 141 |
| 62-1163 | 14.01 | TRANSISTOR AGING BEHAVIOR++ | 52 | 58 | 12 | 122 |
| 62-1165 | 15.02 | NMR SPECTRA ANALYSES+ | 0 | 0 | 4 | 4 |
| 62-1181 | 12.04 | NTDC++ | 11 | 36 | 3 | 50 |
| 62-1185 | 10.03 | HEAT TRANSFER CALCULATIONS+ | 211 | 65 | 118 | 394 |
| 62-1187 | 2.04 | FRUSTRATED REFLECTIONS++ | 0 | 0 | 17 | 17 |
| 62-1195 | 7.02 | LIGHT SCATTERING++ | 0 | 3 | 3 | 6 |
| 62-1203 | 3.07 | CYLINDRICAL SHOCK WAVE | 0 | 4 | 28 | 32 |
| 62-1211 | 12.05 | TECHNICAL INFO RETRIEVAL++ | 3 | 9 | 0 | 12 |
| 62-1212 | 10.09 | COLOR DIFFERENCES | 10 | 3 | 23 | 36 |
| 63-1222 | 7.01 | DILATOMETRIC DATA CALCULATIONS+ | 0 | 0 | 47 | 47 |
| 63-1226 | 12.00 | OTS - KWIC++ | 5 | 11 | 66 | 82 |
| 63-1231 | 13.00 | BLACK BOX COMPUTER SERVICE+ | 3 | 0 | 27 | 30 |
| 63-1233 | 9.07 | BLACK BOX COMPUTER SERVICE+ | 0 | 3 | 0 | 3 |
| 63-1234 | 10.03 | VAPOR TRANSMISSION++ | 67 | 13 | 10 | 90 |
| 63-1237 | 3.01 | PYROMETRY++ | 0 | 0 | 65 | 65 |
| 63-1250 | 12.00 | KWIC++ | 6 | 15 | 97 | 118 |
| 63-1252 | 11.05 | ARMY ORDNANCE++ | 4 | 23 | 0 | 27 |
| 63-1257 | 7.08 | CALC OF CALCIUM PHOSPHATE++ | 8 | 76 | 70 | 154 |
| 63-1259 | 11.03 | RESEARCH IN PROBABILITY++ | 20 | 81 | 15 | 116 |
| 63-1263 | 15.05 | LINEAR CLASSICAL SYSTEM++ | 16 | 8 | 80 | 104 |
| 63-1276 | 14.02 | INSTRUMENTATION++ | 15 | 8 | 0 | 23 |
| 63-1277 | 1.02 | BLACK BOX COMPUTER SERVICE++ | 8 | 7 | 5 | 20 |
| 63-1281 | 2.04 | CORRECTION-SMEARING | 17 | 4 | 3 | 24 |
| 63-1285 | 11.05 | RTS FUNDS++ | 8 | 0 | 36 | 44 |
| 63-1287 | 3.07 | DATA ANALYSES OF GASES++ | 35 | 1 | 261 | 297 |
| 63-1289 | 3.08 | IONIZED GASES++ | 236 | 23 | 5 | 264 |
| 63-1290 | 3.00 | MOLECULAR ENERGY LEVELS++ | 0 | 0 | 4 | 4 |
| 63-1291 | 7.01 | JOB CALCULATIONS++ | 15 | 194 | 18 | 227 |

| TASK NUMBER | | TITLE | ASSEMBLY TIME | CODE CHECKING | PRODUCTION TIME | TOTAL TIME ON COMPUTER |
|---|---|---|---|---|---|---|
| NBS SERVICES | | | ( M I N U T E S ) | | | |
| 63-1302 | 7.03 | COMPUTER CALCULATIONS++ | 8 | 0 | 3 | 11 |
| 63-1308 | 2.05 | BUTTRESS THREADS++ | 0 | 15 | 14 | 29 |
| 63-1309 | 4.02 | LINEAR REGRESSION ANALYSIS++ | 9 | 3 | 23 | 35 |
| 63-1315 | 3.03 | VIRIAL COEFFICIENTS++ | 40 | 70 | 217 | 327 |
| 63-1318 | 10.03 | THERMISTOR PROGRAM++ | 49 | 2 | 3 | 54 |
| 63-1320 | 9.07 | CRYSTAL STRUCTURE | 14 | 41 | 7 | 62 |
| 63-1323 | 3.00 | PLASMA TRANSPORT++ | 4 | 0 | 98 | 102 |
| 63-1325 | 4.07 | THERMOFLUX++ | 133 | 109 | 26 | 268 |
| 63-1332 | 3.01 | TEMPERATURE PHYSICS++ | 0 | 13 | 1 | 14 |
| 63-1333 | 2.02 | BLACK BOX COMPUTER SERVICE+ | 0 | 0 | 3 | 3 |
| 63-1334 | 15.00 | PHASE TRANSITION++ | 24 | 3 | 0 | 27 |
| 63-1338 | 15.04 | SECTION COMPUTATIONS++ | 0 | 0 | 22 | 22 |
| 63-1340 | 3.03 | FUNCTION OF TEMPERATURE++ | 0 | 0 | 47 | 47 |
| 63-1341 | 13.02 | LINE WIDTH | 0 | 6 | 2 | 8 |
| 63-1342 | 6.01 | OMNITAB+ | 0 | 1 | 5 | 6 |
| 63-1343 | 3.01 | OMNITAB+ | 0 | 6 | 12 | 18 |
| 63-1351 | 1.02 | TEST DATA++ | 13 | 2 | 15 | 30 |
| 63-1355 | 13.04 | RUTILE BAND STRUCTURE | 3 | 4 | 2 | 9 |
| 63-1359 | 13.05 | OMNITAB+ | 0 | 0 | 15 | 15 |
| 63-1375 | 3.07 | THERMAL PROPERTIES+ | 31 | 44 | 13 | 88 |
| 63-1377 | 13.05 | WHISKER GROWTH EQUATION | 37 | 58 | 4 | 99 |
| 63-1378 | 12.05 | DCA++ | 187 | 942 | 494 | 1623 |
| 63-1381 | 3.08 | POLY-ELECTROLYTES | 0 | 17 | 0 | 17 |
| 63-1388 | 3.02 | COMBUSTION CALORIMETRY++ | 15 | 28 | 28 | 71 |
| 63-1389 | 6.04 | PROVING RINGS++ | 0 | 0 | 8 | 8 |
| 64-1400 | 13.02 | STATISTICS++ | 35 | 2 | 241 | 278 |
| 64-1401 | 10.07 | LONG TIME CEMENT STUDY 1++ | 0 | 0 | 5 | 5 |
| 64-1402 | 10.07 | LONG TIME CEMENT STUDY 2++ | 0 | 1 | 105 | 106 |
| 64-1405 | 6.08 | TEMPERATURE SENSING++ | 0 | 0 | 13 | 13 |
| 64-1406 | 6.08 | HYPERSONIC COMBUSTION++ | 1 | 5 | 0 | 6 |
| 64-1407 | 5.02 | SPECTROANALYSIS++ | 0 | 0 | 2 | 2 |
| 64-1408 | 10.01 | ELASTIC SOLIDS | 6 | 6 | 1 | 13 |
| 64-1412 | 4.02 | REF++ | 0 | 0 | 2 | 2 |
| 64-1415 | 8.0 | OMNITAB+ | 0 | 5 | 0 | 5 |
| 64-1418 | 2.06 | STATISTICAL COMPUTATION++ | 0 | 0 | 94 | 94 |
| 64-1419 | 2.06 | STATISTICAL COMPUTATION++ | 5 | 16 | 29 | 50 |
| 64-1420 | 3.02 | OMNITAB+ | 1 | 0 | 3 | 4 |
| 64-1423 | 3.07 | COORDINATE ANALYSIS++ | 7 | 9 | 21 | 37 |
| 64-1431 | 3.07 | RESEARCH++ | 28 | 15 | 110 | 153 |
| 64-1437 | 7.08 | AMALGAM STRAIN-TIME DATA++ | 0 | 0 | 68 | 68 |
| 64-1438 | 8.00 | MATRIX OPERATIONS | 20 | 4 | 13 | 37 |

CURRENT APPLICATIONS OF AUTOMATIC COMPUTER

| TASK NUMBER | NBS SERVICES | TITLE | ASSEMBLY TIME | CODE CHECKING | PRODUCTION TIME | TOTAL TIME ON COMPUTER |
|---|---|---|---|---|---|---|
| | | | ( M I N U T E S ) | | | |
| 64-1440 | 10.09 | OMNITAB+ | 20 | 0 | 9 | 29 |
| 64-1443 | 4.10 | MAGNET TEST PROGRAM++ | 2 | 0 | 30 | 32 |
| 64-1445 | 30.00 | TEXTILE INDUSTRY STUDY++ | 5 | 0 | 53 | 58 |
| 64-1448 | 15.00 | BLACK BOX COMPUTER SERVICE+ | 0 | 8 | 2 | 10 |
| 64-1450 | 10.07 | GLASS BEAD DATA | 1 | 2 | 26 | 29 |
| 64-1453 | 3.01 | RES THERMOMETER CALC++ | 0 | 1 | 0 | 1 |
| 64-1454 | 7.04 | ACTIVE ENERGIES++ | 8 | 0 | 10 | 18 |
| 64-1456 | 11.00 | INFORMATION RETRIEVAL++ | 53 | 71 | 79 | 203 |
| 64-1459 | 4.00 | GIANT RESIDENCE ANALYSIS++ | 0 | 0 | 8 | 8 |
| 64-1460 | 13.05 | FIELD EMISSION++ | 10 | 3 | 8 | 21 |
| 64-1462 | 4.23 | POSITRON PRODUCTION++ | 9 | 183 | 6 | 198 |
| 64-1463 | 13.00 | TRANSITION PROBABILITIES | 16 | 8 | 73 | 97 |
| 64-1464 | 10.07 | OMNITAB+ | 0 | 0 | 1 | 1 |
| 64-1470 | 12.5 | PICNIC PROJECT++ | 5 | 38 | 193 | 236 |
| 64-1473 | 3.07 | POLAR GASES++ | 53 | 15 | 145 | 213 |
| 64-1474 | 15.00 | ATOM CORRELATION++ | 91 | 0 | 61 | 152 |
| 64-1476 | 3.2 | THERMOVELOCITY++ | 5 | 0 | 54 | 59 |
| 64-1478 | 4.21 | LEAST SQUARES++ | 0 | 0 | 7 | 7 |
| 64-1479 | 13.4 | NUCLEAR QUADRUPOLE | 9 | 7 | 14 | 30 |
| 64-1480 | 12.5 | TAPE TASK ROUTINE++ | 3 | 6 | 0 | 9 |
| 64-1483 | 9.7 | POWDER PATTERNS++ | 0 | 0 | 16 | 16 |
| 64-1484 | 6.3 | OMNITAB+ | 0 | 0 | 18 | 18 |
| 64-1485 | 12.5 | MANAGEMENT PROBLEMS++ | 0 | 8 | 5 | 13 |
| 64-1486 | 3.1 | OMNITAB+ | 0 | 0 | 26 | 26 |
| 64-1487 | 6.1 | VIBRATION CALIBRATION++ | 0 | 0 | 28 | 28 |
| 64-1489 | 5.2 | HOMOGENEITY TESTING++ | 0 | 0 | 6 | 6 |
| 64-1492 | 4.1 | ELECTROMAG CROSS SECT++ | 26 | 310 | 0 | 336 |
| 64-1493 | 6.4 | PROVING RINGS++ | 0 | 0 | 86 | 86 |
| 64-1496 | 2.4 | EXP FOR INVAR TAPE++ | 4 | 0 | 5 | 9 |
| 64-1497 | 2.5 | INTERFEROMETER | 0 | 0 | 3 | 3 |
| 64-1500 | 41.4 | FORTRAN CLASS | 15 | 1 | 14 | 30 |
| 64-1502 | 8.7 | POT POLYELECTROLYTE++ | 0 | 6 | 0 | 6 |
| 64-1503 | 6.1 | OMNITAB+ | 0 | 0 | 29 | 29 |
| 64-1507 | 4.24 | COULOMB WAVE FUNCTION++ | 0 | 0 | 5 | 5 |
| 64-1512 | 6.2 | OMNITAB+ | 1 | 1 | 64 | 66 |
| 64-1515 | 3.8 | VARIATIONAL INTEGRAL++ | 2 | 0 | 0 | 2 |
| 64-1517 | 12.3 | OPTICAL SCANNER++ | 0 | 6 | 0 | 6 |
| 64-1518 | 30.0 | OPER RES INCORP++ | 4 | 170 | 324 | 498 |
| 64-1521 | 6.1 | INFRASONIC COMP++ | 0 | 3 | 0 | 3 |
| 64-1522 | 2.6 | OMNITAB+ | 4 | 16 | 21 | 41 |
| 64-1523 | 2.1 | FORTRAN CLASS++ | 0 | 3 | 0 | 3 |

CURRENT APPLICATIONS OF AUTOMATIC COMPUTER

| TASK NUMBER | | TITLE | ASSEMBLY TIME | CODE CHECKING | PRODUCTION TIME | TOTAL TIME ON COMPUTER |
|---|---|---|---|---|---|---|
| NBS SERVICES | | | ( M I N U T E S ) | | | |
| 64-1528 | 18.0 | LUMBER STANDARDS | 18 | 19 | 52 | 89 |
| 64-1531 | 12.0 | INFORMATION PROCESSING++ | 2 | 0 | 18 | 20 |
| 64-1533 | 5.2 | CAST IRON++ | 0 | 0 | 2 | 2 |
| 64-1535 | 4.33 | MICOFTIES++ | 25 | 7 | 85 | 117 |
| 64-1536 | 8.5 | SEVEN INVERTED MATRICES | 0 | 0 | 2 | 2 |
| 64-1537 | 14.1 | FIST++ | 2 | 7 | 0 | 9 |
| 64-1538 | 15.2 | LEAST SQUARES | 0 | 0 | 1 | 1 |
| 64-1539 | 6.4 | SQUARE BAR++ | 52 | 5 | 24 | 81 |
| 64-1540 | 12.5 | DESCRIPTORS++ | 1 | 0 | 0 | 1 |
| 64-1542 | 15.6 | FRANCK-CONDON FACTORS+ | 0 | 0 | 14 | 14 |
| 64-1543 | 15.6 | FRANCK-CONDON FACTORS+ | 0 | 0 | 63 | 63 |
| 64-1545 | 1.2 | STAND REFER DATA CALC++ | 14 | 1 | 10 | 25 |
| 64-1547 | 5.1 | MOSSBAUER++ | 8 | 3 | 29 | 40 |
| 64-1553 | 3.2 | OMNITAB+ | 0 | 0 | 1 | 1 |
| 64-1557 | 14.1 | PNEUMATIC BRIDGES+ | 0 | 0 | 2 | 2 |
| 64-1559 | 12.5 | IPRS++ | 4 | 11 | 0 | 15 |
| 63-3005 | 11.02 | FREE MACHINE TIME+++ | 85 | 26 | 36 | 147 |
| 63-3008 | 11.02 | SECRETARYS MACHINE TIME+++ | 25 | 23 | 25 | 73 |
| 64-3011 | 11.02 | ERROR-USER+++ | 0 | 0 | 95 | 95 |
| | | TOTALS (NBS SERVICES) | 4367 | 4692 | 10512 | 19571 |
| NON-NBS SERVICES | | | | | | |
| 57-0216 | NSF | HANDBOOK OF MATHEMATICAL TABLES | 24 | 18 | 32 | 74 |
| 58-0348 | OOR | MACHINE TRANSLATION OF RUSSIAN | 30 | 94 | 3 | 127 |
| 58-0366 | USIA | RADIATION PATTERNS OF ANTENNAS | 0 | 0 | 1 | 1 |
| 59-0425 | CU | MOLECULAR ORBITALS+ | 126 | 57 | 15 | 198 |
| 59-0434 | GC | PETROLOGICAL COMPUTATIONS+ | 60 | 68 | 108 | 236 |
| 59-0441 | USRED | SYSTEMS ENGINEERING++ | 59 | 102 | 401 | 562 |
| 60-0457 | PHA | PUBLIC HOUSING PROBLEM++ | 3 | 16 | 149 | 168 |
| 60-0476 | HDL | GAS TUBE CHARACTERISTIC II | 0 | 0 | 941 | 941 |
| 60-0486 | UONT | MORSE WAVE FUNCTION++ | 0 | 0 | 73 | 73 |
| 60-0492 | IMF | MONETARY RESEARCH REPORTS++ | 90 | 157 | 149 | 396 |
| 60-0506 | WBANK | WORLD BANK REPORTS++ | 127 | 0 | 188 | 315 |
| 61-0513 | NASA | ORBITING STUDIES | 12 | 0 | 13 | 25 |
| 61-0540 | ACC | DIFFUSION CALCULATIONS+ | 1 | 0 | 190 | 191 |
| 61-0569 | AGO | HUMAN FACTORS RESEARCH++ | 191 | 58 | 259 | 508 |
| 61-0830 | BPR | HIGHWAY TRAFFIC STUDIES++ | 41 | 2 | 1115 | 1158 |
| 61-0902 | BPR | HIGHWAY TRAFFIC STUDIES++ | 1 | 0 | 576 | 577 |
| 61-0903 | BPR | HIGHWAY TRAFFIC STUDIES++ | 16 | 17 | 235 | 268 |

CURRENT APPLICATIONS OF AUTOMATIC COMPUTER

| TASK NUMBER | | TITLE | ASSEMBLY TIME | CODE CHECKING | PRODUCTION TIME | TOTAL TIME ON COMPUTER |
|---|---|---|---|---|---|---|
| NON-NBS SERVICES | | | ( M I N U T E S ) | | | |
| 61-0945 | WB | FORECASTING++ | 2 | 0 | 209 | 211 |
| 62-1004 | BUSHP | RHOMBIC ANTENNAS+ | 0 | 3 | 46 | 49 |
| 62-1014 | NIH | METABOLIC DISEASES++ | 477 | 310 | 1386 | 2173 |
| 62-1018 | NRL | HYDROMAGNETIC PROBLEMS+ | 150 | 195 | 68 | 413 |
| 62-1021 | DCH | HIGHWAY STUDIES++ | 146 | 488 | 3050 | 3684 |
| 62-1030 | VA | ELECTROCARDIOGRAPHIC ANALYSIS | 1284 | 2184 | 617 | 4085 |
| 62-1044 | FCC | RADIO INTENSITIES++ | 10 | 0 | 42 | 52 |
| 62-1046 | BPR | TRAFFIC PREDICTION++ | 710 | 249 | 1709 | 2668 |
| 62-1056 | HDL | PD ENGINEERING++++ | 22 | 19 | 159 | 200 |
| 62-1071 | HDL | RHINITIS STUDIES++ | 0 | 0 | 5 | 5 |
| 62-1076 | NAS | EVALUATION OF APPLICATIONS+ | 0 | 0 | 47 | 47 |
| 62-1091 | WPA | LOWER BOUNDS TO EIGENVALUES | 1 | 0 | 1 | 2 |
| 62-1110 | ICC | ICC SYSTEMS STUDY++ | 2 | 0 | 10 | 12 |
| 62-1113 | HDL | TRANSPORT ANALYSES++++ | 56 | 170 | 99 | 325 |
| 62-1114 | HDL | RADIATION EFFECTS++ | 25 | 24 | 0 | 49 |
| 62-1121 | CARIN | CARNEGIE INSTITUTE STUDIES++ | 173 | 30 | 47 | 250 |
| 62-1130 | COENG | FALLOUT SHELTER COMPUTATIONS | 88 | 70 | 574 | 732 |
| 62-1140 | VA | VA MEDICAL++ | 370 | 53 | 677 | 1100 |
| 62-1158 | GC | MINERALOGY STUDIES++ | 12 | 81 | 157 | 250 |
| 62-1169 | UONT | ATOMIC COLLISIONS++ | 2 | 0 | 124 | 126 |
| 62-1171 | VA | HOSPITAL PROGRAM PLANNING+ | 245 | 199 | 238 | 682 |
| 62-1172 | PEACE | PEACE CORPS EVALUATIONS++ | 27 | 12 | 20 | 59 |
| 62-1175 | HDL | ION DISTRIBUTIONS+ | 20 | 5 | 22 | 47 |
| 62-1179 | HDL | CATALOG INFORMATION+ | 0 | 5 | 33 | 38 |
| 62-1189 | QM | TABLES FOR SEQUENTIAL METHODS | 18 | 77 | 854 | 949 |
| 62-1215 | NASA | MISSILE SATELLITE++ | 66 | 0 | 2669 | 2735 |
| 62-1216 | BPR | ARIZONA++ | 2 | 76 | 198 | 276 |
| 63-1221 | BPR | RHODE ISLAND++ | 15 | 0 | 98 | 113 |
| 63-1236 | COMM | DATATROL++ | 41 | 15 | 199 | 255 |
| 63-1239 | PHS | PUBLIC HEALTH SERVICE++ | 18 | 11 | 169 | 198 |
| 63-1240 | TREAS | SECRET SERVICE FORGERY | 12 | 7 | 7 | 26 |
| 63-1246 | PHS | SCREENING EVALUATION+ | 35 | 26 | 24 | 85 |
| 63-1249 | RC | ISOTOPE TRACER ANALYSIS++ | 0 | 12 | 38 | 50 |
| 63-1253 | GU | BLACK BOX COMPUTER SERVICE++ | 93 | 68 | 134 | 295 |
| 63-1254 | DEFCO | HIGH FREQUENCY PROPAGATION++ | 193 | 82 | 577 | 852 |
| 63-1262 | NRL | NUCLEONICS++ | 17 | 261 | 1 | 279 |
| 63-1264 | NRL | NUCLEONICS++ | 314 | 368 | 422 | 1104 |
| 63-1271 | COMM | ECONOMICS STUDY++ | 0 | 24 | 339 | 363 |
| 63-1272 | BPR | ROADS STUDY++ | 3 | 4 | 292 | 299 |
| 63-1279 | HDL | MAGNETIC FIELD++ | 0 | 0 | 3 | 3 |
| 63-1280 | UARIZ | NIH++ | 1 | 16 | 0 | 17 |

| TASK NUMBER | | TITLE | ASSEMBLY TIME | CODE CHECKING | PRODUCTION TIME | TOTAL TIME ON COMPUTER |
|---|---|---|---|---|---|---|
| NON-NBS SERVICES | | | ( M I N U T E S ) | | | |
| 63-1293 | COMM | BODDY CALCULATION++ | 7 | 12 | 0 | 19 |
| 63-1296 | HDL | OPTIMUM LIFE++ | 2 | 146 | 0 | 148 |
| 63-1299 | HDL | 1410 PROGRAM++ | 0 | 1 | 3 | 4 |
| 63-1301 | HDL | SERGEANT SPARE PARTS++ | 4 | 0 | 137 | 141 |
| 63-1305 | DSA | ARMY++ | 0 | 0 | 1490 | 1490 |
| 63-1307 | HDL | MISCELLANEOUS PROGRAMMING++ | 27 | 30 | 41 | 98 |
| 63-1310 | HDL | SHOCK WAVE TEST++ | 21 | 0 | 52 | 73 |
| 63-1313 | IDA | OMNITAB+ | 11 | 12 | 0 | 23 |
| 63-1314 | BPR | FLORIDA HIGHWAYS++ | 14 | 4 | 490 | 508 |
| 63-1317 | AID | SORTING AND TABULATING | 28 | 15 | 70 | 113 |
| 63-1324 | HEW | GENERAL KINETICS++ | 3 | 86 | 0 | 89 |
| 63-1336 | NAVWE | ARC++ | 97 | 0 | 1151 | 1248 |
| 63-1345 | HDL | ROCKET TRAJECTORIES++ | 20 | 21 | 82 | 123 |
| 63-1350 | HDL | ME DATA++ | 6 | 66 | 6 | 78 |
| 63-1352 | OCDM | NEAR | 3 | 0 | 742 | 745 |
| 63-1356 | NIH | COMPUTER CONSULTING | 33 | 7 | 2 | 42 |
| 63-1358 | PHS | TRAINING GRANTS | 11 | 2 | 11 | 24 |
| 63-1360 | FPC | FEDERAL POWER COMMISSION++ | 6 | 0 | 107 | 113 |
| 63-1362 | VA | RESEARCH++ | 30 | 13 | 49 | 92 |
| 63-1365 | HDL | 1410++ | 0 | 0 | 4 | 4 |
| 63-1368 | PHS | HEART DISEASE | 64 | 0 | 21 | 85 |
| 63-1371 | TREAS | ALTERNATE TAX PLANS++ | 17 | 0 | 890 | 907 |
| 63-1373 | JHAPL | HYPERVELOCITY IMPACT | 5 | 1 | 5 | 11 |
| 63-1385 | HDL | TRANSDUCER PROGRAM++ | 3 | 0 | 0 | 3 |
| 63-1391 | HEW | BIOMEDICAL STA PROG++ | 22 | 0 | 526 | 548 |
| 63-1393 | NASA | COMPUTER SYSTEMS | 111 | 21 | 19 | 151 |
| 64-1394 | DSA | ARMY COST MODEL (RAND)++ | 66 | 32 | 5410 | 5508 |
| 64-1403 | HDL | WORLD TEMPERATURE DIST++ | 10 | 0 | 8 | 18 |
| 64-1411 | HDL | AUTOCORRELATION++ | 19 | 7 | 61 | 87 |
| 64-1414 | HDL | AD 70 PROGRAM++ | 51 | 24 | 1002 | 1077 |
| 64-1425 | FAA | EKG RESEARCH++ | 0 | 10 | 29 | 39 |
| 64-1429 | HDL | RESEARCH MISC++ | 15 | 29 | 67 | 111 |
| 64-1432 | BRINS | BROOKINGS++ | 0 | 0 | 39 | 39 |
| 64-1433 | HEW | NMR SPECTRA | 0 | 0 | 5 | 5 |
| 64-1434 | AMERD | AMERAD++ | 22 | 13 | 0 | 35 |
| 64-1435 | OBE | CAPITOL COEFFICIENTS++ | 0 | 0 | 19 | 19 |
| 64-1436 | HDL | DIPOLE MOMENT COMP++ | 8 | 1 | 4 | 13 |
| 64-1439 | HDL | SHOCK PRESSURES++ | 0 | 0 | 1 | 1 |
| 64-1442 | HEW | COLFACS | 6 | 200 | 725 | 931 |
| 64-1447 | SSA | SOCIAL SECURITY RES++ | 3 | 2 | 29 | 34 |
| 64-1451 | DEF | PROGRAM 2++ | 22 | 2 | 124 | 148 |

CURRENT APPLICATIONS OF AUTOMATIC COMPUTER

| TASK NUMBER | | TITLE | ASSEMBLY TIME | CODE CHECKING | PRODUCTION TIME | TOTAL TIME ON COMPUTER |
|---|---|---|---|---|---|---|
| NON-NBS SERVICES | | | ( M | I N U T | E S ) | |
| 64-1457 | NRL | SOLAR RADIATION DATA RED++ | 36 | 26 | 0 | 62 |
| 64-1458 | HDL | ANALIGHT++ | 32 | 47 | 8 | 87 |
| 64-1461 | COMM | BP ANALYSIS++ | 2 | 4 | 20 | 26 |
| 64-1466 | HEW | HEALTH EXAMINATION DATA | 45 | 26 | 119 | 190 |
| 64-1467 | NRL | THEORET NUCLEAR PHYSICS++ | 101 | 15 | 6 | 122 |
| 64-1469 | DSA | CAMERON STATION | 0 | 0 | 301 | 301 |
| 64-1475 | NRL | RESEARCH++ | 19 | 9 | 7 | 35 |
| 64-1477 | ECONA | ECONOMIC AFFAIRS++ | 0 | 0 | 4 | 4 |
| 64-1482 | AFIP | BIOPHYSICS++ | 91 | 0 | 201 | 292 |
| 64-1488 | NASA | INTERPLANETARY CALC | 182 | 97 | 19 | 298 |
| 64-1494 | DCA | REFILE++ | 19 | 1 | 8 | 28 |
| 64-1498 | TREAS | REGRESSION EQUATION++ | 0 | 9 | 3 | 12 |
| 64-1504 | ACIR | 1970 PROJECTIONS++ | 0 | 24 | 1 | 25 |
| 64-1516 | HDL | ECM STUDY++ | 7 | 9 | 0 | 16 |
| 64-1519 | GSURV | CONTOUR GENERATOR++ | 2 | 0 | 1 | 3 |
| 64-1526 | HDL | BATTERY PROGRAM++ | 234 | 30 | 232 | 496 |
| 64-1534 | IBM | CORRELATION MATRICES++ | 5 | 28 | 8 | 41 |
| 64-1549 | HDL | OPTICAL INTEGRAL++ | 0 | 23 | 1 | 24 |
| 64-1551 | HDL | AD CONVERSION++ | 4 | 14 | 0 | 18 |
| 64-1554 | HDL | PREDICT PROGRAM++ | 2 | 0 | 0 | 2 |
| 64-1561 | HEW | RADIOLOGY++ | 2 | 0 | 0 | 2 |
| | | TOTALS (NON-NBS SERVICES) | 6981 | 6852 | 34172 | 48005 |
| | | TOTALS (NBS AND NON-NBS) | 11348 | 11544 | 44684 | 67576 |

\+ PROBLEM PROGRAMMED IN THE COMPUTATION LABORATORY, PRODUCTION RUNS CONTINUED UNDER DIRECTION OF SPONSOR.

++ PROBLEM PROGRAMMED BY THE SPONSOR AND RUN UNDER HIS DIRECTION.

+++ FUNCTIONS PERTAIN TO THE INTERNAL OPERATIONS OF THE COMPUTATION LABORATORY.

++++ CLASSIFIED TASK.

AS ASSEMBLY TIME.

CC CODE CHECKING TIME.

PR PRODUCTION TIME.

# Lectures and Technical Meetings

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 Division Lectures

BETCHOV, R. (Aerospace Corporation, Los Angeles, California) Kraichnan's theory of turbulence. June 11, 1964.

BLEICHER, M. (University of Wisconsin, Madison, Wisconsin) Series of three lectures on Analytic number theory. January 2, 3 and 6, 1964.

KNORR, G. E. (Plasma Physics Laboratory, Princeton, New Jersey) Numerical investigation of the non-linear Vlasov equation for plasma oscillations. June 4, 1964.

RANKIN, R. A. (Indiana University, Bloomington, Indiana) Quadratic forms. April 2, 1964

REINER, I. (University of Illinois, Urbana, Illinois) Group Theory. June 8, 1964.

## Building Research Division Staff Meeting

YOUDEN, W. J. Statistics in its proper place. January 28, 1964.

## Radiation Physics Division Seminar

YOUDEN, W. J. Rejection of observations. March 5, 1964

## NBS Seminars

KLOSS, K. Hilbert's 10th problem. Presented before the NBS Automata Theory Seminar, March 20, 1964.

KLOSS, K. Wang's tiling problem (The first part of a two part lecture). Presented before the NBS Automata Theory Seminar, April 3, 1964.

KLOSS, K. The second part of the lecture listed above. April 10, 1964.

KLOSS, K. Available grammar models for one-dimensional languages. Presented before the NBS Seminar on Automated Picture and Language Processing, June 8, 1964.

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

ALT, F. L. — Standardization of programming languages. American Management Association, New York, N.Y. March 6, 1964.

A survey of automatic translation in the United States. Presented at the U.S.-Japanese Seminar on Mechanical Translation, Tokyo, Japan, April 20, 1964.

BERNSTEIN, B. — Thermodynamics of elastic fluids. Presented at the Naval Research Laboratory, June 11, 1964.

Thermodynamics of an ideal elastic fluid. Presented at the University of Maryland, March 20, 1964.

BERNSTEIN, B., KEARSLEY, E.A. & ZAPAS, L. J. — The thermodynamics of an ideal elastic fluid. Presented at the High Polymer Physics Division of The American Physical Society. March 23-26, 1964 at Philadelphia, Pennsylvania.

BRAMBLE, J. H. — On the numerical solution of the Dirichlet Problem for $\Delta u + ku = F$. Presented at the Annual Meeting of the American Mathematical Society, University of Miami, Miami, Florida, January 23-27, 1964.

CAMERON, J. M. — Calibration Designs. Methodology Section, Washington Statistical Society, Washington, D.C., January 22, 1964.

EDMONDS, J. — Some convex hulls in graph theory. Presented before the Mathematical Association, Naval Ordnance Laboratory, February 24, 1964.

GHAFFARI, A. — On the non-existence of limit-cycles of a system of differential equations of nonlinear oscillations. Presented at the Annual Meeting of the American Mathematical Society, University of Miami, Miami, Florida, January 23-27, 1964.

GOLDMAN, A. J. — A generalization of Rennie's inequality. Presented before the Mathematical Association of America, May 2, 1964, at Westinghouse Defense Center, Glen Burnie, Md.

The transportation model of linear programming and some extensions. Presented before the Commerce Department Conference on the Use of Models in Transportation Problems, June 4, 1964.

HABER, S. — Numerical Evaluation of Multiple Integrals. Presented at the Institute for Fluid Dynamics and Applied Mathematics, University of Maryland. March 11, 1964.

HAIN, K.H.S. — Integration schemes for total hyperbolic partial differential equations. Presented at the University of Maryland, April 15, 1964.

JOEL, L. S. — A simple production-distribution dynamic model of the cotton grey goods industry. Presented before the Commerce Department Conference on the Use of Models in Transportation Problems, June 4, 1964

KIRSCH, R. A. — Compatibility of Science Information Centers. Presented at the American University, February 21, 1964.

Articular Description of Biological Patterns with a Computer. Presented at Laboratory of Neuroanatomical Sciences Seminar, National Institute of Health, March 23,'64.

Artificial Intelligence. Presented at U.S. Veterans Administration Center, Martinsburg, West Virginia, April 23, 1964.

LAGNESE, J. E. A new differential operator of the pure wave type. Presented at the University of Delaware, Newark, Delaware, Jan. 8, 1964.

A new class of self-adjoint differential operators of pure wave type. Presented at the Annual Meeting of the American Mathematical Society, University of Miami, Miami, Florida, Jan. 23-27, 1964.

LEVY, J. Markov chain analysis of a sorting machine. Presented before the Operations Research Society of America and the Canadian Operational Research Society, Montreal, Quebec, Canada, May 29, 1964.

MITTLEMAN, D. I. Demands on Undergraduate Programs of Mathematics Created by Industry and Research. Presented at Albright College, Reading, Pennsylvania. Sponsored by the Institute for the College and University Mathematics Teachers of Pennsylvania. April 8, 1964.

OLVER, F. W. J. Error bounds for asymptotic expansions with an application to Bessel functions of large argument. Presented at the Mathematics Research Center, Madison, Wisconsin, May 5, 1964.

PEAVY, S. T. Use of Computers in Dietetics. Sponsored by the Instrumentation Field Station-Heart Disease Control Program. Washington, D.C., Jan 15, 1964.

Communicating with the Machine: Fundamentals of Programming. Presented at the American Association of University Women. Sponsored by the U.S. Civil Service Commission, Office of Career Development. Washington, D.C., April 1, 1964.

ROSENBLATT, J. R. Distribution-free two-sample tests. Rutgers - The State University, New Brunswick, N.J., April 8, 1964.

SPECKMAN, J. A. Estimation by duplication. Virginia Academy of Science, Charlottesville, Va., May 10.

VINTI, J.P. Participation in a meeting of the Mathematisches Forschungsinstitut at Oberwolfach, West Germany, March 15-20, 1964 on the subject: "Mathematische Methoden der Himmelsmechanik und Astronautik und damit zuzammenhängende Fragen der numerischen Mathematik". On March 19, 1964 he presented a paper on "The spheroidal method in the theory of the orbit of an artificial satellite".

Theory of the spheroidal method in the theory of the orbit of an artificial satellite. Presented at the U. S. Naval Ordnance Laboratory. White Oak, Silver Spring, Md., April 20, 1964.

Theory of the spheroidal method in the theory of the orbit of an artificial satellite. Presented at the Data Systems Division, NASA, GSFC, June 5, 1964.

Theory of the spheroidal method in the theory of the orbit of an artificial satellite. Presented at Catholic University, Wash., D.C., June 16, 1964.

WALSH, P. J. The future role of user oriented and user designed interpretive program packages. Sponsored by the Office of Naval Research, Washington, D.C., March 31, 1964.

Components and capabilities of computers. Sponsored by the Office of Career Development, U.S. Civil Service Commission. Wash. D.C., May 4, 1964.

WATT, W. C. Problems in Microgrammar. Presented at Washington Linguistics Club, May 21, 1964.

WITZGALL, C. On matching problems. Presented before the Army Research Office Working Group on Computers, Harry Diamond Laboratories., February 2, 1964.

An algorithm for all-integer programming with quadratic constraints. Presented before the Department of Mathematics, Rensselaer Polytechnic Institute, Troy, New York, February 10, 1964.

YOUDEN, W. J. (1) Realistic estimates of the error of measurement, February 13, 1964.
(2) Testing a test method. February 14. Presented before the Dept. of Civil Engineering, University of Illinois, Urbana, Ill.

When Laboratories disagree. New Jersey Section, American Chemical Society, South Orange, N.J., February 24, 1964.

Picking winners and losers. Pensacola-Mobile Section, American Society for Quality Control, Mobile, Alabama, Feb. 26, 1964.

Panel discussion on future problems of science. Westinghouse Science Talent Search, Washington, D.C., February 28, 1964

Combining science and math in instruction. Maryland State Department of Education, Baltimore, Md., March 18, 1964.

The evolution of designed experiments. Institute of Statistics, University of North Carolina, Raleigh, N.C., May 1, 1964.

Science of measurement. Maryland Academy of Sciences, Finalists in National Science Fair, and Maryland Junior Science and Humanities Symposium, Baltimore, Md., May 6, 1964.

# Publication Activities

## 1. PUBLICATIONS THAT APPEARED DURING THIS PERIOD

### 1.1 Mathematical Tables

Handbook of mathematical functions. NBS Applied Mathematics Series 55. Available from the U. S. Government Printing Office, Washington, D.C. 20402, $6.50.

### 1.3 Technical Papers

Exact conditions for the preservation of a canonical distribution in a Markovian relaxation process. H. C. Andersen, I. Oppenheim, Kurt E. Shuler (Director's Office), George H. Weiss. J. Math. Physics 5, 522-536, April 1964.

Inequalities for solutions of mixed boundary value problems for elastic plates. J. H. Bramble and L. E. Payne. J. of Research NBS, 68B, No. 2, pp. 75-92, 1964.

The effect of error in measurement of elastic constants on the solutions of problems in classical elasticity. J. H. Bramble and L. E. Payne. J. of Research NBS, 67B, pp. 157-168, July-Sept.1963.

Pointwise bounds in the first biharmonic boundary value problem. J. H. Bramble and L. E. Payne. J. of Math.and Phys., 42, No. 4, pp. 278-286, 1963.

Statistics of irreversible termination in homogeneous anionic polymerization. Bernard D. Coleman, (Mellon Institute), Fred Gornick (NBS Macromolecules Synthesis and Structure Section), and George Weiss. J. Chemical Physics 39, 3233-3239, Dec. 1963.

Existence of k-edge connected ordinary graphs with prescribed degrees. Jack Edmonds. J. of Research NBS 68B, No. 2, pp. 73-74, 1964.

On Rayleigh's non-linear vibration equation. A. Ghaffari. Proc. of the International Symposium on Non-Linear Vibrations, Kiev, USSR, September 12-18, 1961, Vol II, pp. 130-133.

A generalization of Rennie's inequality. A. J. Goldman. J. of Research NBS, 68B, No. 2, pp. 59-64, 1964.

Optimal matchings and degree-constrained subgraphs. A. J. Goldman. J. of Research NBS, 68B, No. 1, pp. 27-30, 1964.

A note on some quadrature formulas for the interval $(-\infty, \infty)$. S. Haber. Mathematics of Computation, Vol. 18, 313-314, 1964.

Weierstrass points of $\Gamma_0(n)$. J. Lehner and M. Newman. Annals of Mathematics, 79, No. 1 360-368, 1964.

A complete description of the normal subgroups of genus one of the modular group. M. Newman. American Journal of Mathematics, 86, 17-24, 1964.

Free subgroups and normal subgroups of the modular group. M. Newman. Illinois J. of Mathematics, 8, 262-265, 1964.

Error analysis of Miller's recurrence algorithm. F. W. J. Olver. Mathematics of Computation, 18, No. 85, pp. 65-74, Jan. 1964.

Error bounds for asymptotic expansions in turning-point problems. F. W. J. Olver. J. of the Society for Industrial and Applied Mathematics, 12, No. 1, pp. 200-214, March 1964.

Error bounds for asymptotic expansions with an application to cylinder functions of large argument. F. W. J. Olver. Proc. of a Symp. on Asymptotic Solutions of Differential Equations and their Applications (Madison, Wisconsin, 1964). New York, John Wiley, 1964.

Determinations based on duplication of readings. Janace A. Speckman. J. Res. NBS, 68B, No. 2, pp. 49-53, Apr.-June 1964.

Miscellaneous studies in probability and statistics: distribution theory, small-sample problems, and occasional tables. Statistical Engineering Laboratory. NBS Tech. Note No. 238, April 1964.

On an extreme rank sum test for outliers. W. A. Thompson, Jr., and T. A. Willke. Biometrika, 50, part 3 & 4, 375-383, Dec. 1963.

Fitting $y = \beta x$ when the variance depends on x. John Van Dyke. J. Research NBS, 68B, No. 2, 67-72, April-June 1964.

A note on a generalized elliptic integral. George H. Weiss. J. Research NBS, 68B, No. 1, pp. 1-2, Jan.-March 1964.

Calculation of certain multiple generating functions. George H. Weiss. J. Research NBS, 68B, No. 1, pp. 13-15, Jan.-March 1964.

Effects of a distribution of gap acceptance functions on pedestrian queues. George H. Weiss. J. Research NBS, 68B, No. 1, pp. 31-33, Jan.-March, 1964.

A simple derivation of the Faxén solution to the Lamm equation. George Weiss. J. Math. Phys. 5, 675-676, 1964.

Exact Faxén solution for centrifugation when sedimentation depends linearly on concentration. George Weiss and Irwin H. Billick (Macromolecules Synthesis and Structure Section). Nature 201, 912-913, Feb. 29, 1964.

General application of Youden's rank sum test for outliers and tables of one-sided percentage points. Thomas A. Willke. J. Research NBS 68B, 55-58, April-June 1964.

An all-integer programming algorithm with parabolic constraints. C. Witzgall. J. Soc. Ind. Appl. Math. 11, No. 4, pp. 855-871, 1963.

La revolución Fisheriana en los metodos de experimentación. W. J. Youden. Estadística, J. of the Inter-American Statistical Institute, Sept. 1963. (Translation of "The Fisherian revolution in methods of experimentation", J. Am. Statist. Assoc. 46, pp. 47-50, 1951).

Statistics in its proper place. W. J. Youden. J. Wash. Academy of Sci. 54, pp. 53-57, Mar.1964.

1.4 Reviews and Notes

Examples relating to the simplex method. A. J. Goldman and Daniel Kleinman. Operations Research 12, (Letters to the Editor), No. 1, pp. 159-161, 1964.

Digital information Processors. Reviewed by H. Oser. Math. of Comp. 18, No. 86, pp. 340-343, April 1964.

Studies in Management Science and Applied Probability. Reviewed by George H. Weiss. Technometrics, 4, No. 4, pp. 616-617, Nov. 1962.

## 2. MANUSCRIPTS IN THE PROCESS OF PUBLICATION

### 2.3 Technical Papers

Non-equilibrium thermodynamics of canonically invariant relaxation processes. H. Andersen, I.Oppenheim, K. Shuler (Director's Office), and G. H. Weiss. Submitted to a technical journal.

Thermodynamics of perfect elastic fluids. B. Bernstein, E. A. Kearsley, and L. J. Zapas. Submitted to J. of Research NBS, Section B, Math. and Math. Physics.

Evaluation of exact solutions to the Lamm equation. I. Billick (Macromolecules Synthesis and Structure Section) and G. H. Weiss. Submitted to a technical journal.

A simple method for calculating orthogonal bases for a vector space and its complement. J. M. Cameron. Submitted to a technical journal.

Use of general purpose coding systems for statistical calculations. J. M. Cameron and J. Hilsenrath (NBS Equation of State Section). To appear in Proc. of IBM Symposium on Scientific Computing.

Paths, trees and flowers. Jack Edmonds. To appear in the Canadian J. of Math.

On the surface duality of linear graphs. Jack Edmonds. Submitted to a technical journal.

On matching problems. J. Edmonds, A.J. Goldman, C. Witzgall, C.T. Zahn, Jr. To appear in Proceedings of the Army Research Office (Durham).

Hadamard matrices of order cube plus one. K. Goldberg. Accepted for publication in the Proc. of the Am. Math. Soc.

Generation and composition of functions. A. J. Goldman. Submitted to a technical journal.

Entire functions all of whose derivatives are integral at the origin. F. Gross. To appear in the Duke Mathematical Journal.

Entire Solutions of the functional equation $h(f(z)) = g(z)$. Fred Gross. To appear in Proc. of the Am. Math. Soc.

Functional equations and fix-points. Fred Gross. To appear in the Pacific J. of Math.

The inverse multiplier for Abelian group difference sets. E.C. Johnsen. To appear in Canadian J. of Math.

Computer interpretation of english text and picture patterns. R. A. Kirsch. To appear in the Inst. of Electrical and Electronic Engineers Trans. on Electronic Computers, Aug. 1964.

A new differential operator of the pure wave type. J.E. Lagnese. To appear in Contributions to Differential Equations.

Representations of Discrete Groups. Joseph Lehner. To appear in Number Theory Symposium of the Am. Math. Soc.

Almost primes generated by a polynomial. R. Miech. To appear in Acta Arithmetica.

Connection between shielding and stability in a collisionless plasma. E. Minardi, F. Englemann, and M. Feix. To appear in Il Nuovo Cimento.

Symplectic modular groups. M. Newman and J. R. Smart. To appear in Acta Arithmetica.

Note on the partition function. M. Newman. To appear in American Mathematical Monthly.

Normal subgroups of the modular group which are not congruence subgroups. M. Newman. To appear in Proc. of the Am. Math. Soc.

Congruence subgroups of positive genus of the modular group. M. Newman, M. Knopp. To appear in Ill. J. of Math.

On the asymptotic solutions of second-order differential equations having an irregular singularity of rank one. F.W.J. Olver. Submitted to a technical journal.

Whittaker functions of large argument. F.W.J. Olver. Submitted to a technical journal.

Relaxation of a Lorentz gas with a repulsive $r^{-s}$ force law. H. Oser, K. Shuler (Director's Office), and G. H. Weiss. Submitted to a technical journal.

Some remarks on Certain Generalized Dedekind Sums. Hans Rademacher. To appear in Acta Arithmetica.

The spheroidal method in the theory of the orbit of an artificial satellite. J. P. Vinto. To appear in the Proceedings of the Symposium on Celestial Mechanics, held March 1964, at the Mathematische Forschungsinstitut at Oberwolfach, West Germany.

On convex metrics. C. Witzgall. Submitted to a technical journal.

Sampling and statistical design. W. J. Youden. To appear in Proceedings, Symposium on Environmental Measurements, U. S. Public Health Service, 1963.

The evolution of designed experiments. W. J. Youden. To appear in Proceedings, IBM Symposium on Scientific Computing.

Approximating symmetric relations by equivalence relations. C. T. Zahn, Jr. Submitted to a technical journal.

## 2.4 Reviews and Notes

Realization of semi-multipliers as multipliers. Harriet Fell and A. J. Goldman. To appear in Am. Math. Monthly (Math. Notes).

Barely faithful algebras. Harriet Fell and John Mather. To appear in Am. Math. Monthly (Math. Notes).

Tables of the cumulative binomial probability distribution for small values of p. Reviewed by H. Oser. To appear in Science.

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