

# NATIONAL BUREAU OF STANDARDS REPORT

8675

## PROJECTS and PUBLICATIONS of the APPLIED MATHEMATICS DIVISION

A Semiannual Report  
July through December 1964



U.S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS

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\* NBS Group, Joint Institute for Laboratory Astrophysics at the University of Colorado.

\*\* Located at Boulder, Colorado.

# NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT

205.0

NBS REPORT

8675

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A Semiannual Report  
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U.S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS  
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# APPLIED MATHEMATICS DIVISION

July through December 1964

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\* Part time

<sup>o</sup> On leave of absence

\*\* Postdoctoral Resident Research Associate

<sup>oo</sup> Temporary appointment

\*\*\* Guest worker

<sup>ooo</sup> Student trainee

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# Status of Projects

## 1. NUMERICAL ANALYSIS

### RESEARCH IN NUMERICAL ANALYSIS AND RELATED FIELDS Task 20501-12-2050110/55-55

Origin: NBS  
Manager: Morris Newman  
Full task description: July - September 1954 issue, p. 1

Authorized 8/29/54

Status: CONTINUED. M. Newman and J. Lehner have determined all the real 2-dimensional representations of the free product of 2 finite cyclic groups. They have also classified and described those discontinuous groups of real linear fractional transformations whose associated Riemann surface possesses the maximum number of automorphisms.

M. Newman has given a proof of a theorem on the automorphs of skew-symmetric matrices of use in the classification of quotient groups of matrices.

S. Haber proposed a version of his modified Monte-Carlo quadrature which would automatically use a form of the "Method of Antithetic Variates" of Hammersly and Morton. A theoretical analysis of this procedure was begun and numerical experiments planned. He continued studies related to fix-points of entire functions, and obtained new proofs of classical theorems of E. Borel on the growth of entire functions.

K. Goldberg investigated the problem of finding the maximum determinant of those row-stochastic matrices which transform a fixed real vector into a non-negative one. He solved the related problem of finding  $\max \prod_{i=1}^n x_i$  with  $\sum_{i=1}^n x_i$  fixed and  $a_i \geq x_i \geq 0$ ,  $i = 1, 2, \dots, n$  for a given set of positive  $a_i$ . He also solved another related problem: which real matrices take (non-negative) ordered vectors into (non-negative) ordered matrices such that their inverses have the same property?

R. A. Brualdi completed the two papers: "A note on multipliers of difference sets" and "Kernels and the Kronecker product of graphs".

F. W. J. Olver is continuing his work in asymptotic expansions under Task 20501-11-2050421/63.

#### Publications:

- (1) On a problem of G. Sansone. M. Newman. Annali di Matematica, Pura ed Applicata (4) 65, 27-34 (1964).
- (2) Symplectic modular groups. M. Newman and J. R. Smart. Acta Arithmetica, Vol. 9, 83-89 (1964).
- (3) Note on the partition function. M. Newman. American Mathematical Monthly, Vol. 71, p. 1022 (1964).
- (4) Character subgroups of F-groups. M. I. Knopp and M. Newman. To appear in the Journal of Research NBS.
- (5) A theorem on the automorphs of a skew-symmetric matrix. M. Newman. To appear in the Michigan Mathematical Journal.
- (6) Bounds for class numbers. M. Newman. To appear in American Mathematical Society Proceedings of Symposium for Number Theory.
- (7) A bounded automorphic form of dimension zero is constant. M. I. Knopp, J. Lehner, M. Newman. To appear in Duke Mathematical Journal.
- (8) Normal subgroups of the modular group which are not congruence subgroups. M. Newman. To appear in Proceedings of the American Mathematical Society.
- (9) Congruence subgroups of positive genus of the modular group. M. Knopp, M. Newman. To appear in Illinois Journal of Mathematics.

## Status of Projects

- (10) A functional inequality. S. Haber. Submitted to a technical journal.
- (11) Hadamard matrices of order cube plus one. K. Goldberg. Submitted to Proceedings of the American Mathematical Society.
- (12) Convergence and abstract spaces in functional analysis. E. Oruman. Submitted to a technical journal.
- (13) The zeros of infrapolynomials with prescribed values at given points. J. L. Walsh and O. Shisha. Proceedings of the American Mathematical Society, Vol. 14, No. 5, 839-844 (Oct. 1963).
- (14) Zeros of polynomials and fractional order difference of their coefficients. G. T. Cargo and O. Shisha. Journal of Mathematical Analysis and Applications, Vol. 7, No. 2, 176-182 (Oct. 1963).
- (15) On the structure of infrapolynomials with prescribed coefficients. O. Shisha. Pacific Journal of Mathematics, Vol. 14, No. 3, 1039-1051 (1964).
- (16) On the location of the zeros of some infrapolynomials with prescribed coefficients. O. Shisha and J. L. Walsh. Pacific Journal of Mathematics, Vol. 14, No. 3, 1103-1109 (1964).
- (17) The inverse multiplier for abelian group difference sets. E. C. Johnsen. Canadian Journal of Mathematics, Vol. 16, 787-796 (1964).
- (18) Almost primes generated by a polynomial. R. Miech. Acta Arithmetica, Vol. 10, 9-30 (1964).
- (19) Entire functions all of whose derivatives are integral at the origin. F. Gross. Duke Mathematical Journal, Vol. 31, No. 4, 617-622 (1964).
- (20) Entire solutions of the function equation  $\alpha(\beta(z)) = \alpha(\gamma(z)) + c$ . F. Gross. Submitted to Duke Mathematical Journal.
- (21) An analogue of Fermat's last theorem for entire functions. F. Gross. Submitted to American Mathematical Monthly Notes.
- (22) Functional equations and fix points. F. Gross. Submitted to the Pacific Journal of Mathematics.
- (23) Entire solutions of the functional equation  $h(f(z)) = g(z)$ . F. Gross. Submitted to the Proceedings of the American Mathematical Society.
- (24) A note on multipliers of difference sets. R. A. Brualdi. To appear in the Journal of Research NBS.

### RESEARCH IN MATHEMATICAL TOPICS APPLICABLE TO NUMERICAL ANALYSIS Task 20501-12-2050411/55-56

Origin: NBS  
Sponsor: Office of Naval Research  
Manager: Morris Newman  
Full Task description: July-September 1954 issue, p. 5  
Status: COMPLETED.

Authorized 8/13/54

### ASYMPTOTIC EXPANSIONS Task 20501-11-2050421/63

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

Authorized 9/10/63

Status: CONTINUED. F. W. J. Olver has completed a rigorous error analysis of phase-integral methods for second-order ordinary differential equations in a domain containing a simple turning point. Applications to wave-penetration problems are now being studied.



## Status of Projects

### Publications:

- (1) On the asymptotic solutions of second-order differential equations having an irregular singularity of rank one, with an application to Whittaker functions. F. W. J. Olver. To appear in the Journal of the Society for Industrial and Applied Mathematics. (This paper combines papers (2) and (3) reported Jan-June 1964.)
- (2) Error bounds for asymptotic solutions of second-order differential equations having an irregular singularity of arbitrary rank. F. W. J. Olver and F. Stenger. To appear in the Journal of the Society for Industrial and Applied Mathematics.

## Status of Projects

### Publications:

- (1) On the asymptotic solutions of second-order differential equations having an irregular singularity of rank one, with an application to Whittaker functions. F. W. J. Olver. To appear in the Journal of the Society for Industrial and Applied Mathematics. (This paper combines papers (2) and (3) reported Jan-June 1964.)
- (2) Error bounds for asymptotic solutions of second-order differential equations having an irregular singularity of arbitrary rank. F. W. J. Olver and F. Stenger. To appear in the Journal of the Society for Industrial and Applied Mathematics.

## 2. MATHEMATICAL TABLES AND PROGRAMMING RESEARCH

### 20502-40-2050121/57-0216 MATHEMATICAL TABLES

Origin and Sponsor: NBS

Manager: I. A. Stegun

Objective: To continue work on long-range mathematical tables projects, update, correct and reissue already published tables.

Background: Many tables projects were inactive during past years as priority was given to the completion of AMS-55 -- The Handbook of Mathematical Functions. Progress on these tasks will continue as dictated by the relative priority in the overall program of the Laboratory and by available funds.

Status: CONTINUED. Tables of Power Points of Analysis of Variance Tests and Tables of the Sievert Integral are being prepared for publication. An errata list has been prepared for AMS-55 and current printings are being corrected.

### 20502-12-2050122/63-1999 CURRENT RESEARCH IN THE COMPUTATION LABORATORY

Origin and Sponsor: NBS, Section 205.02

Manager: I. A. Stegun

Full task description: July-December 1963 issue, p. 3

Status: INACTIVE.

### 20502-12-2050120/55-0065 AUTOMATIC CODING

Origin and Sponsor: NBS

Manager: G. W. Reitwiesner

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

Status: CONTINUED. During the third quarter of 1964, task 0065 was used to complete and to report upon a test of computer indexing performance through matrix inversion by partitioning.

### 3. PROBABILITY AND MATHEMATICAL STATISTICS

#### RESEARCH IN PROBABILITY AND MATHEMATICAL STATISTICS

Task 20503-12-2050131/63-1259

Origin: NBS

Authorized 10/1/62

Manager: Joan Raup Rosenblatt

Full task description: July - December 1962

Status: Continued. Thomas A. Willke is preparing a note describing the performance of Chauvenet's criterion for rejection of outlying observations (Wm. Chauvenet, Spherical and Practical Astronomy. Vol. II, J. B. Lippincott Co., Philadelphia, 1891, p. 564). Although many other rules have been proposed by modern writers, advocates of Chauvenet's rule are still found. Dr. Willke, employing tabulations of the distribution of extreme order statistics and also empirical sampling techniques, shows that the Chauvenet rule leads to the rejection of about 25 percent of good observations in samples of size 10 from a normal distribution, when the standard deviation is known. When the sample standard deviation  $s = \sum(x_i - \bar{x})^2/(n - 1)$  is used, the rejection rate is about 35 percent. And if  $(n - 1)$  is replaced by  $n$  in  $s$ , then the rejection rate rises to 40 percent. Similar results are given for other small sample sizes.

J. M. Cameron has begun work on calibration and weighing designs, a summary of this problem area being given in an address at the annual meeting of the American Statistical Association in Chicago. In addition he has prepared a note on three algorithms for computing the generalized inverse of a matrix.

In response to a question raised by W. J. Youden, Joan R. Rosenblatt has found that the "outlier" in a set of three observations is also the observation closest to the true mean about three times in ten. More precisely: among three independent, identically distributed normal random variables, the one whose value is farthest from the sample mean is the same as the one closest to the true mean with probability

$$\frac{3}{\pi} \arcsin \left( \frac{\sqrt{3}}{6} \right) = .28.$$

This result appears to be moderately robust, at least for symmetric distributions, since the corresponding probability is one-third for the rectangular distribution and  $7/30 = .23$  for the double-exponential distribution. The probability that the sample median is the observation closest to the true mean is exactly one-half for a sample of three from continuous symmetric distribution; this statement is equivalent to the proposition that  $(X_{(1)} + X_{(2)})/2$  and  $(X_{(2)} + X_{(3)})/2$  are distribution-free confidence limits for the mean at the probability level 0.50 (derivable from the Wilcoxon signed-ranks test).

Joan R. Rosenblatt has been investigating a conjecture by Churchill Eisenhart that some one of the observations in a sample is closer to the population mean than is the sample mean. The conjecture is that for samples of  $n$  observations from a continuous distribution with zero mean,

$$\Pr\{\bar{x}^2 < \min(x_1^2, \dots, x_n^2)\} \rightarrow 0 \text{ as } n \rightarrow \infty.$$

## Status of Projects

### Publications:

- (1) 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.
- (2) A simple method for calculating orthogonal bases for a vector space and its complement. J. M. Cameron. Submitted to a technical journal.
- (3) Estimation for a one-parameter exponential model. Janace A. Speckman and Richard G. Cornell (Florida State University). To appear in the Journal of the American Statistical Association.
- (4) Chapter IC - Statistical Concepts of a Measurement Process, and Chapter ID - Statistical Analysis of Measurement Data. H. H. Ku. To appear in Industrial Metrology, American Society of Tool and Manufacturing Engineers.
- (5) Realistic evaluation of the precision and accuracy of instrument calibration systems. Churchill Eisenhart. Proceedings of the Ninth Conference on the Design of Experiments in Army Research Development and Testing, ARO-D Report 64-2, Office of the Chief of Research and Development, U. S. Army, 1964, pages 469-536. (Reprinted from J. Research, NBS - C. Engineering and Instrumentation, 67C, 1963, pages 161-187.)

## MEASUREMENT OF RELIABILITY

Task 20503-12-2050130/56-182

Origin: NBS  
Manager: Joan R. Rosenblatt  
Full task description: January - March 1956 issue, p. 13

Authorized 3/23/56

Status: INACTIVE.

4. MATHEMATICAL PHYSICS  
RESEARCH IN MATHEMATICAL PHYSICS AND RELATED FIELDS  
Task 20504-12-2050141/55-57

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

Authorized 9/1/54

Status: CONTINUED. Dr. B. Bernstein of this section, together with Dr. E.A. Kearsley and Mr. L. Zapas, of 213.05, are continuing their study of the implications for material behavior implicit in their theory of the perfect elastic fluid.

Investigations concerning the elasticity inherent in their theory have shown that such a material exhibits an apparent elasticity, with a strain energy which depends upon the past history of the material. This is a continuation of the study to show how viscous and elastic effects manifest themselves in a visco-elastic fluid.

Formal solutions of the problem of determining the stress response to various strain histories in different geometries are being obtained and catalogued. This will facilitate the process of checking the theoretical predictions with experimental data.

In connection with this work, Mr. Zapas has been able to correlate the responses in different types of motions with the use of this theory. These motions have included stress relaxation, creep, recovery, and constant rate of strain in simple extension, biaxial strain, and pure shear in situations approximated by stress relaxation, and in steady simple shear flows. Good agreement with measured relations of viscosity to rate of shear has been obtained.

Drs. L.E. Payne and J.H. Bramble have completed a study of a priori bounds for the solutions of the equations of classical incompressible elasticity, and a manuscript on this has been prepared. The results are expected to be useful in obtaining pointwise bounds for the steady-state solutions of the Navier-Stokes equations.

Drs. Payne and Bramble are currently investigating the question of obtaining bounds in the case of problems for which the equations describing their motion are coupled non-linearly. Examples of such equations may be found in the theory of thermoelasticity.

Dr. W.H. Pell has continued his collaboration with Mr. A. Kirstein, of Section 213.04 on the development of criteria for the design of machine elements which are elastic circular plates under point loads equi-angularly spaced on a circle concentric with the boundary. The relevant theory has been developed previously, and is now being applied to specific cases for which experimental data are available. The check of experimentally obtained deflections with theory is strikingly good. The process of calculating slopes, stresses, and strains and comparison with experimental values is now under way.

## Status of Projects

### Publications:

- (1) Thermodynamics of perfect elastic fluids. B. Bernstein, E.A. Kearsley, and L.J. Zapas. Journal of Research NBS, 68B, pp. 103-113, 1964.
- (2) Elastic stress-strain relations in perfect elastic fluids. B. Bernstein, E.A. Kearsley, and L.J. Zapas. Submitted to Trans. Soc. Rheology.
- (3) A new differential operator of the pure wave type. J.E. Lagnese. To appear in Journal of Differential Equations.

## PLASMA RESEARCH

Task 20504-12-2050140/59-442

Origin: NBS

Authorized 6/30/59

Manager: C.M. Tchen

Full task description: April-June 1959 issue, p. 15

Status: CONTINUED. Dr. C.M. Tchen has continued his research on plasmas during this period largely in the two areas indicated below:

- (1) Spectra of turbulence and magnetic field in the photosphere.

The exchange of energy from that of the turbulence in a plasma into the magnetic field causes a damping of the turbulence by magnetic fluctuations. A theory has been based on this mechanism which has been used to interpret magnetograph data in the photosphere by Vasilyeva.

- (2) Anomalous diffusion across a magnetic field.

The diffusion is controlled by collision and by collective motion. The collective motion consists of oscillations and turbulence. A general formula of diffusion has been developed and study is currently under way on the role of turbulence.

### Publication:

- (1) Stochastic theory of diffusion in a plasma across a magnetic field. C.M. Tchen. To appear in the Proceedings of the International Symposium on Plasma Diffusion, Feldafing, Germany, June 29-July 3, 1964.



## DYNAMICS OF PLASMAS

Task 20504-12-2050417/62-1157

Origin: NBS  
Sponsor: National Aeronautics and Space Administration  
Manager: C.M. Tchen  
Full task description: October-December 1961 issue, p. 12

Authorized 10/3/61

Status: CONTINUED. Dr. C.M. Tchen has continued his researches on the magnetohydrodynamic and kinetic theories of plasmas. Emphasis in this period has been on an investigation relative to the spectrum of stationary homogeneous magnetohydrodynamic turbulence.

The equations determining the spectral distributions of kinetic and magnetic energies are formulated from the magnetohydrodynamic equations. The exchange of energy between the turbulence and the magnetic field is treated by the method of the reduction of the quadruple correlation. The transfer of energy between the harmonics is investigated by a transport theory based on the mixing length and on the antisymmetry property of the transfer. The turbulent and magnetic spectra are obtained for the various ranges of interest. The results reduce to those of the Kolmogoroff-Heisenberg theory in the framework of the hydrodynamic turbulence. A manuscript has been prepared and submitted to a scientific journal for publication.

Work has been continued in the following two areas: (a) Nonlinear oscillations in a plasma, (b) One-dimensional problems of the interaction of a plasma with a magnetic field.

### Publications:

- (1) Plasma oscillations with collective correlations. C.M. Tchen. Proceedings of the 6th International Conference on Ionization Phenomena in Gases, Paris, July 8-13, 1963, vol. I, pp. 195-199.
- (2) Spectrum of stationary homogeneous magnetohydrodynamic turbulence. C.M. Tchen. Submitted to a scientific journal.

## THEORY OF SATELLITE ORBITS

Task 20504-12-2050441/62-1166

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

Authorized 1/9/62

Status: CONTINUED. Dr. J.P. Vinti prepared for publication, in the Proceedings of the Symposium on Celestial Mechanics at the Mathematisches Forschungsinstitut in Oberwolfach, Germany, a paper delivered there on March 19, 1964, on "The Spheroidal Method in the Theory of the Orbit of an Artificial Satellite."

## Status of Projects

On August 22, 1964, Dr. Vinti presented a paper at Symposium 25 of the International Astronomical Union, held at Thessaloniki, Greece, the title being "Effects of a Constant Force on a Keplerian Orbit." It has now been prepared for publication in the Proceedings of Symposium 25. The new results on this topic include a method for resolving the Hamiltonian, after calculating the first-order terms and splitting off the second-order short-periodic terms, into long-periodic and secular terms. In contradistinction to the case where the perturbing potential is a zonal harmonic, this resolution requires use of an infinite Fourier series rather than a trigonometric polynomial. It is feasible whenever the applied force lies outside the plane of the orbit. In the coplanar case the orbit eventually intersects the earth, so that the long-periodic and second-order terms are of less interest.

### Publications:

- (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.
- (2) Effects of a constant force on a Keplerian orbit. J.P. Vinti. To appear in Proceedings of Symposium 25 of the International Astronomical Union, Thessaloniki, Greece, August 15-22, 1964.

## 5. OPERATIONS RESEARCH

### OPERATIONS RESEARCH

Task 205-12-2050115/61-546

Origin and Sponsor: NBS  
Manager: Alan J. Goldman

Authorized 12/30/60

Full task description: October-December 1960 issue, p. 3

Status: CONTINUED. The following activities were carried out by members of the staff:

(1) The Operations Research Section has put special emphasis on performing and promoting research on theory and computational methods for the optimization and arrangement of discrete systems which arise in industry and technology. In particular, project funds support much of the activity reported separately under Combinatorial Mathematics, including the two week conference on Matroid Theory organized by J. Edmonds.

(2) P. Meyers continued research on remetrizing a space so as to make the Banach Contraction Theorem applicable. He proved that this was possible for certain classes of "local contractions" and also showed how the topological conclusions of the theorem could be augmented by one more simple conclusion so that the converse of the theorem would also hold modulo a remetrization.

(3) A.J. Goldman proved that a proposed variation of the multi-dimensional Riemann integral yielded a trivial theory (constants "essentially" the only integrable functions). He investigated questions arising in Lebesgue measure and integration theory, which point up the following unresolved problem: For every real set  $B$  which is not Borel, is there a Lebesgue-measurable function  $f$  such that  $f^{-1}(B)$  is not Lebesgue-measurable?

D. Kleinman investigated "simplest representation" problems for weighted quota games. John Mather used abstract-algebra techniques to derive lower bounds, sharp in some cases, for the minimum number of multiplications and divisions needed to evaluate rational functions. K. Kloss developed a technique for testing primeness of an integer, which has proved at least 10 times as fast as previous methods. C. Witzgall began investigation of the combinatorial structure of orthogonal linear manifolds, with the aim of obtaining new optimization methods from Lemke's recent solution method for bimatrix games. He and A.J. Goldman studied the application of linear programming to efficient determination of the extreme points (half-spaces) of the convex hull (intersection) of a finite family.

(4) L.S. Joel continued work and consultation on modelling some aspects of the textile industry, and J. Levy continued 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. 4270697.)

J. Levy and A.J. Goldman continued studies of the effects of buffer capacity in certain mail sorting systems. C. Witzgall and J. Levy began a comparative study of best-path algorithms. C. Witzgall improved and documented a computer code for finding the transportation-cost-minimizing location of a central facility, assuming (a) costs proportional to Euclidean distance, and (b) a distribution of customers which is a finite superposition of uniform distributions over polygons. P. Meyers expanded previous work on cost-benefit analysis of address-code abbreviation rules in mail sorting systems, and also extended some of C. Witzgall's simple models of optimal location problems. D. Kleinman completed work on the simulation of certain sorting systems. (Reported here for convenience; supported under Project No. 4230450.)

K. Kloss designed and implemented an assembly language for the NBS PILOT computer. The language, called "PEAP" (Pilot Extended Assembly Program) is patterned after the IBM language "FAP" omitting the subroutine and macro abilities of FAP, and incorporating some novel features not found in other assembly languages. He worked on the design of a comprehensive loading program; a preliminary version is now running. Both PEAP and the loader have been used and found satisfactory by a number of programmers. (Reported here for convenience; supported under Project No. 4230152.)

A.J. Goldman continued collaboration with Dr. B. Levin (Transport Systems Section) on a survey of mathematical and simulation models relevant for transportation research and development. He participated in the NBS summer conference on transport systems analysis, and in the preparation of its report. (Reported here for convenience; supported under Project No. 4260407.)

(5) Miscellaneous consulting and advisory services were largely devoted to NBS' preparation for contributing to the Commerce Department's Northeast Corridor Transportation Study. Other recipients included the Budget Bureau, the Commerce Department's Panel on Transportation Research and Development, Catholic University, University of Maryland, IBM, and members of seven NBS divisions.

#### Publications:

- (1) Generation and composition of functions. A.J. Goldman. Journal of Research NBS, 68B, No. 3, pp. 99-101, 1964.
- (2) Equivalence of certain inequalities complementing those of Cauchy-Schwarz and Hölder. J.B. Diaz, A.J. Goldman and F.T. Metcalf. Journal of Research NBS, 68B, No. 4, pp. 147-149, 1964.
- (3) Weak generalized inverses and minimum variance linear unbiased estimation. A.J. Goldman and M. Zelen. Journal of Research NBS, 68B, No. 4, pp. 151-172, 1964.
- (4) A variant of the two-dimensional Riemann integral. A.J. Goldman. To appear in Journal of Research NBS, 69B, 1965.
- (5) On measurable sets and functions. A.J. Goldman. To appear in Journal of Research NBS, 69B, 1965.
- (6) Some extensions of Banach's contraction theorem. P. Meyers. To appear in Journal of Research NBS, 69B, 1965.
- (7) On convex metrics. C. Witzgall. Submitted to a technical journal.
- (8) Approximating symmetric relations by equivalence relations. C.T. Zahn, Jr. To appear in Journal Soc. Ind. Appl. Math.
- (9) Realization of semi-multipliers as multipliers. Harriet Fell and A.J. Goldman. To appear in Amer. Math. Monthly (Math. Notes).
- (10) Barely faithful algebras. Harriet Fell and John Mather. To appear in Amer. Math. Monthly (Math. Notes).

#### SST ECONOMIC ANALYSIS

Task 20505-12-2050451

Origin: Commerce Dept. (SST Economic Analysis Study)

Authorized 8/10/64

Sponsor: Federal Aviation Agency

Managers: A.J. Goldman (205.05), W.G. Hall (205.02)

Objective: To provide expertise and technical services on the mathematical, simulation, and computational aspects of the Commerce Department's economic analysis of the proposed commercial supersonic transport plane.

Background: This analysis is being undertaken by the Department at the request of the President, who has directed that it be given high priority.

Status: NEW. (1) A simulation model for competition among carriers and aircraft types over world routes was developed, implemented in a digital computer program, and documented in its present rough form. Analytically tractable approximations to this model were investigated, with special attention to the convergence of plausible iterative methods to a competitive equilibrium. (2) Familiarization with and adaptation of simulation models developed by Project contractors were achieved. An efficient algorithm based on dynamic programming ideas was developed for the problem of finding the maximum-profit-before-maintenance routing of a vehicle which accrues profit  $p(i,j)$  and requires time  $t(i,j)$  in going from city  $C_1$  to  $C_j$ , and which needs maintenance --- available at only some of the cities --- after at most  $T$  hours. (3) A conceptual framework has been developed in which to determine the rates of return and present worths -- to U.S. government, manufacturers, airlines, or a composite of all three --- of various policy alternatives and technological possibilities.



This "cost-benefit" model has been largely implemented in a computer program, with elaborate book-keeping features to permit easy case specification by the user. (4) To provide numerical inputs for other Project activities, relations developed by Project contractors and the FAA for estimating advanced aircraft costs (development, production, operational) from engineering data have been expressed in digital computer programs. (5) Work is in progress on developing a model and computer program for estimating the effects on U.S. balance of payments of various possible outcomes of the introduction of new aircraft types.

#### COMMERCIAL REFILE PROBLEM DCA

Task 205-12-2050465/63-1494

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: TERMINATED. Previous results were orally communicated to the sponsor. Jack Edmonds extended A. Lehman's theory of "Shannon switching games". These include a game played alternately by "Cut", who at each turn destroys an unprotected link of the given network, and "Short" who at each turn protects an undestroyed link of the network. The objective of "Short" is to protect some subnetwork which connects together a prescribed subset of the nodes. Edmonds has provided an efficient algorithm for determining the winner and a winning strategy. In addition, he obtained theorems on the existence of several linkwise disjoint and nodewise identical connecting subnetworks.

Publication:

On Lehman's switching game and a theorem of Tuttle and Nash-Williams. Jack Edmonds. To appear in Journal of Research NBS, 69B, 1965.

#### COMBINATORIAL MATHEMATICS

Task 205-12-2040455/62-1205

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 obtained results on matchings in ternary graphs.

J. Mather proved Rota's conjecture on the homology invariance of certain complexes associated with a finite abstract lattice.

J. Edmonds obtained an efficient algorithm for "the Chinese postman's problem", finding a tour in a given network which traverses each arc at least once and which has minimum length. The method is applied to decoding certain error-correcting codes.

Edmonds continued investigations on matroids. Efficient algorithms were obtained (1) for selecting from a set of vectors, carrying numerical weights, a basis with minimum total weight; (2) for selecting from a set of vectors a maximum number of mutually disjoint bases; (3) for covering a set of vectors by a minimum number of its bases; (4) for analyzing "switching games".

A seminar on matroids was held at NBS, Aug. 31 - Sept. 11, 1964. Thirty U.S. and Canadian mathematicians participated. There were about four lectures each day for nine days. Several related papers (including W.T. Tutte's extensive "Lectures on Matroids") and a report on the seminar will appear in the NBS Journal of Research, 69B, 1965.

Publications:

- (1) Paths, trees, and flowers. Jack Edmonds. To appear in the Canadian Journal of Mathematics.
- (2) On the surface duality of graphs. Jack Edmonds. To appear in Journal of Research NBS, 69B, 1965.
- (3) Maximum matching and a polyhedron with  $(0,1)$ -vertices. Jack Edmonds. To appear in Journal of Research NBS, 69B, 1965.
- (4) A modification of Edmonds' maximum matching algorithm. C. Witzgall and C.T. Zahn, Jr. To appear in Journal of Research NBS, 69B, 1965.
- (5) Minimum partition of a matroid into independent subsets. Jack Edmonds. To appear in Journal of Research NBS, 69B, 1965.
- (6) On Lehman's switching game and a theorem of Tutte and Nash-Williams. To appear in Journal of Research NBS, 69B, 1965.
- (7) Invariance of the homology of a lattice. J. Mather. Submitted to a technical journal.



## 6. MATHEMATICAL AND COMPUTATIONAL SERVICES

### 20502-40-2050645/56-0186 MECHANICAL MEASUREMENTS OF GAGE BLOCKS

Origin and Sponsor: NBS, Section 212.22

Manager: B. S. Prusch

Full task description: July-September 1956 issue, p. 33

Status: CONTINUED. Computations were performed to check 33 laboratory sets of gage blocks as requested by the sponsor.

### 20502-40-2050647/58-0266 DEPOLYMERIZATION PROCESSES

Origin and Sponsor: NBS, Section 311.13

Manager: R. Zucker

Full task description: July-September 1957 issue, p. 36

Status: CONTINUED. Production runs were made and results submitted to sponsor.

### 20502-40-2050645/58-0339 COMPUTATION OF VISCOELASTICITY PROPERTIES OF MATERIALS

Origin and Sponsor: NBS, Section 213.05

Manager: H. Oser

Full task description: January-March 1958 issue, p. 38

Status: CONTINUED. New objective. Several smaller computer programs were written for the purpose of comparison between recent measurements in the Rheology Section and predictions of the Bernstein-Kearsley-Zapas theory.

### 20502-40-2050645/60-0486 MORSE WAVE FUNCTIONS AND FRANCK-CONDON FACTORS

Origin and Sponsor: NBS, Section 221.01

Manager: R. Zucker

Full task description: January-March 1960 issue, p. 28

Status: CONTINUED. Production runs were made and results submitted to sponsor.

### 20502-40-2050645/60-0513 RADIATIVE ENVELOPES OF MODEL STARS

Origin and Sponsor: National Aeronautics and Space Administration

Managers: P. J. Walsh and S. Haber (205.01)

Full task description: July-September 1960 issue, p. 23

Status: INACTIVE.

### 20502-40-2050645/61-0538 SPECTRAL REFLECTANCE

Origin and Sponsor: NBS, Section 421.8

Managers: S. Haber (205.01) and P. J. Walsh

Full task description: October-December 1960 issue, p. 23

Status: TERMINATED.

### 20502-40-2050647/62-1018 HYDROMAGNETIC PROBLEMS

Origin and Sponsor: Naval Research Laboratory

Manager: Sally Peavy

Objective: An attempt to calculate the dynamic behavior of high temperature plasmas in puls magnetic fields with the use of two fluid (ions and electrons) hydromagnetic equations.

Background: This problem arises from interest in thermonuclear research and general problems of radiation high temperature plasmas.

Status: CONTINUED. Problem is in process of being checked out.

### 20502-40-2050647/62-1022 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. The project is being continued though little work has been done this period.

## Status of Projects

### 20501-12-2050416/62-1091 LOWER BOUNDS FOR EIGENVALUES

Origin: Wright-Patterson AFB

Manager: H. Oser

Full task description: October-December 1961 issue, p. 4

Status: REACTIVATED. The Bazley-Fox technique was used to obtain bounds for eigenvalues for perturbed operators of the Laguerre, Hermite and Legendre types. Denoting these operators by  $L[u] - \lambda v = 0$ , we considered perturbations of the type

$$L[u] - \lambda v = mx^2u$$

where  $0 \leq m \leq 100$ . Upper and lower bounds drift apart with increasing  $m$ , as expected. Detailed results will be reported in the technical literature soon.

### 20502-40-2050647/62-1130 FALLOUT SHELTER COMPUTATIONS

Origin and Sponsor: Office of Civil Defense

Manager: Maxine Paulsen

Full task description: October-December 1961 issue, p. 25

Status: CONTINUED. Processing second generation data through P.C.U. 84.

### 20502-40-2050647/62-1178 LOGARITHMIC COEFFICIENTS

Origin and Sponsor: NBS, Section 310.03

Manager: R. J. Arms

Full task description: January-March 1962 issue, p. 27

Status: DISCONTINUED.

### 20502-40-2050647/62-1179 CATALOGUE INFORMATION

Origin and Sponsor: HDL

Manager: Ruth Varner

Full task description: January-March 1962 issue, p. 27

Status: INACTIVE.

### 20502-40-2050647/62-1189 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: COMPLETED.

### 20502-40-2050647/62-1193 SOLUTION TO SECOND ORDER PARTIAL DIFFERENTIAL ELLIPTIC EQUATIONS

Origin and Sponsor: NBS, Section 221.05

Manager: P. J. Walsh

Full task description: April-June 1962 issue, p. 28

Status: TERMINATED.

### 20502-40-2050647/62-1196 HEAT OF ADSORPTION

Origin and Sponsor: NBS, Section 223.21

Manager: Ruth Varner

Full task description: April-June 1962 issue, p. 29

Status: TERMINATED.

### 20502-40-2050647/62-1203 CYLINDRICAL SHOCK WAVE

Origin and Sponsor: NBS, Section 221.04

Managers: Sally Peavy and S. Haber

Full task description: April-June 1962 issue, p. 30

Status: INACTIVE.

### 20502-40-2050647/63-1240 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: INACTIVE.

## Status of Projects

### 20502-40-2050647/63-1377 WHISKER GROWTH IN A VAPOR ATMOSPHERE

Origin and Sponsor: NBS, Section 312.05

Managers: H. Oser and J. A. Simmons (312.05)

Full task description: January-June 1963 issue, p. 28

Status: COMPLETED. The iterative procedure was completely reprogrammed after preliminary runs indicated rather long execution times. The project was transferred to the Goddard Space Flight Center, National Aeronautical Space Administration, which has taken over the sponsorship.

### 20502-40-2050647/64-1410 INTEGRO-DIFFERENTIAL EQUATIONS

Origin and Sponsor: Institute for Defense Analysis

Manager: R. J. Arms

Full task description: July-December 1963 issue, p. 16

Status: DISCONTINUED.

### 20502-40-2050647/64-1442 COLFACS

Origin and Sponsor: HEW

Managers: Ruth Zucker and J. D. Waggoner

Full task description: January-June 1964 issue, p. 18

Status: COMPLETED.

### 20502-40-2050647/64-1450 GLASS BEAD DATA

Origin and Sponsor: NBS, Section 421.07

Manager: R. Zucker

Full task description: See January-March 1961 issue, p. 22, PARTICLE SIZE CALCULATIONS

Status: INACTIVE.

### 20502-40-2050647/64-1479 NUCLEAR QUADRUPOLE

Origin and Sponsor: NBS, Section 222.04

Manager: P. J. Walsh

Full task description: January-June 1964 issue, p. 21

Status: INACTIVE

### 20502-40-2050647/64-1488 INTERPLANETARY CALCULATIONS

Origin and Sponsor: NASA

Manager: R. J. Arms

Full task description: January-June 1964 issue, p. 22

Status: CONTINUED. Programming is continuing.

### 20502-40-2050647/64-1569 NERVE FIBERS

Origin and Sponsor: U. S. Naval Medical Research Institute

Manager: R. J. Arms

Objective: To solve a nonlinear partial differential equation with rather awkward boundary conditions. In particular, solve a simplified problem of the "steady state" solution.

Background: Problem arises from the study of nerve responses. It is desired to find a mathematical model of nerve stimulation which has theoretical justification and which agrees reasonably with measurements. Problem submitted by Dr. David E. Goldman.

Status: NEW. The steady state problem is solved numerically in some cases. Parameters have not yet been found so that numerical results agree with measurements. The steady problem requires improvement in an iteration phase.

## Status of Projects

20502-40-2050645/62-1027 NEW SYSTEMS

Origin and Sponsor: NBS, Section 205.02

Manager: P. J. Walsh, V. Dantzler, W. Lipton

Full task description: July-September 1961 issue, p. 22

Status: CONTINUED. Version 10 of the IBSYS replaced version 8 of the IBSYS in the early part of September. A series of lectures on the IBSYS were given by some members of the staff during the summer months. APARS, describing known errors, were distributed when this version of the system was placed into operation. The OMNITAB subsystem was expanded to include some new operations and was placed under version 10. A list of the commands available under OMNITAB was also distributed.

A powerful, flexible debugging facility has been introduced into a later version of IBSYS. This version (12) is being prepared for use at NBS and will replace the current version in March, 1965. Most of the errors described in the APARS distributed with version 10 have been removed. A list of APARS which applies to version 12 is under preparation and will be released when version 12 formally becomes the operating version of IBSYS.

20500-12-2050404/65-1456 RESEARCH ON BIOLOGICAL PATTERN DATA PROCESSING

Authorized 1-21-64

Origin: NBS

Sponsor: National Institutes of Health

Manager: Russell A. Kirsch

Full task description: January-June 1964 issue, p. 19.

Status: CONTINUED. Progress has been made in developing grammars for description of articular structure of images. Experiments have been done with language processing using a time-sharing system. Analysis of pictures is being done on the IBM 7094 and Pilot computers, processing data recorded on magnetic tape from pictures scanned on a mechanical scanner at the National Bureau of Standards. Pictorial subjects are prepared at the National Institutes of Health.

A series of ten seminars on Automated Picture and Language Processing was planned by this group and conducted with speakers from NBS and outside organizations interested in research in this field.

20500-12-2050406/65

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: INACTIVE.

### Publications:

- (1) Computer Interpretation of English Text and Picture Patterns. Russell A. Kirsch. IEEE Transactions on Electronic Computers, EC-13:4, August, 1964.
- (2) Some Remarks on Microgrammars. William C. Watt. Proceedings of the Washington Linguistics Club, 2:1, Spring 1964.



## 7. STATISTICAL ENGINEERING SERVICES

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

Task 13911-61-1390951/51-1

Origin: NBS

Authorized 7/1/50

Managers: J. M. Cameron, H. H. Ku

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

Status: CONTINUED. During this period members of the section provided statistical assistance to a number of Bureau personnel. The following are representative examples:

C. Eisenhart, W. J. Youden and J. M. Cameron in collaboration with E. L. Crow and T. Zapf of the NBS Boulder Laboratories presented a 4-day seminar on Precision and Accuracy to personnel of the calibration laboratories at Boulder.

In collaboration with I. Malitson and M. Dodge of the refractometry laboratory, work was begun by J. M. Cameron on a computer program for automation of the analysis, reporting and record keeping of measurements of refractive index. In addition to providing statistical procedures for the surveillance of factors affecting the accuracy and precision of the measurement process, it is planned that the computer output will constitute the laboratory notebook and will include the results of ancillary calculations used to check the data for consistency.

David Hogben worked with W. C. Wolfe (Organic Building Materials Section) on the analysis and interpretation of the results of a long series of experiments on floor tiles.

J. A. Speckman consulted with J. Cross (Pressure and Vacuum Section) and began a study on the precision and accuracy of piston gage calibrations.

#### Publications:

- (1) Relaxation of a Lorentz gas with a repulsive  $r^{-5}$  force law. H. Oser, K. Shuler (Director's Office), and G. H. Weiss. J. Chemical Physics 41, 2661-2665, 1 Nov. 1964.
- (2) Evaluation of exact solutions to the Lamm equation. I. Billick (Macromolecules Synthesis and Structure Section) and G. H. Weiss. Submitted to a technical journal.
- (3) Non-equilibrium thermodynamics of canonically invariant relaxation processes. H. Andersen and I. Oppenheim (Mass. Inst. of Technology), K. Shuler (Director's Office), and G. H. Weiss. J. Chemical Physics 41, 3012-3019, 15 Nov. 1964.
- (4) Sampling and statistical design. W. J. Youden. Proceedings, Symposium on Environmental Measurements, U. S. Public Health Service, 1963. U. S. Government Printing Office, 35-39, July 1964.
- (5) The evolution or designed experiments. W. J. Youden. To appear in Proceedings, IBM Symposium on Scientific Computing.
- (6) Uncertainties associated with proving ring calibration. T. E. Hockersmith (Mechanics Division) and H. H. Ku. To appear in the Transactions of the Instrument Society of America.
- (7) Mortality patterns in eight strains of flour beetles. W. J. Youden, D. B. Mertz and T. Park (Univ. of Chicago). Submitted to a technical journal.
- (8) Evaluation of analytical data. W. J. Youden. To appear in Encyclopedia of Industrial Analysis.

Status of Projects

STATISTICAL SERVICES

Task 20503-40-2050132/58-346

Origin and Sponsors: Various Agencies

Authorized 3/31/58

Manager: J. M. Cameron

Full task description: January-March 1958 issue, p. 45

Status: CONTINUED. J. M. Cameron participated in the NBS Mass Measurement Seminar conducted by the Mass and Volume Section for senior personnel from industrial and governmental calibration laboratories and presented talks on "Error of Measurement" (with Paul E. Pontius), "Calibration designs" and "Use of computers in data analysis". In addition, a problem session on least squares was conducted.



## Current Applications of Automatic Computer

THIS IS A RECORD OF THE USE OF THE IBM 7094 FOR THE PERIOD OF  
JULY 1, THROUGH DECEMBER 31, 1964

| TASK NUMBER  | TITLE                                 | AS  | CC  | PR   | TOTAL |   |   |   |    |
|--------------|---------------------------------------|-----|-----|------|-------|---|---|---|----|
|              |                                       | (   | M   | I    | N     | U | T | E | S) |
| NBS SERVICES |                                       |     |     |      |       |   |   |   |    |
| 51-0002      | 20503 STATISTICAL ENGINEERING         | 16  | 20  | 272  | 308   |   |   |   |    |
| 63-0003      | 20503 CLASS+++                        | 2   | 0   | 26   | 28    |   |   |   |    |
| 54-0030      | 22201 SPECTRUM ANALYSIS++             | 40  | 8   | 767  | 815   |   |   |   |    |
| 54-0031      | 22201 SPECTRUM ANALYSIS++             | 1   | 0   | 4    | 5     |   |   |   |    |
| 54-0032      | 22201 SPECTRUM ANALYSIS++             | 89  | 23  | 20   | 132   |   |   |   |    |
| 54-0033      | 22207 SPECTRUM ANALYSIS++             | 17  | 6   | 2024 | 2047  |   |   |   |    |
| 54-0034      | 22207 SPECTRUM ANALYSIS++             | 1   | 3   | 246  | 250   |   |   |   |    |
| 55-0065      | 20502 AUTOMATIC CODING                | 122 | 64  | 198  | 384   |   |   |   |    |
| 55-0082      | 22101 THERMOMETER CALIBRATION+        | 0   | 0   | 137  | 137   |   |   |   |    |
| 56-0131      | 21212 CALCULATIONS IN OPTICS+         | 1   | 0   | 4    | 5     |   |   |   |    |
| 57-0216      | 20502 MATHEMATICAL TABLES             | 22  | 19  | 13   | 54    |   |   |   |    |
| 57-0219      | 22102 THERMAL PROPERTIES+             | 16  | 15  | 20   | 51    |   |   |   |    |
| 57-0250      | 21211 SPECTROPHOTOMETRIC DATA+        | 5   | 0   | 12   | 17    |   |   |   |    |
| 58-0256      | 42106 COMPOSITE WALL STUDIES++        | 130 | 89  | 71   | 290   |   |   |   |    |
| 58-0266      | 31113 DEPOLYMERIZATION PROCESSES      | 0   | 0   | 24   | 24    |   |   |   |    |
| 58-0272      | 22104 EQUATION OF STATE++             | 90  | 26  | 27   | 143   |   |   |   |    |
| 58-0314      | 22104 APPROXIMATIONS FOR GAS MIXTURES | 66  | 178 | 243  | 487   |   |   |   |    |
| 58-0339      | 21305 VISCOELASTICITY PROPERTIES      | 6   | 4   | 8    | 18    |   |   |   |    |
| 60-0489      | 22101 INVERSION OF LINE PROBE DATA+   | 28  | 26  | 27   | 81    |   |   |   |    |
| 61-0523      | 23101 NEUTRON CROSS SECTION STUDIES++ | 22  | 175 | 53   | 250   |   |   |   |    |
| 61-0559      | 22101 THERMOCOUPLE CALIBRATION+       | 3   | 2   | 29   | 34    |   |   |   |    |
| 61-0562      | 31113 CUBIC LATTICES+                 | 2   | 0   | 47   | 49    |   |   |   |    |
| 62-1000      | 42305 POST OFFICE OPERATIONS STUDY++  | 84  | 92  | 70   | 246   |   |   |   |    |
| 62-1003      | 22341 MOLECULAR SPECTROSCOPY+         | 4   | 0   | 52   | 56    |   |   |   |    |
| 62-1005      | 23104 RADIATION INTERACTION++         | 502 | 251 | 519  | 1272  |   |   |   |    |
| 62-1006      | 23104 RADIATION INTERACTION++         | 628 | 281 | 460  | 1369  |   |   |   |    |
| 62-1011      | 22205 DISPERSION INTEGRALS++          | 0   | 0   | 1    | 1     |   |   |   |    |
| 62-1013      | 31100 STATISTICAL METHODS++           | 10  | 14  | 3    | 27    |   |   |   |    |
| 62-1015      | 22311 THERMAL FUNCTIONS++             | 22  | 8   | 8    | 38    |   |   |   |    |
| 62-1019      | 12500 NBS PERSONNEL REPORT++          | 18  | 91  | 272  | 381   |   |   |   |    |
| 62-1020      | 22103 EIGENVALUES+                    | 3   | 0   | 0    | 3     |   |   |   |    |
| 62-1027      | 20502 NEW SYSTEM                      | 190 | 110 | 397  | 697   |   |   |   |    |
| 62-1029      | 31306 D-SPACING CALCULATIONS+         | 0   | 0   | 1    | 1     |   |   |   |    |
| 62-1033      | 31306 CRYSTAL STRUCTURE CALIBRATION++ | 118 | 138 | 669  | 925   |   |   |   |    |
| 62-1034      | 22201 PHOTOIONIZATION CROSS SECTION++ | 19  | 0   | 23   | 42    |   |   |   |    |

# CURRENT APPLICATIONS OF AUTOMATIC COMPUTER

| TASK NUMBER   | TITLE                           | AS                | CC  | PR  | TOTAL |
|---------------|---------------------------------|-------------------|-----|-----|-------|
|               |                                 | ( M I N U T E S ) |     |     |       |
| NBS SERVICES  |                                 |                   |     |     |       |
| 62-1035 31101 | CREEP DATA ANALYSIS++           | 32                | 15  | 90  | 137   |
| 62-1036 31105 | FILM THICKNESS++                | 4                 | 3   | 21  | 28    |
| 62-1038 31111 | STANDARDIZATION ANALYSES++      | 2                 | 8   | 8   | 18    |
| 62-1055 31204 | ELLIPSOIDAL COMPUTATION++       | 0                 | 0   | 1   | 1     |
| 62-1064 21221 | GAGE BLOCK STUDIES++            | 0                 | 0   | 16  | 16    |
| 62-1066 21102 | STANDARD CELLS++                | 0                 | 0   | 13  | 13    |
| 62-1080 31302 | BLACK BOX COMPUTER SERVICE+     | 0                 | 0   | 24  | 24    |
| 62-1081 31301 | BLACK BOX COMPUTER SERVICE+     | 0                 | 0   | 8   | 8     |
| 62-1089 31305 | ELASTIC CONSTANTS++             | 4                 | 3   | 53  | 60    |
| 62-1125 31304 | MATRIX COMPUTATIONS             | 13                | 3   | 57  | 73    |
| 62-1157 20504 | PLASMA RESEARCH++               | 5                 | 12  | 0   | 17    |
| 62-1163 42501 | TRANSISTOR AGING BEHAVIOR++     | 58                | 59  | 0   | 117   |
| 62-1165 22341 | NMR SPECTRA ANALYSES+           | 2                 | 0   | 5   | 7     |
| 62-1181 42304 | NTDC++                          | 19                | 66  | 0   | 85    |
| 62-1185 42103 | HEAT TRANSFER CALCULATIONS+     | 109               | 6   | 73  | 188   |
| 62-1187 21221 | FRUSTRATED REFLECTIONS++        | 0                 | 0   | 1   | 1     |
| 62-1195 31102 | LIGHT SCATTERING++              | 0                 | 0   | 1   | 1     |
| 62-1203 22104 | CYLINDRICAL SHOCK WAVE          | 7                 | 1   | 58  | 66    |
| 62-1212 42108 | COLOR DIFFERENCES               | 0                 | 0   | 27  | 27    |
| 63-1222 31101 | DILATOMETRIC DATA CALCULATIONS+ | 2                 | 13  | 18  | 33    |
| 63-1231 22207 | BLACK BOX COMPUTER SERVICE+     | 6                 | 0   | 28  | 34    |
| 63-1234 42103 | VAPOR TRANSMISSION++            | 58                | 17  | 30  | 105   |
| 63-1237 22101 | PYROMETRY++                     | 0                 | 0   | 44  | 44    |
| 63-1257 31105 | CALC OF CALCIUM PHOSPHATE++     | 0                 | 25  | 6   | 31    |
| 63-1259 20503 | RESEARCH IN PROBABILITY++       | 2                 | 21  | 14  | 37    |
| 63-1263 22351 | LINEAR CLASSICAL SYSTEM++       | 17                | 0   | 69  | 86    |
| 63-1276 42502 | INSTRUMENTATION++               | 17                | 0   | 0   | 17    |
| 63-1277 21102 | BLACK BOX COMPUTER SERVICE++    | 0                 | 0   | 2   | 2     |
| 63-1285 20505 | RTS FUNDS++                     | 5                 | 0   | 8   | 13    |
| 63-1287 22104 | DATA ANALYSES OF GASES++        | 0                 | 3   | 69  | 72    |
| 63-1289 22105 | IONIZED GASES++                 | 359               | 62  | 79  | 500   |
| 63-1290 22100 | MOLECULAR ENERGY LEVELS++       | 3                 | 0   | 14  | 17    |
| 63-1291 31101 | JOB CALCULATIONS++              | 81                | 71  | 105 | 257   |
| 63-1302 31103 | COMPUTER CALCULATIONS++         | 2                 | 0   | 3   | 5     |
| 63-1309 23101 | LINEAR REGRESSION ANALYSIS++    | 26                | 15  | 17  | 58    |
| 63-1315 22103 | VIRIAL COEFFICIENTS++           | 6                 | 29  | 47  | 82    |
| 63-1318 42103 | THERMISTOR PROGRAM++            | 0                 | 0   | 5   | 5     |
| 63-1320 31306 | CRYSTAL STRUCTURE               | 0                 | 0   | 20  | 20    |
| 63-1323 22100 | PLASMA TRANSPORT++              | 0                 | 0   | 19  | 19    |
| 63-1325 23101 | THERMOFLUX++                    | 52                | 172 | 104 | 328   |
| 63-1333 21212 | BLACK BOX COMPUTER SERVICE+     | 3                 | 1   | 4   | 8     |

CURRENT APPLICATIONS OF AUTOMATIC COMPUTER

| TASK NUMBER  | TITLE                             | AS  | CC   | PR  | TOTAL |   |   |   |    |
|--------------|-----------------------------------|-----|------|-----|-------|---|---|---|----|
| NBS SERVICES |                                   | (   | M    | I   | N     | U | T | E | S) |
| 63-1340      | 22103 FUNCTION OF TEMPERATURE++   | 14  | 0    | 65  | 79    |   |   |   |    |
| 63-1342      | 21301 OMNITAB+                    | 0   | 1    | 24  | 25    |   |   |   |    |
| 63-1343      | 22101 OMNITAB+                    | 0   | 0    | 14  | 14    |   |   |   |    |
| 63-1351      | 21102 TEST DATA++                 | 16  | 2    | 9   | 27    |   |   |   |    |
| 63-1375      | 22104 THERMAL PROPERTIES+         | 14  | 1    | 26  | 41    |   |   |   |    |
| 63-1377      | 31205 WHISKER GROWTH EQUATION     | 134 | 131  | 0   | 265   |   |   |   |    |
| 63-1378      | 42305 DCA++                       | 185 | 2384 | 776 | 3345  |   |   |   |    |
| 63-1388      | 22102 COMBUSTION CALORIMETRY++    | 20  | 5    | 52  | 77    |   |   |   |    |
| 63-1399      | 22102 HEAT MEASUREMENT++          | 2   | 2    | 0   | 4     |   |   |   |    |
| 64-1400      | 22202 STATISTICS++                | 33  | 1    | 299 | 333   |   |   |   |    |
| 64-1401      | 42107 LONG TIME CEMENT STUDY 1++  | 2   | 0    | 139 | 141   |   |   |   |    |
| 64-1402      | 42107 LONG TIME CEMENT STUDY 2++  | 0   | 0    | 4   | 4     |   |   |   |    |
| 64-1406      | 21306 HYPERSONIC COMBUSTION++     | 11  | 16   | 0   | 27    |   |   |   |    |
| 64-1407      | 31002 SPECTROANALYSIS++           | 0   | 0    | 3   | 3     |   |   |   |    |
| 64-1408      | 42101 ELASTIC SOLIDS              | 2   | 3    | 4   | 9     |   |   |   |    |
| 64-1416      | 31303 OMNITAB+                    | 1   | 0    | 5   | 6     |   |   |   |    |
| 64-1418      | 21231 STATISTICAL COMPUTATION++   | 0   | 0    | 111 | 111   |   |   |   |    |
| 64-1419      | 21231 STATISTICAL COMPUTATION++   | 13  | 0    | 51  | 64    |   |   |   |    |
| 64-1420      | 22102 OMNITAB+                    | 0   | 0    | 18  | 18    |   |   |   |    |
| 64-1423      | 22104 COORDINATE ANALYSIS++       | 18  | 5    | 84  | 107   |   |   |   |    |
| 64-1437      | 31105 AMALGAM STRAIN-TIME DATA++  | 0   | 0    | 32  | 32    |   |   |   |    |
| 64-1438      | 31200 MATRIX OPERATIONS           | 13  | 5    | 29  | 47    |   |   |   |    |
| 64-1440      | 42108 OMNITAB+                    | 56  | 5    | 83  | 144   |   |   |   |    |
| 64-1445      | 42706 TEXTILE INDUSTRY STUDY++    | 5   | 1    | 145 | 151   |   |   |   |    |
| 64-1448      | 22300 BLACK BOX COMPUTER SERVICE+ | 0   | 1    | 0   | 1     |   |   |   |    |
| 64-1453      | 22101 RES THERMOMETER CALC++      | 0   | 0    | 1   | 1     |   |   |   |    |
| 64-1456      | 20500 INFORMATION RETRIEVAL++     | 1   | 422  | 105 | 528   |   |   |   |    |
| 64-1462      | 23123 POSITRON PRODUCTION++       | 5   | 8    | 17  | 30    |   |   |   |    |
| 64-1463      | 22200 TRANSITION PROBABILITIES    | 4   | 0    | 65  | 69    |   |   |   |    |
| 64-1470      | 42305 PICNIC PROJECT++            | 6   | 43   | 18  | 67    |   |   |   |    |
| 64-1473      | 22104 POLAR GASES++               | 11  | 1    | 59  | 71    |   |   |   |    |
| 64-1474      | 22300 ATOM CORRELATION++          | 119 | 5    | 345 | 469   |   |   |   |    |
| 64-1478      | 23121 LEAST SQUARES++             | 0   | 0    | 10  | 10    |   |   |   |    |
| 64-1479      | 22204 NUCLEAR QUADRUPOLE          | 0   | 0    | 4   | 4     |   |   |   |    |
| 64-1483      | 31306 POWDER PATTERNS++           | 21  | 1    | 137 | 159   |   |   |   |    |
| 64-1484      | 21303 OMNITAB+                    | 0   | 0    | 7   | 7     |   |   |   |    |
| 64-1486      | 22101 OMNITAB+                    | 0   | 2    | 4   | 6     |   |   |   |    |
| 64-1487      | 21301 VIBRATION CALIBRATION++     | 0   | 19   | 77  | 96    |   |   |   |    |
| 64-1492      | 23101 ELECTROMAG CROSS SECT++     | 95  | 176  | 24  | 295   |   |   |   |    |
| 64-1493      | 21304 PROVING RINGS++             | 0   | 0    | 113 | 113   |   |   |   |    |
| 64-1495      | 20100 FLEX TO LINO FILM           | 19  | 21   | 1   | 41    |   |   |   |    |

# CURRENT APPLICATIONS OF AUTOMATIC COMPUTER

| TASK NUMBER   | TITLE                    | AS                | CC  | PR   | TOTAL |
|---------------|--------------------------|-------------------|-----|------|-------|
| NBS SERVICES  |                          | ( M I N U T E S ) |     |      |       |
| 64-1496 21221 | EXP FOR INVAR TAPE++     | 0                 | 3   | 0    | 3     |
| 64-1503 21301 | OMNITAB+                 | 6                 | 9   | 70   | 85    |
| 64-1512 21302 | OMNITAB+                 | 0                 | 0   | 14   | 14    |
| 64-1517 42303 | OPTICAL SCANNER++        | 0                 | 18  | 0    | 18    |
| 64-1518 20101 | OPER RES INCORP++        | 0                 | 34  | 24   | 58    |
| 64-1523 21211 | FORTRAN CLASS++          | 1                 | 27  | 0    | 28    |
| 64-1531 42300 | INFORMATION PROCESSING++ | 0                 | 1   | 5    | 6     |
| 64-1539 21304 | SQUARE BAR++             | 28                | 2   | 9    | 39    |
| 64-1540 42305 | DESCRIPTORS++            | 1                 | 7   | 8    | 16    |
| 64-1547 31001 | MOSSBAUER++              | 86                | 12  | 84   | 182   |
| 64-1552 21105 | DIPOLE++                 | 21                | 0   | 24   | 45    |
| 64-1557 42501 | PNEUMATIC BRIDGES+       | 0                 | 0   | 7    | 7     |
| 64-1559 42305 | IPRS++                   | 16                | 63  | 23   | 102   |
| 64-1560 22101 | MUELLER BRIDGE CALIB++   | 2                 | 2   | 2    | 6     |
| 65-1563 21221 | THERMAL EXPANSION++      | 8                 | 0   | 22   | 30    |
| 65-1565 42304 | AFESD++                  | 2                 | 69  | 0    | 71    |
| 65-1567 31001 | MOSSBAUER++              | 0                 | 2   | 55   | 57    |
| 65-1568 42300 | INTERNATIONAL BUSINESS++ | 9                 | 0   | 160  | 169   |
| 65-1573 20505 | FAA++                    | 695               | 369 | 1461 | 2525  |
| 65-1575 22101 | HIGH TEMP ENTH++         | 0                 | 0   | 1    | 1     |
| 65-1579 31203 | PEAK POSITIONS++         | 0                 | 2   | 17   | 19    |
| 65-1581 21323 | TRIAL DATA++             | 30                | 1   | 31   | 62    |
| 65-1582 42102 | FIRE RESEARCH++          | 12                | 1   | 0    | 13    |
| 65-1583 22105 | TIME INTERVALS++         | 13                | 9   | 0    | 22    |
| 65-1584 23122 | THERMOFLUX++             | 58                | 167 | 194  | 419   |
| 65-1585 31003 | LEAST SQUARES++          | 1                 | 0   | 0    | 1     |
| 65-1586 21321 | OMNITAB++                | 8                 | 0   | 38   | 46    |
| 65-1589 31306 | CRYSTAL DATA++           | 2                 | 0   | 174  | 176   |
| 65-1591 23124 | COULOMB WAVE FUNCTIONS++ | 0                 | 0   | 1    | 1     |
| 65-1592 42700 | LUMBER STUDY++           | 1                 | 0   | 7    | 8     |
| 65-1593 31002 | ARC TEMP MEASUREMENTS++  | 3                 | 0   | 0    | 3     |
| 65-1594 22104 | SHOCK WAVE++             | 127               | 15  | 147  | 289   |
| 65-1598 21303 | OMNITAB++                | 0                 | 2   | 2    | 4     |
| 65-1599 31204 | OMNITAB+                 | 0                 | 0   | 1    | 1     |
| 65-1601 22105 | SOUND PROPAGATION++      | 0                 | 0   | 7    | 7     |
| 65-1603 22101 | LINE PROBE DATA++        | 24                | 6   | 12   | 42    |
| 65-1605 21222 | OPTICAL COMPUTATION++    | 3                 | 8   | 6    | 17    |
| 65-1608 22301 | OMNITAB++                | 0                 | 0   | 2    | 2     |
| 65-1610 42305 | AFIPS INDEX++            | 0                 | 0   | 15   | 15    |
| 65-1611 31202 | WAVELENGTH++             | 2                 | 0   | 0    | 2     |
| 65-1615 22205 | ANGFOL++                 | 0                 | 15  | 13   | 28    |

# CURRENT APPLICATIONS OF AUTOMATIC COMPUTER

| TASK NUMBER           |       | TITLE                          | AS                | CC   | PR    | TOTAL |
|-----------------------|-------|--------------------------------|-------------------|------|-------|-------|
|                       |       |                                | ( M I N U T E S ) |      |       |       |
| NBS SERVICES          |       |                                |                   |      |       |       |
| 65-1616               | 22102 | CHNOPS++                       | 0                 | 10   | 72    | 82    |
| 65-1622               | 40000 | RESEARCH++                     | 0                 | 0    | 3     | 3     |
| 65-1624               | 20505 | FISH-ORI++                     | 0                 | 10   | 0     | 10    |
| 65-1628               | 31103 | HEAT CAPACITY++                | 0                 | 0    | 1     | 1     |
| 65-1629               | 40000 | MANAGEMENT OBJECTIVES++        | 0                 | 0    | 1     | 1     |
| 65-1630               | 42600 | NE CORRIDOR++                  | 10                | 2    | 0     | 12    |
| 65-1634               | 31101 | GAMMA FUNCTIONS                | 0                 | 5    | 0     | 5     |
| 65-1635               | 31307 | INTEGRAL EVALUATION            | 3                 | 3    | 3     | 9     |
| 63-3003               | 20502 | MACHINE TIME ONLY+++           | 19                | 5    | 1     | 25    |
| 63-3005               | 20502 | FREE MACHINE TIME+++           | 119               | 52   | 126   | 297   |
| 63-3008               | 20502 | SECRETARYS MACHINE TIME+++     | 150               | 43   | 177   | 370   |
| 64-3011               | 20502 | ERROR-USER+++                  | 1                 | 2    | 229   | 232   |
| 65-3012               | 20502 | TAPE TEST+++                   | 0                 | 0    | 132   | 132   |
| TOTALS (NBS SERVICES) |       |                                | 5452              | 6485 | 14249 | 26186 |
| NON-NBS SERVICES      |       |                                |                   |      |       |       |
| 58-0348               | 21    | MACHINE TRANSLATION OF RUSSIAN | 10                | 7    | 0     | 17    |
| 59-0425               | 90    | MOLECULAR ORBITALS+            | 52                | 184  | 46    | 282   |
| 59-0434               | 90    | PETROLOGICAL COMPUTATIONS+     | 17                | 29   | 106   | 152   |
| 59-0441               | 21    | SYSTEMS ENGINEERING++          | 407               | 696  | 201   | 1304  |
| 60-0457               | 86    | PUBLIC HOUSING PROBLEM++       | 8                 | 32   | 171   | 211   |
| 60-0476               | 21    | GAS TUBE CHARACTERISTIC II     | 0                 | 0    | 539   | 539   |
| 60-0486               | 20    | MORSE WAVE FUNCTION++          | 0                 | 0    | 19    | 19    |
| 60-0492               | 90    | MONETARY RESEARCH REPORTS++    | 314               | 44   | 211   | 569   |
| 60-0506               | 80    | WORLD BANK REPORTS++           | 226               | 0    | 349   | 575   |
| 61-0540               | 21    | DIFFUSION CALCULATIONS+        | 67                | 116  | 118   | 301   |
| 61-0569               | 21    | HUMAN FACTORS RESEARCH++       | 331               | 267  | 90    | 688   |
| 61-0830               | 90    | HIGHWAY TRAFFIC STUDIES++      | 17                | 8    | 1671  | 1696  |
| 61-0903               | 90    | HIGHWAY TRAFFIC STUDIES++      | 23                | 36   | 344   | 403   |
| 62-1004               | 17    | RHOMBIC ANTENNAS+              | 0                 | 0    | 11    | 11    |
| 62-1014               | 75    | METABOLIC DISEASES++           | 394               | 403  | 1232  | 2029  |
| 62-1018               | 17    | HYDROMAGNETIC PROBLEMS+        | 162               | 75   | 35    | 272   |
| 62-1021               | 99    | HIGHWAY STUDIES++              | 105               | 319  | 853   | 1277  |
| 62-1030               | 36    | ELECTROCARDIOGRAPHIC ANALYSIS  | 543               | 1628 | 609   | 2780  |
| 62-1044               | 27    | RADIO INTENSITIES++            | 40                | 4    | 42    | 86    |
| 62-1046               | 90    | TRAFFIC PREDICTION++           | 336               | 616  | 3294  | 4246  |
| 62-1056               | 21    | PD ENGINEERING++++             | 12                | 6    | 161   | 179   |
| 62-1071               | 21    | RHINITIS STUDIES++             | 4                 | 0    | 7     | 11    |
| 62-1076               | 90    | EVALUATION OF APPLICATIONS+    | 10                | 0    | 13    | 23    |

# CURRENT APPLICATIONS OF AUTOMATIC COMPUTER

| TASK NUMBER      |    | TITLE                         | AS                | CC  | PR   | TOTAL |
|------------------|----|-------------------------------|-------------------|-----|------|-------|
| NON-NBS SERVICES |    |                               | ( M I N U T E S ) |     |      |       |
| 62-1091          | 57 | LOWER BOUNDS TO EIGENVALUES   | 87                | 4   | 18   | 109   |
| 62-1113          | 21 | TRANSPORT ANALYSES++++        | 7                 | 17  | 9    | 33    |
| 62-1114          | 21 | RADIATION EFFECTS++           | 197               | 53  | 65   | 315   |
| 62-1119          | 90 | HIGHWAY TRAFFIC STUDIES++     | 2                 | 3   | 244  | 249   |
| 62-1121          | 90 | CARNEGIE INSTITUTE STUDIES++  | 82                | 1   | 37   | 120   |
| 62-1130          | 43 | FALLOUT SHELTER COMPUTATIONS  | 30                | 17  | 366  | 413   |
| 62-1140          | 36 | VA MEDICAL++                  | 230               | 27  | 809  | 1066  |
| 62-1158          | 90 | MINERALOGY STUDIES++          | 0                 | 0   | 89   | 89    |
| 62-1169          | 90 | ATOMIC COLLISIONS++           | 20                | 0   | 87   | 107   |
| 62-1171          | 36 | HOSPITAL PROGRAM PLANNING+    | 105               | 64  | 330  | 499   |
| 62-1179          | 21 | CATALOG INFORMATION+          | 1                 | 3   | 180  | 184   |
| 62-1189          | 21 | TABLES FOR SEQUENTIAL METHODS | 0                 | 0   | 3    | 3     |
| 62-1215          | 80 | MISSILE SATELLITE++           | 0                 | 0   | 1376 | 1376  |
| 62-1216          | 90 | ARIZONA++                     | 0                 | 1   | 1090 | 1091  |
| 63-1221          | 90 | RHODE ISLAND++                | 0                 | 0   | 3    | 3     |
| 63-1236          | 13 | DATATROL++                    | 58                | 0   | 351  | 409   |
| 63-1239          | 75 | PUBLIC HEALTH SERVICE++       | 70                | 1   | 8    | 79    |
| 63-1246          | 75 | SCREENING EVALUATION+         | 7                 | 0   | 9    | 16    |
| 63-1249          | 90 | ISOTOPE TRACER ANALYSIS++     | 2                 | 0   | 22   | 24    |
| 63-1253          | 90 | BLACK BOX COMPUTER SERVICE++  | 17                | 32  | 56   | 105   |
| 63-1254          | 21 | HIGH FREQUENCY PROPAGATION++  | 2                 | 0   | 132  | 134   |
| 63-1262          | 17 | NUCLEONICS++                  | 33                | 350 | 9    | 392   |
| 63-1264          | 17 | NUCLEONICS++                  | 403               | 660 | 502  | 1565  |
| 63-1271          | 13 | ECONOMICS STUDY++             | 0                 | 22  | 203  | 225   |
| 63-1272          | 90 | ROADS STUDY++                 | 5                 | 0   | 320  | 325   |
| 63-1280          | 90 | NIH++                         | 7                 | 5   | 0    | 12    |
| 63-1293          | 13 | BODDY CALCULATION++           | 16                | 5   | 53   | 74    |
| 63-1299          | 21 | 1410 PROGRAM++                | 3                 | 8   | 13   | 24    |
| 63-1305          | 21 | ARMY++                        | 0                 | 0   | 1104 | 1104  |
| 63-1307          | 21 | MISCELLANEOUS PROGRAMMING++   | 1                 | 9   | 11   | 21    |
| 63-1313          | 90 | OMNITAB+                      | 80                | 36  | 114  | 230   |
| 63-1314          | 90 | FLORIDA HIGHWAYS++            | 30                | 7   | 998  | 1035  |
| 63-1317          | 72 | SORTING AND TABULATING        | 36                | 40  | 354  | 430   |
| 63-1336          | 17 | ARC++                         | 34                | 0   | 1697 | 1731  |
| 63-1350          | 21 | ME DATA++                     | 0                 | 65  | 0    | 65    |
| 63-1360          | 26 | FEDERAL POWER COMMISSION++    | 59                | 0   | 32   | 91    |
| 63-1365          | 21 | 1410++                        | 121               | 25  | 10   | 156   |
| 63-1371          | 20 | ALTERNATE TAX PLANS++         | 87                | 0   | 1129 | 1216  |
| 63-1391          | 75 | BIOMEDICAL STA PROG++         | 0                 | 0   | 163  | 163   |
| 64-1394          | 21 | ARMY COST MODEL (RAND)++      | 5                 | 463 | 2069 | 2537  |
| 64-1403          | 21 | WORLD TEMPERATURE DIST++      | 35                | 3   | 183  | 221   |



# CURRENT APPLICATIONS OF AUTOMATIC COMPUTER

| TASK NUMBER      |    | TITLE                      | AS  | CC  | PR   | TOTAL |   |   |   |    |
|------------------|----|----------------------------|-----|-----|------|-------|---|---|---|----|
| NON-NBS SERVICES |    |                            | (   | M   | I    | N     | U | T | E | S) |
| 64-1411          | 21 | AUTOCORRELATION++          | 15  | 0   | 0    | 15    |   |   |   |    |
| 64-1414          | 21 | AD 70 PROGRAM++            | 20  | 0   | 47   | 67    |   |   |   |    |
| 64-1426          | 10 | DC HIGHWAY++               | 0   | 0   | 6    | 6     |   |   |   |    |
| 64-1429          | 75 | RESEARCH MISC++            | 113 | 33  | 46   | 192   |   |   |   |    |
| 64-1432          | 90 | BROOKINGS++                | 12  | 0   | 104  | 116   |   |   |   |    |
| 64-1433          | 75 | NMR SPECTRA                | 0   | 0   | 2    | 2     |   |   |   |    |
| 64-1435          | 13 | CAPITOL COEFFICIENTS++     | 0   | 0   | 32   | 32    |   |   |   |    |
| 64-1436          | 21 | DIPOLE MOMENT COMP++       | 1   | 0   | 2    | 3     |   |   |   |    |
| 64-1439          | 21 | SHOCK PRESSURES++          | 0   | 0   | 33   | 33    |   |   |   |    |
| 64-1447          | 75 | SOCIAL SECURITY RES++      | 1   | 0   | 88   | 89    |   |   |   |    |
| 64-1451          | 21 | PROGRAM 2++                | 6   | 13  | 179  | 198   |   |   |   |    |
| 64-1457          | 17 | SOLAR RADIATION DATA RED++ | 25  | 5   | 4    | 34    |   |   |   |    |
| 64-1467          | 17 | THEORET NUCLEAR PHYSICS++  | 11  | 9   | 113  | 133   |   |   |   |    |
| 64-1475          | 17 | RESEARCH++                 | 42  | 49  | 1    | 92    |   |   |   |    |
| 64-1482          | 90 | BIOPHYSICS++               | 11  | 0   | 113  | 124   |   |   |   |    |
| 64-1488          | 80 | INTERPLANETARY CALC        | 143 | 85  | 177  | 407   |   |   |   |    |
| 64-1498          | 20 | REGRESSION EQUATION++      | 0   | 14  | 0    | 14    |   |   |   |    |
| 64-1504          | 55 | 1970 PROJECTIONS++         | 0   | 0   | 5    | 5     |   |   |   |    |
| 64-1516          | 21 | ECM STUDY++                | 68  | 20  | 0    | 88    |   |   |   |    |
| 64-1526          | 21 | BATTERY PROGRAM++          | 107 | 41  | 238  | 386   |   |   |   |    |
| 64-1534          | 90 | CORRELATION MATRICES++     | 1   | 0   | 0    | 1     |   |   |   |    |
| 64-1549          | 21 | OPTICAL INTEGRAL++         | 2   | 47  | 37   | 86    |   |   |   |    |
| 64-1551          | 21 | AD CONVERSION++            | 0   | 3   | 0    | 3     |   |   |   |    |
| 64-1554          | 21 | PREDICT PROGRAM++          | 124 | 43  | 2553 | 2720  |   |   |   |    |
| 64-1561          | 75 | RADIOLOGY++                | 9   | 8   | 0    | 17    |   |   |   |    |
| 65-1562          | 17 | DIPOLE CALC++              | 18  | 3   | 9    | 30    |   |   |   |    |
| 65-1564          | 90 | RADC CONTRACT++            | 0   | 174 | 228  | 402   |   |   |   |    |
| 65-1569          | 17 | EXCAVATION                 | 72  | 1   | 39   | 112   |   |   |   |    |
| 65-1570          | 13 | PIPE STRESS++              | 1   | 1   | 11   | 13    |   |   |   |    |
| 65-1572          | 21 | LANCE++                    | 15  | 0   | 224  | 239   |   |   |   |    |
| 65-1576          | 43 | RAIL COAST PROGRAMS++      | 1   | 0   | 9    | 10    |   |   |   |    |
| 65-1577          | 21 | EIGENVALUES++              | 185 | 41  | 111  | 337   |   |   |   |    |
| 65-1587          | 90 | COMPUTER TECHNIQUE++       | 0   | 0   | 7    | 7     |   |   |   |    |
| 65-1588          | 90 | NASA CONTRACT++            | 1   | 0   | 990  | 991   |   |   |   |    |
| 65-1590          | 13 | BALANCE OF PAYMENTS++      | 3   | 0   | 5    | 8     |   |   |   |    |
| 65-1595          | 21 | ANALOG TO DIGITAL TAPE++   | 1   | 0   | 7    | 8     |   |   |   |    |
| 65-1597          | 21 | FACTORIAL ANCV++           | 0   | 0   | 1    | 1     |   |   |   |    |
| 65-1600          | 90 | MILWAUKEE++                | 0   | 0   | 147  | 147   |   |   |   |    |
| 65-1604          | 13 | OBE++                      | 17  | 3   | 0    | 20    |   |   |   |    |
| 65-1606          | 21 | PERT COST++                | 0   | 1   | 7    | 7     |   |   |   |    |
| 65-1607          | 90 | NSF++                      | 0   | 0   | 15   | 15    |   |   |   |    |

# CURRENT APPLICATIONS OF AUTOMATIC COMPUTER

| TASK NUMBER               |    | TITLE                   | AS                | CC    | PR    | TOTAL |
|---------------------------|----|-------------------------|-------------------|-------|-------|-------|
| NON-NBS SERVICES          |    |                         | ( M I N U T E S ) |       |       |       |
| 65-1609                   | 36 | MARTINSBURG++           | 0                 | 0     | 9     | 9     |
| 65-1612                   | 21 | CORG AMMUNITION STUDY++ | 3                 | 1147  | 150   | 1300  |
| 65-1614                   | 75 | BEDS++                  | 32                | 204   | 0     | 236   |
| 65-1617                   | 21 | TIME ANALYSIS++         | 5                 | 5     | 8     | 18    |
| 65-1618                   | 14 | CRYSTALLOGRAPHY++       | 0                 | 0     | 30    | 30    |
| 65-1619                   | 90 | UNEMPLOYMENT SURVEY++   | 2                 | 22    | 4     | 28    |
| 65-1620                   | 90 | ECONOMETRIC MODEL++     | 13                | 0     | 24    | 37    |
| 65-1621                   | 13 | MARINE DATA++           | 39                | 19    | 33    | 91    |
| 65-1631                   | 21 | ANALOG RESEARCH++       | 0                 | 3     | 0     | 3     |
| 65-1632                   | 13 | LOAN/INTEREST RATES     | 10                | 11    | 13    | 34    |
| TOTALS (NON-NBS SERVICES) |    |                         | 6079              | 8395  | 30233 | 44707 |
| TOTALS (NBS AND NON-NBS)  |    |                         | 11531             | 14880 | 44482 | 70893 |

+ 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

- FELIX, M. R. (NASA Langley Research Center, Langley, Va.) Some problems in kinetic theories of plasmas. December 17, 1964.
- KLOSS, K. E. (NBS, Washington, D.C.) The Pilot assembler, PEAP. Presented before a group interested in using the NBS "Pilot" computer. October 21, 1964.
- SCHATTEN, R. (NBS, Washington, D.C.) Series of 15 lectures on Norms on spaces of linear transformation. June 16 - August 4, 1964.
- THOMAS, T. Y. (Department of Mathematics, Indiana University, Bloomington, Indiana). Gravitational collapse. December 2, 1964.
- WEENINK, M. P. (F.O.M. Instituut voor Plasma-Fysica Jutphaas, Utrecht, Netherlands). Interaction of high frequency fields with a plasma. November 19, 1964.

### Metrology Division Staff Meeting

- YOU DEN, W. J. The significance of significant figures. September 30, 1964.

### NBS Scientific Staff Meeting

- YOU DEN, W. J. Calibrations and international comparisons. October 30, 1964.

### NBS Seminar on the Theory of Matroids

August 31-September 11, 1964

- AUSLANDER, L. (Yeshiva University, N. Y., and U. S. Naval Research Laboratory) Graphs in surfaces. (2 lectures.)
- CRAPO, H. H. (Northeastern University, Boston, Mass.) Rank generating functions and chromatic polynomials. The single-element extensions of a matroid. (3 lectures.)
- DUFFIN, R. J. (Carnegie Institute of Technology, Pittsburgh, Pa.) The Wang algebra. Extremal lengths. (3 lectures.)
- EDMONDS, J. On work of Whitney. Matroids and projective configurations. Extreme properties of matroids. On work of A. Lehman. (4 lectures.)
- MATHER, J. (NBS, Washington, D.C.) Invariance of the homology of a lattice.
- MINTY, G. J. (University of Michigan, Ann Arbor, Michigan, and Courant Institute of Mathematical Sciences, New York University, New York) Self-dual axioms for matroids. Matroids, electrical networks, and network programming. (3 lectures.)
- RAY CHAUDHURI, D. K. (IBM Watson Research Center, Yorktown Heights, N. Y.) On the line graph of a finite affine plane.

## Lectures and Technical Meetings

- ROTA, G. C. (Massachusetts Institute of Technology, Cambridge, Massachusetts) Lattices and Möbius functions. Enumeration problems and the theory of combinatorial independence. (5 lectures.)
- TRENT, H. M. (U. S. Naval Research Laboratory) Linear graphs and unified formulation methods for engineering systems.
- TUTTE, W. T. (University of Waterloo, Waterloo, Ontario). A homotopy theorem for matroids. Matroids and graphs. Merger's theorem for matroids. (10 lectures.)

### Papers and Invited Talks

#### Presented by Members of the Staff at Meetings of Outside Organizations

- ARMS, R. J. Computational aspects of a boundary value problem. Presented at University of Maryland, Computer Science Center, September 3, 1964.
- Introductory aspects of computer programming. Sponsored by U. S. Civil Service Commission. Washington, D.C., October 14, 1964.
- BERNSTEIN, B. Elasticity in the thermodynamics of perfect elastic fluids. Presented at the 35th Annual meeting of the Society of Rheology, Mellon Institute, Pittsburgh, Pa., Oct. 26-28, 1964.
- CAMERON, J. M. Designs for calibrations. Presented at the Annual meeting of the American Statistical Association, Chicago, Ill., December 27, 1964.
- EDMONDS, J. R. Extreme partitions of a matroid. Presented at the Summer Meeting of the American Mathematical Society, University of Massachusetts, Amherst, August 25-28, 1964.
- GOLDMAN, A. J. A variant of the two-dimensional Riemann integral. Presented before the Mathematical Association of America, Goucher College, Towson, Md. Nov. 21, 1964.
- HAIN, K. H. S. Magnetohydrodynamic computations for a  $\theta$  pinch. Presented at Cornell University (Graduate School of Aerospace Engineering), Ithaca, New York, July 27, 1964.
- JOINER, B. L. The use of extreme value distributions. Presented at Rutgers - The State University, New Brunswick, N. J., October 30, 1964.
- KIRSCH, R. A. Participation in a panel on "Computers - Man's Sixth Sense". Sponsored by Institute of Electrical and Electronics Engineers, Professional Technical Group on Military Electronics, Washington, D.C. Sept. 16, 1964.
- MEYERS, P. R. The converse of Banach's Contraction theorem. Presented before the Mathematical Association of America, Goucher College, Towson, Md. November 21, 1964.
- NEWMAN, M. On a conjecture of Rademacher's. Presented at the University of Wisconsin, Madison, Wisconsin. August 4, 1964.
- Number Theory. Presented at the Washington Philosophical Society, Washington, D.C. November 20, 1964.

# Lectures and Technical Meetings

- OLVER, F. W. J. Error bounds for asymptotic solutions of ordinary differential equations in the neighborhood of an irregular singularity. Presented at the Institute for Fluid Dynamics and Applied Mathematics, University of Maryland, College Park, Md. Oct. 23, 1964.
- PEAVY, S. T. Fundamentals of digital computers. Sponsored by U. S. Civil Service Commission. Washington, D.C., Oct. 7, 1964.
- TCHEN, C. M. Diffusion across a magnetic field in plasma. Presented at the International Symposium on Diffusion in Plasma, Feldafing, Germany, June 29-July 3, 1964.
- Spectrum of stationary homogeneous magnetohydrodynamic turbulence. Presented at Catholic University, Department of Space Sciences and Applied Physics, Washington, D.C., Nov. 10, 1964.
- Magnetohydrodynamic turbulence. Presented at NASA, Langley Field, Va., Nov. 24, 1964.
- Diffusion in a plasma across a magnetic field. Case Institute of Technology, Cleveland, Ohio, Nov. 25, 1964.
- VINTI, J. P. The effects of a constant force on a Keplerian orbit, with applications to the action of solar radiation pressure on the orbit of an artificial satellite of the earth. Presented before the IAU Symposium No. 25, Athens, Greece, Aug. 22, 1964.
- WALSH, P. J. Components and capabilities of computers. Sponsored by U. S. Civil Service Commission. Washington, D.C. Oct. 26, 1964.
- YODEN, W. J. Statistics in Clinical Chemistry. American Association of Clinical Chemists, Boston, Mass., August 17, 1964.
- Statistics. American Association of Clinical Chemists, Washington, D.C. Oct. 13, 1964.
- Controlling the quality of routine analytical work. Association of Official Agricultural Chemists, Washington, D.C., Oct. 20, 1964.
- An operations research yarn. Ninth Annual Conference on Design of Experiment in Army Research Development and Testing, Washington, D.C., Nov. 5, 1964.
- Locating troubles in analytical procedures. Eastern Analytical Symposium and Instrument Exhibit, sponsored by the American Chemical Society, the Society for Applied Spectroscopy, and the American Microchemical Society, New York City, Nov. 11, 1964.
- Picking winners and losers. Food and Allied Industries Division, American Society for Quality Control, University of Maryland, College Park, Md. Nov. 19, 1964.



## Publication Activities

### 1. PUBLICATIONS THAT APPEARED DURING THIS PERIOD

#### 1.3 Technical Papers

Thermodynamics of perfect elastic fluids. B. Bernstein, E. A. Keasley, and L. J. Zapas. J. of Research NBS, 68B, No. 3, pp. 103-113, July-Sept., 1964.

Realistic evaluation of the precision and accuracy of instrument calibration systems. Churchill Eisenhart. Proceedings of the Ninth Conference on the Design of Experiments in Army Research Development and Testing, ARO-D Report 64-2, Office of the Chief of Research and Development, U. S. Army, 1964, pages 469-536. (Reprinted from J. Research, NBS-C. Engineering and Instrumentation, 67C, No. 2, pp. 161-187, 1963.)

Generation and composition of functions. A. J. Goldman. J. of Research NBS, 68B, No. 3, pp. 99-101, 1964.

Equivalence of certain inequalities complementing those of Cauchy-Schwarz and Hölder. A. J. Goldman, J. B. Diaz and F. T. Metcalf. J. of Research, NBS, 68B, No. 4, pp. 147-149, 1964.

Weak generalized inverses and minimum variance linear unbiased estimation. A. J. Goldman and M. Zelen. J. of Research NBS, 68B, No. 4, pp. 151-172, 1964.

Entire functions all of whose derivatives are integral at the origin. F. Gross. Duke Mathematical Journal, Vol. 31, No. 4, 617-622, 1964.

The inverse multiplier for abelian group difference sets. E. C. Johnsen. Canadian J. of Mathematics, Vol. 16, 787-796, 1964.

Connection between shielding and stability in a collisionless plasma. E. Minardi, F. Englemann, and M. Feix. Il Nuovo Cimento, serie X, vol. 30, pp 830-836, 1963.

Normal congruence subgroups of the modular group. M. Newman. Am. Jr. Math. Vol. 85, No. 3, pp 415-427, 1963.

On a problem of G. Sansone. M. Newman. Annali di Matematica, Pura ed Applicata (4) 65, 27-34, 1964.

Symplectic modular groups. M. Newman and J. R. Smart. Acta Arithmetica, Vol. 9, 83-89, 1964.

Comparison of some iterative methods for solving large systems of linear equations. Maxine Lieberman Rockoff, NBS Report 8577, 112 pp. Nov. 2, 1964.

The greatest crossnorm. Robert Schatten. J. of Research NBS 68B, No. 4, pp. 185-193, 1964.

On the structure of infrapolynomials with prescribed coefficients. O. Shisha. Pacific J. of Mathematics., Vol. 14, No. 3, 1039-1051 (1964).

On the location of the zeros of some infrapolynomials with prescribed coefficients. O. Shisha and J. L. Walsh. Pacific J. of Math. Vol. 14, No. 3, 1103-1109 (1964).

## Publication Activities

Plasma oscillations with collective correlations. C. M. Tchen. Proceedings of the 6th International Conference on Ionization Phenomena in Gases, Paris, July 8-13, 1963, Vol. 1, pp. 195-199.

Some remarks on microgrammars. W. C. Watt. Proc. of the Washington Linguistic Club. Vol. 2, No. 1, pp. 13 - 17. Oct. 1964.

Sampling and statistical design. W. J. Youden. Proceedings, Symposium on Environmental Measurements, U. S. Public Health Service, 1963. U. S. Government Printing Office, 35-39, July 1964.

### 1.4 Reviews and Notes

Note on the partition function. M. Newman. Am. Math. Monthly. Vol. 71, No. 9, Nov. 1964.

## 2. MANUSCRIPTS IN THE PROCESS OF PUBLICATION

### 2.2 Manuals, Bibliographies, Indices

Chapter IC - Statistical Concepts of a Measurement Process, and Chapter ID - Statistical Analysis of Measurement Data. H. H. Ku. To appear in Industrial Metrology, American Society of Tool and Manufacturing Engineers.

### 2.3 Technical Papers

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

Use of general 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.

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

On matching Problems. Jack Edmonds. To appear in Proceedings of the Conference of the Army Research Office Working Group on Computers, Feb. 1964.

On Lehman's switching game and a theorem of Tutte and Nash-Williams. Jack Edmonds. To appear in J. of Research NBS, 69B, 1965.

On the surface duality of graphs. Jack Edmonds. To appear in J of Research NBS, 69B, 1965.

Maximum matching and a polyhedron with  $(0,1)$ -vertices. Jack Edmonds. To appear in J. of Research NBS, 69B, 1965.

Minimum partition of a matroid into independent subsets. Jack Edmonds. To appear in J of Research NBS, 69B, 1965.

Scattering Properties of Concentric Soot-water spheres for visible and infrared light. R. W. Fenn. (U. S. Army Electronics Labs) and H. Oser. To appear in J. Applied Optics.

#### Publication Activities

A variant of the two-dimensional Riemann integral. A. J. Goldman. To appear in J. of Research NBS, 69B, 1965.

Equivalence of certain inequalities complementing those of Cauchy-Schwarz and Holder. A. J. Goldman, J. B. Diaz and F. T. Metcalf. To appear in J. of Research NBS.

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

Entire solutions of the functional equation  $h(f(z)) = g(z)$ . F. Gross. Submitted to Proc. of the Am. Math. Soc.

Entire solutions of the function equation  $\alpha(\beta(z)) = \alpha(\gamma(z)) + c$ . F. Gross. Submitted to the Duke Mathematical Journal.

An analogue of Fermat's last theorem for entire functions. F. Gross. Submitted to Am. Mathematical Monthly Notes.

A functional inequality. S. Haber. Submitted to a technical journal.

Uncertainties associated with proving ring calibration. T. E. Hockersmith (Mechanics Division) and H. H. Ku. To appear in the Trans. of the Instrument Soc. of America.

Computer interpretation of English text and picture patterns. R. Kirsch. To appear in IEEE Transactions on Electronic Computers, Aug. 1964.

A bounded automorphic form of dimension zero is constant. M. I. Knopp, J. Lehner, M. Newman. To appear in Duke Mathematical Journal.

Character subgroups of F-groups. M. I. Knopp and M. Newman. To appear in the Jr. of Research NBS.

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

A theorem on the automorphs of a skew-symmetric matrix. M. Newman. To appear in the Michigan Mathematical Journal.

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

Congruence subgroups of positive genus of the modular group. M. Newman and M. I. Knopp. To be published in Illinois J. Math.

Bounds for class numbers. M. Newman. To appear in Am. Math. Soc. Proc. of Symp. for Number Theory.

On the asymptotic solutions of second-order differential equations having an irregular singularity of rank one, with an application to Whittaker functions. F. W. J. Olver. To appear in the J. of the Society for Industrial and Applied Mathematics.

Error bounds for asymptotic solutions of second-order differential equations having an irregular singularity of arbitrary rank. F. W. J. Olver and F. Stenger. To appear in the J. of the Society for Industrial and Applied Mathematics.

Whittaker Functions of large argument. F. W. Olver. To appear in J. of SIAM Section B.

Convergence and abstract spaces in functional analysis. E. Ordman. Submitted to a technical journal.

## Publication Activities

Estimation for a one-parameter exponential model. Janace A. Speckman and Richard G. Cornell (Florida State University). To appear in the J. of the American Statistical Association.

Stochastic theory of diffusion in a plasma across a magnetic field. C. M. Tchen. To appear in Proc. Diffusion Symposium, Munich, Germany.

Spectrum of stationary homogeneous magnetohydrodynamic turbulence. C. M. Tchen. Submitted to a scientific journal.

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.

Effects of a constant force on a Keplerian orbit. J. P. Vinti. To appear in Proceedings of Symposium 25 of the International Astronomical Union, Thessaloniki, Greece, Aug. 15-22, 1964.

PLACEBO IV, Rules, Concordance, Sample Computer Generation. W. C. Watt. To appear as NBS Technical Note 255.

A prerequisite to the utility of microgrammars. W. C. Watt. To appear as Technical Note 258.

On convex metrics. C. Witzgall. To appear in American Math. Monthly.

A modification of Edmonds' maximum matching algorithm. C. Witzgall and C. T. Zahn, Jr. To appear in J. of Research NBS, 69B, 1965.

Mortality patterns in eight strains of flour beetles. W. J. Youden, D. B. Mertz and T. Park (U. of Chicago). Submitted to a technical journal.

### 2.4 Reviews and Notes

A note on multipliers of difference sets. R. A. Brualdi. To appear in Canadian J. of Math.







