STAT

STAT

STAT

TECHNICAL REPORT SUPPLEMENT

TO

ANNUAL CONSOLIDATED REPORT ON RESEARCH AND DEVELOPMENT PROJECTS: CSCRD-1

DA Project 599-01-004   Ord Corps Project TB2-0001

ORDNANCE BASIC RESEARCH

Calender Year 1957

List No. 1   30 April 1958

The technical reports listed herein have been published and distributed, or have been submitted for publication in scientific journals, since the compilation of the above-captioned Annual Report for the Calendar Year 1957.

Following the convention established for the Annual Report, this list has been set up by Scientific Field and Sub-Field, and the Research Proposals have been listed numerically under each Sub-Field. The number assigned to each report in this List, e. g., 270:12, indicates that it is the 12th report in a series prepared in connection with Research Proposal 270. The preceding 11 reports in the series are listed in the Annual Report, and may be found on the appropriate pages.

Requests for copies of these reports (excepting manuscripts) can be made first to Installation libraries, since in practically every instance they have been given wide distribution to R & D Installations direct from the contractors. In the event that this is not the case for a particular report desired, the report may be ordered from ASTIA, through the normal channels. Reports may also be secured from the OOR for a limited period on loan; in the event this is desired, only the number appearing in this list need be furnished to identify the report requested.

Manuscripts generally are not available for distribution, since only one copy is received in the OOR.

Publication of future lists will be at bimonthly intervals.

Information Processing Office
Office of Ordnance Research, U. S. Army
Box CM, Duke Station
Durham, North Carolina

TABLE OF CONTENTS

T A B L E   O F   C O N T E N T S

I   P H Y S I C S:

A. Astronomy and Geophysics

1478:3.   Thermal Radiation from the Sun at 8.5 - Millimeter Wavelength by F. H. Mitchell, R. N. Whitehurst and R. R. Weaver. 20 November 1957, 6 p., figures. (University of Alabama, Department of Physics, Technical Report No. 3, Contract No. DA-01-009-ORD-456).

1482:4.   A Note on the Analysis of the Old Climax Coronal Plates, by D. E. Billings. 3 September 1957, 49 p., tables. (University of Colorado, Report No. HAO-37, Contract No. DA-23-072-ORD-929).

1482:5.   Intensity of Coronal Emission Lines, by Richard T. Hansen. 21 February 1958, various paging. (University of Colorado, Final Report, Contract No. DA-23-072-ORD-929).

B. Atomic and Molecular Physics

291:23.   Electron Spin Resonance Studies of Radiation Damage to Amino Acids, by Howard Shields and Walter Gordy. 20 p., figures. (Duke University, Department of Physics, Progress Report No. 23: 1 November 1957 - 1 February 1958, Contract No. DA-36-034-ORD-1233).

434:13.   Valence Band Spectra of the Metals in the 3d Transition Group, by D. H. Tomboulian. January 1958, 23 p., figures. (Cornell University, Department of Physics, Contract No. DA-30-115-ORD-669).

845:11.   Mass Loss in Barrels of Ballistic Accelerators, by C. R. Whited and W. S. Partridge. (Manuscript submitted to the Journal of Applied Physics, Contract No. DA-04-495-ORD-451).

845:12.   Ionization in the Trail of High-Velocity Pellets, by William S. Partridge and L. Dale Harris, in the Journal of Applied Physics, vol. 28, no. 11 (19 November 1957), p. 1269 - 1271, Contract No. DA-04-495-ORD-451.

845:13.   Time Lag Between High-Speed Pellets and the Ionization in Their Trails, by R. A. Davidson and W. S. Partridge, in the Journal of Applied Physics, vol. 28, no. 11 (November 1957), p. 1304 - 1308, Contract No. DA-04-495-ORD-451).

845:14.   Time Delay Between High-Speed Pellets and Associated Luminosity and Ionization, by P. E. Tucker and R. A. Davidson and W. S. Partridge. (Manuscript submitted to the Journal of Applied Physics, Contract No. DA-04-495-ORD-451).

I PHYSICS

B. Atomic and Molecular Physics (continued)

845:15. Ionization by Ultra-Speed Pellets, by Charles D. Hendricks, Jr., in the Journal of Applied Physics, vol. 28, no. 11 (November 1957), p. 1339-1341, Contract No. DA-04-495-ORD-451).

1505:4. Design and Construction of a Vacuum-Grating Spectrograph for the Infrared, by John A Herndon and Alvin H. Nielsen. 2 December 1957, 122 p., figures, tables. (The University of Tennessee, Departments of Physics and Chemistry, Technical Report No. 2, Contract No. DA-33-008-ORD-1166).

1505:5. The Infrared Spectra and Potential Constants of $N^{14}O_2$ and $N^{15}O_2$, by Edward Arakawa and Alvin H. Nielsen. 5 December 1957, 133 p., figures, tables. (University of Tennessee, Departments of Physics and Chemistry, Technical Report No. 3, Contract No. DA-33-008-ORD-1166).

1505:6. Infrared Spectrum of Formyl Fluoride, by Roy F. Stratton and Alvin H. Nielsen. 5 December 1957, 159 p., figures, tables. (The University of Tennessee, Departments of Physics and Chemistry, Technical Report No. 4, Contract No. DA-33-008-ORD-1166).

1505:7. The Infrared Spectra of Dimethyl Sulfide; Dimethyl Disulfide and Dimethyl Trisulfide, by Barbara Jean Miley and William H. Fletcher. 15 January 1958, 35 p., figures, tables. (University of Tennessee, Departments of Physics and Chemistry, Technical Report No. 5, Contract No. DA-33-008-ORD-1166).

1523:1. Emission Lines from Preionized Levels in Krypton and Xenon, by M. Thekaekara and G. H. Dieke. (Manuscript submitted to the Physical Review, Contract No. DA-36-034-ORD-2037).

1624:4. Ionization Potentials of Ammonia and Some Amines, by K. Watanabe and Joseph R. Mottl, in the Journal of Chemical Physics, vol. 26, no. 6 (June 1957), p. 1773-1774, Contract No. DA-04-200-ORD-480.

1624:5. Absorption and Photoionization Coefficient of Furan Vapor, by K. Watanabe and Toshio Nakayama. (Manuscript submitted to the Journal of Chemical Physics, Contract No. DA-04-200-ORD-480).

1816:2. Preservation of Spin State in Free Atom-Inert Surface Collissions, by H. G. Robinson, E. S. Ensberg and H. G. Dehmelt, in the Journal of the American Physical Society, vol. 3, no. 1, p. 9; Technical Report No. 2: 1 April - 13 November 1957, Contract No. DA-04-200-ORD-620.

I PHYSICS

C. Cosmic Rays and Elementary Particles

531:14. Proposed Experiment Bearing Directly on Helicity of Neutrinos, by Lorne A. Page. (Manuscript submitted to Il Nuovo Cimento, Contract No. DA-36-061-ORD-559).

531:15. Annihilation Method for Measuring Transverse Polarization of Energetic Positrons, by Lorne A. Page. (Manuscript – submitted to the Physical Review, Contract No. DA-36-061-ORD-559).

D. Cryogenics and Liquids

787:9. Unsolved Problems in Acoustics and the Liquid State, by Theodore Litovitz. (Manuscript submitted to the Journal of the Acoustical Society of America, Contract No. DA-36-034-ORD-1221).

787:10. Ultrasonic Velocity in the Liquid-Glass Transition Region, by T. A. Litovitz and T. Lyon. (Manuscript submitted to the Journal of the Acoustical Society of America, Contract No. DA-36-034-ORD-1221).

1508:2. The Study of Progressive Ultrasonic Waves by Means of Light Refraction, by M. A. Brezeale and E. A. Hiedemann. (Manuscript submitted to the Journal of the Acoustical Society of America, Contract No. DA-20-018-ORD-13854).

E. Gases and Gaseous Electronics

442:7. Dissociation Limit of O_2, by P. L. Randolph and R. Geballe. 21 January 1958, 5 p., figures. (University of Washington, Technical Report No. 5, Contract No. DA-04-200-ORD-664).

623:4. The Effect of Mercury on a Metal High Vacuum Valve, by Robert H. McFarland, Richard Anderson and Joseph Wells. (Manuscript submitted to the Review of Scientific Instruments, Contract No. DA-23-072-ORD-1012).

623:5. A Study of the Effectiveness of a Copper Foil Trap for Mercury Vapor in Vacuum, by Robert H. McFarland and Donald G. McDonald. (Manuscript submitted to the Review of Scientific Instruments, Contract No. DA-23-072-ORD-1012).

623:6. An Improved U. V. Filter for Isolation of the 2537A line of a Mercury Low Pressure Lamp, by Robert McFarland, Richard A. Anderson and others. (Manuscript submitted to the Review of Scientific Instruments, Contract No. DA-23-072-ORD-1012).

I   PHYSICS

E.   Gases and Gaseous Electronics (continued)

1543:6.   Thermodynamic Studies of Some Gaseous Metallic Carbides, by
M. G. Inghram. 31 December 1957, 8 p., tables. (University
of Chicago, Technical Report No. 6, Contract No. DA-11-022-
ORD-1993).

F.   General Physics

1571:8.   Topological Formulas for Active Networks, by Wataru Mayeda.
30 January 1958, 48 p., figures, tables. (University of
Illinois, Technical Report No. 8, Contract No. DA-11-022-
ORD-1983).

G.   Instrumentation

H.   Nuclear Physics

893:42.   Energy Dependence of Reactions at Thresholds, by G. Breit,
in the Physical Review, vol. 107, no. 6 (September 1957),
p. 1612-1615. (Technical Report No. 40, Contract No. DA-
19-059-ORD-1447).

893:43.   Velocity Dependent Features of a Static Nucleon-Nucleon
Potential, by G. Breit. (Manuscript submitted to the
Physical Review, Contract No. DA-19-059-ORD-1447).

1353:12.   Nuclear Scattering of Nucleons and Antinucleons, by Hans
Peter Duerr. Not Dated, 15 p., figures. (University of
California, Department of Physics, Technical Report No. 8,
Contract No. DA-04-200-ORD-171, T.O. 11).

1353:13.   Interaction of Antiprotons with Complex Nuclei, by A. E.
Glassgold. Not Dated, 15 p., figures, tables. (University
of California, Physics Department, Technical Report No. 9,
Contract No. DA-04-200-ORD-171, T.O. 11).

1488:7.   Measurement and Analysis of Reactivity Values of Control
Rods, by Thomas LeRoy Jackson. 1958, 88 p., figures, tables.
(North Carolina State College, MS Thesis, Contract No. DA-
36-034-ORD-1656).

I.   Optics and Photography

1601:3.   Theory of the Phase Contrast Principle, by A. G. Smith, M. J.
Saunders and others. 31 January 1958, 81 p., figures, tables.
(University of Florida, Final Report, Contract No. DA-01-009-
ORD-469).

I   PHYSICS

J.   Solid State Physics

421:17.   The Superconducting Transition in Aluminum: Part II, by John F. Cochran and D. E. Mapother. (Manuscript submitted to the Physical Review, Contract No. DA-11-022-ORD-992).

421:18.   The Isotope Effect on the Superconducting Transition in Lead, by R. R. Hake, D. E. Mapother, and D. L. Decker. (Manuscript submitted to the Physical Review, Contract No. DA-11-022-ORD-992).

431:23.   Theory of the Anomalous Skin Effect in Normal and Superconducting Metals, by D. C. Mattis and J. Bardeen. (Manuscript submitted to the Physical Review, Contract No. DA-11-022-ORD-1001).

431:24.   The Meissner Effect and Gauge Invariance, by G. Rickayzen. (Manuscript submitted to the Physical Review, Contract No. DA-11-022-ORD-1001).

826:10.   Compression and Densities of ^{F}our Solidified Hydrocarbons and Carbon Tetrafluoride at 77°K, by John W. Stewart and Ralph I. La Rock. (Manuscript submitted to the Journal of Chemical Physics, Contract No. DA-36-034-ORD-2219).

1176:9.   Research and Development of Electron Density Distribution in Semi-Conductors, by G. A. Jeffrey. September 1957, 52 p., figures, tables. (University of Pittsburgh, Technical Report, Contract No. DA-36-061-ORD-516).

1490:1.   Thermionic Ions from Hydrogen-Palladium, by C. H. Bachman and P. A. Silberg. (Manuscript submitted to the Journal of Applied Physics, Contract No. DA-30-115-ORD-643).

1490:2.   Diffusion of Hydrogen in Palladium, by P. A. Silberg and C. H. Bachman. (Manuscript submitted to the Journal of Applied Physics, Contract No. DA-30-115-ORD-643).

1490:3.   Apparatus for the Production of CdS Crystals by Coevaporation in a Vacuum, by C. H. Bachman and R. J. Miller. (Manuscript submitted to the Journal of Applied Physics, Contract No. DA-30-115-ORD-643).

1490:4.   The Production of Cadmium Sulfide Crystals by Coevaporation in a Vacuum, by R. J. Miller and C. H. Bachman. (Manuscript submitted to the Journal of Applied Physics, Contract No. DA-30-115-ORD-643).

I   PHYSICS

J.   Solid State Physics (continued)

1689:1.   Lack of Metallic Transition in LiH and LiAlH$_4$ Under Static Pressure, by D. T. Griggs, W. G. McMillan, E. D. Michael and others. (Manuscript submitted to the Physical Review, Contract No. DA-04-495-ORD-785).

1722:2.   Optical Properties of Al for hν between 10 and 26 ev, by W. C. Walker, Jr., A. R. Samson, and O. R. Rustgi, in the Journal of the Optical Society of America, vol 48, no. 1 (January 1958), p. 71, Contract No. DA-04-495-ORD-846.

1729:2.   Rayleigh Scattering from Charged Dislocation Lines in Sodium Chloride Crystals, by C. A. Plint, O. Theimer, and W. A. Sibley. (Manuscript submitted to the Philosophical Magazine, Contract No. DA-23-072-ORD-1089).

1845:1.   Semiconducting Properties of Boron, by Vincent P. Jacobsmeyer, S. J., Frank L. Gebhart, and Edward F. Juenke. 54 p., figures, tables. (St. Louis University, Final Report: 1 February 1957 - 31 January 1958, Contract No. DA-23-072-ORD-1101).

I-68:1.   Mass Spectrometric Analysis of Low Concentration HD in Mixtures with Hydrogen, by Edward R. Washwell, William J. McMahon, and Arthur Kant. November 1957, 6 p., figures, tables. (Watertown Arsenal Laboratories, Technical Report 833/7).

30 April 1958

II CHEMISTRY

A. Chemical Engineering and Materials

349:10. Intermolecular Correlation in Light Scattering from Dilute Polymer Solutions, by Andreas C. Albrecht, in Journal of Chemical Physics, vol. 27, no. 5 (November 1957), p. 1014-1023 Contract No. DA-19-020-ORD-1545.

349:11. Random Flight Model in the Theory of the Second Virial Coefficient of Polymer Solutions, by Andreas C. Albrecht, in the Journal of Chemical Physics, vol. 27, no. 5 (November 1957), p. 1002-1013, Contract No. DA-19-020-ORD-1545.

834:29. Studies of the Decomposition Mechanism, Erosive Burning, Sonance and Resonance for Solid Composite Propellants, by R. Schultz, L. Green, Jr. and S. S. Penner. (Manuscript submitted to the Third AGARD Combustion and Propulsion Colloquium in Palermo, Italy, Contract No. DA-04-495-ORD-446).

834:30. The Theory of Monopropellant Droplet Burning, by F. Williams. February 1958, 108 p., figures, tables. (California Institute of Technology, Technical Report No. 21, Contract No. DA-04-495-ORD-446).

834:31. Apparent Emission Intensities from a Wrinkled Laminar Flame Model of a Turbulent Flame, by A. E. Fuhs. March 1958, 38 p., figures. (California Institute of Technology, Technical Report No. 22, Contract No. DA-04-495-ORD-446).

834:32. An Elementary Derivation of the Multicomponent Diffusion Equation, by F. A. Williams. (Manuscript submitted to the American Journal of Physics, Contract No. DA-04-495-ORD-446).

907:4. Gas Compressibilities with the Burnett Apparatus, by I. H. Silberberg and K. A. Kobe. 1 January 1958, 23 p., figures, tables. (The University of Texas, Contract No. DA-23-072-ORD-685).

1430:9. Dielectric Dispersion of Solutions of High Polymers, by Philip C. Scherer. 6 p., figures. (Virginia Polytechnic Institute, Quarterly Progress Report No. 9: 15 August 1957 - 15 November 1957, Contract No. DA-36-034-ORD-1943).

1430:10. Dielectric Dispersion of Solutions of High Polymers, by Philip C. Scherer. 17 p., figures, tables. (Virginia Polytechnic Institute Quarterly Progress Report No. 10: 15 November 1957 - 15 February 1958, Contract No. DA-034-ORD-1943).

II   CHEMISTRY

B.   Combustion and Fuel Chemistry

C.   Deterioration Prevention

D.   Electrochemistry and Corrosion

873:7.   Initiation of Styrene Polymerization at a Cathode, by Jacob Kleinberg and W. E. McEwen. 3 p. (University of Kansas, Department of Chemistry, Technical Report No. 7: 1 May 1957 - 31 August 1957, Contract No. DA-23-072-ORD-1048).

873:8.   Anodic Reductions. IV. Reduction of Nitrobenzene, Nitroso-benzene, Azoxybenzene and Azobenzene, by John Y. Yang, William E. McEwen and Jacob Kleinberg. 15 p. (University of Kansas, Department of Chemistry, Technical Report No. 8: 1 August 1956 - 15 October 1957, Contract No. DA-23-072-ORD-1048).

1486:7.   Impedence and Polarization Measurements in Fused Lithium Chloride-Potassium Chloride, by H. A. Laitinen and H. C. Gaur, in the Journal of the Electrochemical Society, vol. 104, no. 12 (December 1957), p. 730-737, Contract No. DA-11-022-ORD-1987).

1541:1.   Radiotracer Studies of Metal-Metal Ion Exchange I. Cadmium, by Cecil V. King and Robert Skomoroski. February 1958, 28 p., figures, tables. (New York University, Technical Report No. 1, Contract No. DA-30-069-ORD-1682).

1541:2.   Radiotracer Studies of Metal-Metal Ion Exchange II. Iron, by Cecil V. King and Robert Skomorski. March 1958, 20 p. (New York University, Technical Report No. 2, Contract No. DA-30-069-ORD-1682).

1541:3.   Radiotracer Studies of Metal-Metal Ion Exchange III. Zinc, by Cecil V. King and Sheldon Evans. April 1958, 18 p., figures, tables. (New York University, Technical Report No. 3, Contract No. DA-30-069-ORD-1682).

E.   Explosives and Propellants

1422:19.   Reactions of Sodium Phenylacetylide and Sodium Alkoxide with Tosyl and Mesyl Azides by J. H. Boyer, C. H. Mack, N. Goebel amd others. (Manuscript submitted to the Journal of Organic Chemistry, Contract No. DA-01-009-ORD-428).

1422:20.   A One-Step Transformation of Acetophenone into Benzaldehyde, by J. H. Boyer. (Manuscript submitted to the Journal of the American Chemical Society, Contract No. DA-01-009-ORD-428).

II CHEMISTRY

F. Inorganic and Analytical Chemistry

1171:2.   Studies of Thermal Decomposition of Chlorates and Per-
chlorates at Constant Temperatures and Pressures, by Aubrey
E. Harvey. 17 p., figures, tables. (University of Arkansas,
Department of Chemistry, Final Summary Report: 1 September
1954 - 31 January 1958, Contract No. DA-23-072-ORD-1049).

1340:3.   Inorganic Complex Compounds Containing Polydentate Groups.
XIV. The Stability of the Complexes Formed between the
Nickel (II) Ion and Tetraethylenepentamine, by Hans B.
Jonassen and Lowell Westerman, in the Journal of the American
Chemical Society, vol. 79 (1957), p. 4275-4279, Contract No.
DA-01-009-ORD-441).

1340:4.   Inorganic Complex Compounds Containing Polydentate Groups.
XV. Thermochemical Studies of the Heat of Neutralization of
Tetraethylenepentamine Pentahydrochloride and Heat of Reaction
of Tetraethylenepentamine with the Nickel (II) Ion, by Hans
B. Jonassen and Lowell Westerman, in Journal of Physical
Chemistry, vol. 61, (1957), p. 1006-1007, Contract No. DA-01-
009-ORD-441).

1340:5.   Inorganic Complex Compounds Containing Polydentate Groups.
XVI. A Study of the Complex Ions Formed by the Copper (II)
Ion with Triethylenetetramine, Tetraethylenepentamine and
Pentaethylenehexamine, by Hans B. Jonassen, J. Aaron Bertrand
and Frank R. Groves, Jr., in Journal of American Chemical
Society, vol. 79 (1957), p. 4279-4282, Contract No. DA-01-009-
ORD-441)

1340:6.   Inorganic Complex Compounds Containing Polydentate Groups
XVIII. The Stability of Iron (II) and Manganese (II) Tetra-
ethylenepentamine Complexes and Their Reactivity Toward Oxygen,
by Hans B. Jonassen, Anneke Schaafsma and Lowell Westerman.
(Manuscript submitted to the Journal of Physical Chemistry,
Contract No. DA-01-009-ORD-441).

1340:7.   Inorganic Complex Compounds Containing Polydentate Groups.
XVII. Reaction of Complexes of Cobalt (II) Quadridentate
Amines with Hydroxide Ions, by Hans B. Jonassen and Gayle T.
Strickland, in Journal of the American Chemical Society, vol.
80 (1958), p. 312-315, Contract No. DA-01-009-ORD-441.

1604:6.   Metal Ion Complexes of 2-(2-Aminoethylamino) Ethanol - Reaction
of Copper (II) Complexes with Sodium Hydroxide, by James L.
Hall and Warren E. Dean. 15 November 1957, 24 p., figures.
(West Virginia University, Technical Report No. 1; also sub-
mitted to the Journal of the American Chemical Society,
Contract No. DA-36-061-ORD-579).

II CHEMISTRY

G. Lubrication and Surface Phenomena

1511:2. Factors Affecting Gelation in Organophilic Silicate Oil Systems, by May Louise Henderson, Joseph Madachy and others. Not Dated, 40 p., figures, tables. (Western Reserve University, Final Report, Contract No. DA-33-019-ORD-1968).

H. Molecular Structure and Physical Properties

1012:17. Electronic Structure of LiH: III. The Knipp Wave Function, by F. A. Matsen and Fred T. Ormand. (Manuscript submitted to the Journal of Chemical Physics, Contract No. DA-23-072-ORD-774).

1012:18. Open Configuration Calculations for Beryllium, by G. H. Brigman, R. P. Hurst, J. D. Gray and others. (Manuscript submitted to the Journal of Chemical Physics, Contract No. DA-23-072-ORD-774).

1428:3. Studies of Perchloryl Fluoride Flames, by Roscoe Maurice Lodwig. 1958, 57 p., figures, tables. (University of Wisconsin, MS thesis, Contract No. DA-11-022-ORD-1818).

1428:4. The Vapor Pressure of Nickel Fluoride, by Milton Farber, Richard T. Myer and John S. Margrave. 1 March 1958, 3 p., figures. (University of Wisconsin Technical Report, Contract No. DA-11-022-ORD-1818).

1436:10. A Combined Analysis of Variance and Regression Treatment in the Evaluation of the Effects of Substituents on Reactivity, by H. H. Jaffe. (Manuscript submitted to the Journal of Organic Chemistry, Contract No. DA-33-008-ORD-1155).

1436:11. The Basicities of Substituted Pyridene-1-Oxides. A Reaction Series Requiring the Use of σ^+ and σ^-, by H. H. Jaffe. (Manuscript submitted to the Journal of the American Chemical Society, Contract No. DA-33-008-ORD-1155).

1467:2. Electron Spectra of Free Radicals at $4^\circ K$ - HNO, NH and OH., by G. Wilse Robinson and Maclyn McCarty, Jr. (Manuscript submitted to the Journal of Chemical Physics, Contract No. DA-36-034-ORD-2169).

1467:3. Electronic Spectra of Free Radicals at $4^\circ K$ - NH_2, by G. Wilse Robinson and Maclyn McCarty, Jr. (Manuscript submitted to the Journal of Chemical Physics, DA-36-034-ORD-2169).

(continued)
Suppl List 1   10   30 April 1958

II CHEMISTRY

H. Molecular Structure and Physical Properties (continued)

1467:4. Electronic Spectrum of Monomeric Nitrogen Dioxide at Liquid Helium Temperature, by G. Wilse Robinson, Maclyn McCarty, Jr. and others, in the Journal of Chemical Physics, vol. 27, no. 4 (October 1957), p. 972-973, Contract No. DA-36-034-ORD-2169.

1467:5. The Nature of Formaldehyde in its Low-Lying Excited States, by G. W. Robinson and V. Erdmanis Di Giorgio, in Canadian Journal of Chemistry, vol. 36 (1958), p. 31-38, Contract No. DA-36-034-ORD-2169.

1473:2. The Rheological Properties and Strengths Exhibited by Adhesive Materials when Present as Bonds, by Harold Tarkow, Charles B. Norris and others. Not Dated, 57 p., figures, tables. . (Forest Products Laboratory, Final Technical Report).

1475:1. Some Combinatorial Problems of Statistical Mechanics, by Richard Otter. 3 p. (University of Notre Dame du Lac, Final Report: 20 June 1955 - 31 December 1957, Contract No. DA- 11-022-ORD-1856).

1496:3. Dielectric Dispersion of Boric Acid in Water. The Rate of Recombination of H^+ and $H_2BO_3^-$ at $35^{\circ}C$, by W. R. Gilkerson, in the Journal of Chemical Physics, vol. 27, no. 4 (October 1957), p. 914-917, Contract No. DA-36-034-ORD-2140).

1607:5. Calculation of the Energy of Activation of Some Simple Reactions. The Ortho-Para Hydrogen Reaction, by Ellis R. Lippincott and Asa Leifer. December 1957, 19 p., figures. (University of Maryland, Department of Chemistry, Technical Report No. 5, Contract No. DA-36-034-ORD-2175).

1733:3. Infrared Spectra of Iodine Monochloride Charge-Transfer Complexes, by Willis B. Person, Ray E. Humphrey, and others. (Manuscript submitted to the Journal of the American Chemical Society, Contract No. DA-11-022-ORD-2303).

1815:2. Vibrational Spectra of the Crystalline Methyl Halides: I. Infrared Spectrum of $CH_3Cl(S)$, by David A. Dows. (Manuscript submitted to the Journal of Chemical Physics, Contract No. DA-04-495-ORD-900). .

1815:3. Vibrational Spectra of the Methyl Halides: II. Infrared Spectrum of $CH_3Br(S)$, by David A. Dows. (Manuscript submitted to the Journal of Chemical Physics, Contract No. DA-04-495-ORD-900).

II C H E M I S T R Y

H. Molecular Structure and Physical Properties (continued)

1815:4. Vibrational Spectra of the Crystalline Methyl Halides: III. Infrared Spectrum of CH3I(S) and Comparsions Among the Methyl Halides, by David A. Dows. (Manuscript submitted to the Journal of Chemical Physics, Contract No. DA-04-495-ORD-900).

I. Organic Chemistry

651:13. Studies Related to Pyracene. An Improved Synthesis, by Arthur G. Anderson, Jr. and Robert G. Anderson, in the Journal of Organic Chemistry, vol. 22 (1957), p. 1197-1200, Contract No. DA-04-200-ORD-235 .

696:10. The Spectrophotometric Determination of Complexing Agent in a Polynitroaromatic Molecular Compound, by L. H. Klemm, J. W. Sprague, Herman Ziffer and others. (Manuscript submitted to Analytica Chimica Acta, Contract No. DA-04-200-ORD-176).

696:11. Observations on the C-H Out-of-Plane Bending Vibrations of Some Substituted Naphthalenes and Naphthalene Picrates, by L. H. Klemm. (Manuscript submitted to the Spectrochimica Acta, Contract No. DA-04-200-ORD-176).

745:10. Pinacollike Rearrangement of a Cyclo-propane-1,2-dimethylene Glycol, by Robert A. Darby and Robert E. Lutz, in the Journal of Organic Chemistry, vol. 22 (1957), p. 1353. (Technical Report No. 4, Contract No. DA-36-034-ORD-1283).

795:29. Some Reactions of Benzyne and Naphthalyne, by J. F. Bunnett and T. K. Brotherton. (Manuscript submitted to the Journal of Organic Chemistry, Contract No. DA-36-034-ORD-1322).

795:30. Base Catalysis of the Reaction of N-Methylaniline with 2, 4-Dinitrofluorobenzene. Proof of the Intermediate Complex Mechanism for Aromatic Nucleophilic Substitution, by J. F. Bunnett and John J. Randall. (Manuscript submitted to the Journal of the American Chemical Society, Contract No. DA-36-034-ORD-1322).

795:31. The Nucleophillic Reactivity of Aniline, Hydrazine and Phenoxide Ion toward 2,4-Dinitrochlorobenzene, by J. F. Bunnett and George T. Davis. (Manuscript submitted to the Journal of the American Chemical Society, Contract No. DA-36-034-ORD-1322).

(continued)
Suppl List 1

30 April 1958

II CHEMISTRY

I. Organic Chemistry (continued)

795:32. A General Principle for the Syntheses of Heterocylic Compounds, by B'jorn F. Hrutfiord and J. F. Bunnett. (Manuscript submitted to the Journal of the American Chemical Society, Contract No. DA-36-034-ORD-1322).

858:3. Conformational Equilibrium in Cyclohexyl Bromide, by Ernest L. Eliel and Ralph G. Haber. (Manuscript submitted to Chemistry and Industry). (A part of #4, Contract No. DA-11-022-ORD-2279)..

858:4. The Relative Reactivity of Epimers in Simple and Fused Cyclohexane Systems, by Ernest L. Eliel and Ralph G. Haber. 20 January 1958, various paging, figures, tables. (University of Notre Dame, Technical Report No. 1, containing #3, Contract No. DA-11-022-ORD-2279).

858:5. Conformational Analysis. II. Esterification Rates of Cyclohexanols, by Ernest L. Eliel and Carl A. Leikach, in the Journal of the American Chemical Society, vol. 79 (1957), p. 5986-5994, Contract No. DA-11-022-ORD-2279.

880:5. Multiple Variation in Structure-Reactivity Correlations, by Sidney I. Miller. September 1957, 13 p., figures. (Illinois Institute of Technology, Department of Chemistry, Technical Report No. 3, Contract No. DA-11-022-ORD-1514).

1037:2. Studies in the Mechanism of Free Radical Addition of Hydrogen Bromide to Olefins, by Paul I. Abell. 37 p., tables. (University of Rhode Island, Department of Chemistry, Final Report: 28 October 1953 - 31 October 1957, Contract No. DA-19-020-ORD-3171).

1354:4. The Relative Electronic Effects of Oxygen and Sulfur, by William E. Parham. 1 December 1957, Various paging. (University of Minnesota, Final Report, Containing #1, #2, and #3, Contract No. DA-11-022-ORD-1716).

1403:2. Bridged Polycyclic Compounds. VII. The Bromination of Quadricyclo $(2,2,1,0^{2;6},0^3,5)$ heptane-2,3-dicarboxylic Acid, by Stanley J. Cristol and Robert T. La Londe. (Manuscript submitted to the Journal of the American Chemical Society, Contract No. DA-23-072-ORD-912).

1429:5. Structure of 2,6,6-Trimethyl-2,4-cyclohexadienone Dimer, by Theordore L. Brown, David Y. Curtin and Robert R. Fraser. (Manuscript submitted to the Journal of the American Chemical Society, Contract No. DA-11-022-ORD-1985).

II CHEMISTRY

I. Organic Chemistry (continued)

1443:18. Five-.vs. Six-Membered Ring Formation in the Cyclization of 2,3,4-Triphenylbutyric Acid; the Relative Importance of Sterochemistry, by Daniel Lednicer and Charles R. Hauser. (Manuscript submitted to the Journal of the American Chemical Society, Contract No. DA-36-034-ORD-2040).

1443:19. α,β-Diphenylbutyroitrile (Erythro Isomer), by C. R. Hauser and W. R. Dunnavant. (Manuscript submitted to Organic Syntheses, Contract No. DA-36-034-ORD-2040).

1443:20. α,α,β-Triphenyl Prepionitrile, by C. R. Hauser and W. R. Dunnavant. (Manuscript submitted to Organic Syntheses, Contract No. DA-36-034-ORD-2040).

1443:21. α,β-Diphenylpropionic Acid, by C. R. Hauser and W. R. Dunnavant. (Manuscript submitted to Organic Syntheses, Contract No. DA-36-034-ORD-2040).

1443:22. α,α,β-Triphenylpropionic Acid, by C. R. Hauser and W. R. Dunnavant. (Manuscript submitted to Organic Syntheses, Contract No. DA-36-034-ORD-2040).

1443:23. Reductive Metalation of Benzophenone and Benzalacetophenone by Alkali Metals in Liquid Ammonia and Some Condensations of the Resulting Dialkali Salts, by Phillip J. Hamrick, Jr. and Charles R. Hauser. (Manuscript submitted to the Journal of the American Chemical.Society, Contract No. DA-36-034-ORD-2040).

1447:2. Heterocycles of Bivalent and Quadrivalent Tin, by Henry G. Kerivila and Oscar F. Beumel, Jr. (Manuscript submitted to the Journal of the American.Chemical Society, Contract No. DA-19-020-ORD-3651).

1666:1. Conformational Analysis. II. The 2-Bromo-4-t-Butyl-cyclohexanones, by Norman L. Allinger and Janet Allinger. (Manuscript submitted to the Journal of the American Chemical Society, Contract No. DA-20-018-ORD-14652).

1730:2. Rates of Solvolysis of Some Deuterated 2-Phenylethyl p-Toluenesulfonates, by William H. Saunders, Jr., Smiljko Asperger and David H. Edison. (Manuscript submitted to the Journal of the American Chemical Society, Contract No. DA-30-115-ORD-781).

1730:3. The Thermal Rearrangement of Triarylmethyl Azides, by William H. Saunders, Jr. and Judith C. Ware. (Manuscript submitted to the Journal of the American Chemical Society, Contract No. DA-30-115-ORD-781).

II CHEMISTRY

I. Organic Chemistry (continued)

1734:4.   Derivatives of Diimide as Intermediates in Organic Reactions, by Louis A. Carpino. 13 p. (University of Massachusetts, Final Report: January 22 - November 30, 1957, Contract No. DA-19-059-ORD-2468).

1734:5.   A New Synthesis of Unsaturated Acids. III. Structures of the Halogenation Products of 4-Unsubstituted and 4-monosubstituted-2-pyrazolin-5-ones, by Louis A. Carpino. (Manuscript submitted to the Journal of the American Chemical Society, Contract No. DA-19-059-ORD-2468).

1871:1.   A Kinetic Study of the ortho-Claisen Rearrangement, by Harlan L. Goering and Robert R. Jacobson. (Manuscript submitted to the Journal of the American Chemical Society, Contract No. DA-11-022-ORD-2498).

2019:1.   Phenylmethanedithiol Diacetate, by Lamar Field and Charles B. Hoelzel. (Manuscript submitted to the Journal of Organic Chemistry, Contract No. DA-33-008-ORD-1637).

J. Plastics and Polymers

987:5   Solvent Effects and Initiator Efficiency in the Benzoyl Peroxide-Dimethylaniline System, by Cheves Walling and Norman Indictor. 18 February 1958, 17 p., figures, tables. (Columbia University, Technical Report No. 3, Contract No. DA-30-069-ORD-1270).

1073:20.   Lithium Initiated Copolymerization of Styrene and Methyl-methacrylate, by K. F. O'Driscoll, R. J. Boudreau and A. V. Tobolsky. 5 November 1957, 8 p., figures, tables. (Princeton University, Technical Report No. 19, Contract No. DA-36-034-ORD-2190).

1073:21.   Kinetics of Anionic Polymerization of Styrene, by K. F. O'Driscoll and A. V. Tobolsky. 22 January 1958, 11 p., figures, tables. (Princeton University, Technical Report No. 22, Contract No. DA-36-034-ORD-2190).

1073:22.   Research in High Polymer Chemistry. Rates of Initiation in Vinyl Polymerization, by A. Eisenberg, K. F. O'Driscoll and others. 7 January 1957, various paging, figures. (Princeton University, Technical Report No. 21, Contract No. DA-36-034-ORD-2190).

II   CHEMISTRY

J.   Plastics and Polymers (continued)

1073:23.   Lithium Initiated Copolymerization of Styrene and Methyl-methacrylate. II, by K. F. O'Driscoll and A. V. Tobolsky. 10 February 1958, 5 p. (Princeton University, Technical Report No. 23, Contract No. DA-36-034-ORD-2190).

1140:5.   Anisotropic Light Scattering by Streaming Flexible Linear Macromolecules, by Hari L. Bhatnagar and A. Steyenson. 15 January 1958, 9 p. (Wayne State University, Department of Chemistry, Technical Report No. 5, Contract No. DA-20-018-ORD-13388).

1399:5.   Polymerization of 4-t-Butyl-2-Cyclohexylaminomethylphenol, by W. J. Burke, B. A. Baron, P. D. Gardner and others. (Manuscript submitted to the Journal of the American Chemical Society, Contract No. DA-04-495-ORD-660).

1501:5.   Surface Tension of Synthetic High Polymer Solutions, by Suham Al-Madfai and H. L. Frisch. (Manuscript submitted to the Journal of American Chemical Society, Contract No. DA-04-495-ORD-721).

K.   Reaction Kinetics and Equilibria

1010:3.   Chemical Reactions of Ionic Beams, by Walter J. Moore. November 1957, 3 p. (Indiana University, Department of Chemistry, Contract No. DA-33-008-ORD-891).

1311:3.   A Recording Luminescence Spectrophotometer, by E. C. Lim and E. H. Gilmore. (Manuscript submitted to the Review of Scientific Instruments, Contract No. DA-23-072-ORD-581).

1311:4.   A Method for Evaluating Rate Constants in the Jablonski Model of Excited Species in Rigid Glasses, by E. H. Gilmore and E. C. Lim. (Manuscript submitted to the National Academy of Sciences, Contract No. DA-23-072-ORD-581).

1408:2.   Color Complexes of Catechol with Molybdate, by G. P. Haight and Vasken Paragamian. (Manuscript submitted to the Journal of Analytical Chemistry, Contract No. DA-36-034-ORD-2138).

1411:3.   Applicability of the Knudsen Effusion Method to the Study of Decomposition Reactions. The Decomposition of Magnesium Hydroxide, by Eric Kay and N. W. Gregory. (Manuscript submitted to the Journal of Physical Chemistry, Contract No. DA-04-200-ORD-696).

II CHEMISTRY

K. Reaction Kinetics and Equilibria (continued)

1536:3. Heats of Combustion of Some Peroxides and the Heats of Formation of Acetate, Propionate, and Butyrate Radicals, by L. Jaffe, E. J. Prosen and M. Szwarc, in the Journal of Chemical Physics, vol. 27, no. 2. (August 1957), p. 416-420, Contract No. DA-30-115-ORD-678).

1536:4. Kinetics of Decomposition of Iso-Butyryl Peroxides and Reactions of Iso-Propyl Radicals, by J. Smid and M. Szwarc. Not Dated, 10 p., figures, tables. (Syracuse University; also submitted to the Journal of Chemical Physics, Contract No. DA-30-115-ORD-678).

1536:5. Pseudo Energy Transfer in Some Unimolecular Decompositions, by M. Szwarc and L. Herk. Not Dated, 5 p., figures. (Syracuse University, Contract No. DA-30-115-ORD-678).

III MATHEMATICS

A. Algebra and Number Theory

B. Analysis

244:43. On Deformations of Complex Analytic Structures, by K. Kodaira and D. C. Spencer. July 1957, 217 p. (Princeton University, Technical Report No. 7, Contract No. DA-36-034-ORD-2164).

244:44. On the Existence of Deformations of Complex Analytic Structures, by K. Kodaira, L. Nirenberg, and D. C. Spencer. (Manuscript submitted to Annals of Mathematics, Contract No. DA-36-034-ORD-2164).

264:33. A Limit Theorem for the Periodogram, by Solomon Bochner and Tatsuo Kawata. (Manuscript submitted to the Annals of Mathematical Statistics, Contract No. DA-36-034-ORD-2001).

264:34. Probability and Differential Equations, by William Feller, George Hufford, and others. December 1957, various paging. (Princeton University, Department of Mathematics, Technical Report No. 6, containing #25, #32 and #35, Contract No. DA-36-034-ORD-2001).

264:35. The Birth and Death Processes as Diffusion Processes, by William Feller. (Manuscript submitted to the Journal des Mathematiques, Contract No. DA-36-034-ORD-2001). (A Part of #34).

264:36. A Property of Brownian Motion Paths, by H. F. Trotter. (Manuscript submitted to the Illinois Journal of Mathematics, Contract No. DA-36-034-ORD-2001).

641:15. Duality in General Ergodic Theory, by Robert Heyneman. January 1958, 52 p. (University of California, Department of Mathematics, Technical Report No. 15, Contract No. DA-04-200-ORD-171, T. O. 5).

641:16. Analytic Perturbation of Operators, by Frantisek Wolf. (University of California, Terminal Report: 1 July 1957 - 30 September 1957, Contract No. DA-04-200-ORD-171, T. O. 5).

913:7. The Existence of Vector Function Spares with Duals of Integral Type, by Marston Morse and William Transue. (Manuscript submitted to the Colloquium Mathematicum, Contract No. DA-33-019-ORD-1265).

913:8. The Local Characterization of Vector Function Spaces with Duals of Integral Type, by Marston Morse and William Transue. (Manuscript submitted to the the Michigan Mathematical Journal, Contract No. DA-33-019-ORD-1265).

III MATHEMATICS

B. **Analysis** (continued)

983:15. Representations of the a^i Operators and Applications to Equations for Massless Particles, by Harry E. Moses and J. S. Lomont. (Manuscript submitted to the Physical Review, Contract No. DA-30-069-ORD-2154).

1046:3. Existence, Uniqueness, and Effective Computation of the Solutions of Partial Differential Equations, by Michael Golomb. Not Dated, 3 p. (Purdue Research Foundation, Final Report, Contract No. DA-33-008-ORD-1045).

1299:15. The Topologization of a Sequence Space by Toeplitz Matrices, by P. Erdos and G. Piranian. (Manuscript submitted to the Michigan Mathematical Journal, Contract No. DA-20-018-ORD-13584).

1323:8. Relations Between Mean Curvature and Conformal Type, by Robert Osserman. 1 October 1957, 7 p. (Stanford University, Technical Report No. 7, Contract No. DA-04-200-ORD-343).

1323:9. Open Riemann Surfaces, by H. L. Royden. (Manuscript submitted to the Proceedings of the Colloquium on the Theory of Functions, Contract No. DA-04-200-ORD-343).

1469:1. Periodic Solutions of Singular Perturbation Problems, by Edward R. Rang. 72 p. (University of Minnesota, Technical Report No. 1: 15 September 1956 - 15 September 1957, Contract No. DA-11-022-ORD-2042).

1469:2. Simplification of Systems of Linear Differential Equations Involving A Turning Point, by H. L. Turritin and W. A. Harris, Jr. 13 December 1957, 35 p. (University of Minnesota, Technical Report No. 2, Contract No. DA-11-022-ORD-2042).

1469:3. A Boundary Value Problem for a System of Ordinary Linear Differential Equations Involving Powers of a Parameter, by William A. Harris, Jr. 20 March 1958, 137 p. (University of Minnesota, Department of Mathematics, Technical Report No. 3, Contract No. DA-11-022-ORD-2042).

1517:8. Bibliography on Riemann Surfaces, by Leo Sario. December 1957, 42 p. (University of California, Department of Mathematics, Technical Report No. 6, Contract No. DA-04-495-ORD-722).

1517:9. On the Stability of Boundary Components, by Kotaro Oihawa. April 1958, 128 p. (University of California, Department of Mathematics, Technical Report No. 7, Contract No. DA-04-495-ORD-722).

III MATHEMATICS

B. <u>Analysis</u> (continued)

1617:6. Function Algebras, by A. M. Gleason. (Manuscript submitted to the Proceeding of the Conference on Analytic Functions, Contract No. DA-19-020-ORD-3778).

1617:7. A Deflation Map, by E. Weiss. (Manuscript submitted to the Japanese Journals, Contract No. DA-19-020-ORD-3778).

1617:8. Obstruction Theory in Fibre Spaces, by Robert Hermann. (Manuscript submitted to the Illinois Journal of Mathematics, Contract No. DA-19-020-ORD-3778).

1626:5. Numerical Evaluation of Multiple Integrals. II, by Preston C. Hammer and Arthur H. Stroud. November 1957, 20 p., tables. (University of Wisconsin, Technical Report No. 5, Contract No. DA-11-022-ORD-2301).

1626:6. Remarks on the Disposition of Points in Numerical Integration Formulas, by Arthur H. Stroud. January 1958, 7 p., tables. (University of Wisconsin, Department of Mathematics, Technical Report No. 6, Contract No. DA-11-022-ORD-2301).

1626:7. Numerical Integration Formulas of Degree 2., by Arthur H. Stroud. February 1958, 8 p. (University of Wisconsin, Department of Mathematics, Technical Report No. 7, Contract No. DA-11-022-ORD-2301).

1660:1. A New Class of Continued Fraction Expansions for the Ratios of Heine Functions, by Evelyn Frank. (Manuscript submitted to the Transactions of the American Mathematical Society, Contract No. DA-11-022-ORD-2196).

1685:5. On a Closure Property of Measurable Sets, by Earl Jr. Mickle. (Manuscript submitted to the Proceedings of American Mathematical Society, Contract No. DA-33-019-ORD-2114).

1685:6. On a Decomposition Theorem of Federer, by Earl J. Mickle. (Manuscript submitted to the Transactions of the American Mathematical Society, Contract No. DA-33-019-ORD-2114).

I-52:1. Diagonalization of Operator Matrices, with Applications to Partial Differential Equations, by Ben Fitzpatrick. 1 September 1957. (Redstone Arsenal, Report No. 2R24F).

C. <u>Foundation and Game Theory</u>

D. <u>Geometry and Topology</u>

III MATHEMATICS

E. Mechanics

223:41. Distributed and Lumped Networks, by R. J. Duffin. 1 February 1958, 39 p., figures. (Carnegie Institute of Technology, Department of Mathematics, Technical Report No. 37, Contract No. DA-36-061-ORD-490).

223:42. A Function-Theoretic Solution of Certain Integral Equations. II, by Albert E. Heins and Richard C. Mac Camy. March 1958, 20 p. (Carnegie Institute of Technology, Technical Report No. 38, Contract No. DA-36-061-ORD-490).

247:37. A Weak Solution for a System of Equations of Elliptic-Hyperbolic Type, by Cathleen S. Morawetz. (Manuscript submitted to the Communications on Pure and Applied Mathematics, Contract No. DA-30-069-ORD-2153).

407:40. Sonic Limit Singularities. Part I: General Theory, by G. S. S. Ludford and S. H. Schot. (Manuscript submitted to Archive for Rational Mechanics and Analysis, Contract No. DA-36-034-ORD-1486).

1271:20. Stress-Deformation Relations for Anistropic Solids, by G. F. Smith and R. S. Rivlin, in Archive for Rational Mechanics and Analysis, vol. 1, no. 2 (1957) p. 107-112, Contract No. DA-19-020-ORD-4531).

1271:21. Plane Strain in a Network of Slightly Extensible Cords, by S. M. Genensky and R. S. Rivlin. March 1958, 76 p., figures. (Brown University, Technical Report No. 3, Contract No. DA-19-020-ORD-4531).

F. Numerical and Graphical Methods

1210:48. On the Speed of Convergence of Cyclic and Quasicyclic Jacobi Methods For Computing Eigenvalues of Hermitian Matrices, by Peter Henrici. (Manuscript submitted to the Journal of the Society for Industrial and Applied Mathematics, Contract No. DA-04-495-ORD-559).

1210:49. Generation and Use of Orthogonal Polynomials for Data-Fitting with a Digital Computer, by George E. Forsythe, in the Journal of the Society for Industrial and Applied Mathematics, vol. 5, no. 2 (June 1957), p. 74-88, Contract No. DA-04-495-ORD-559).

1210:50. A Saddle Point Characterization of the Schwinger Stationary Points in Exterior Scattering Problems, by C. L. Dolph, in the Journal of the Society for Industrial and Applied Mathematics, vol. 5, no. 3 (September 1957), p. 89-104, Contract No. DA-04-495-ORD-559).

III MATHEMATICS

F. Numerical and Graphical Methods (continued)

1210:51. Determination of Three Percentiles of the Wn Distribution Function, by Bernard Sherman, in the Journal of the Association for Computing Machinery, vol. 4, no. 4 (October 1957), p. 472-476, Contract No. DA-04-495-ORD-559).

1210:52. Mathematics: Polynonials of Best Approximation on a Real Finite Point Set, by J. L. Walsh and T. S. Motzkin, in the Proceedings of the National Academy of Sciences, vol. 43, no. 9 (September 1957), p. 845-846, Contract No. DA-04-495-ORD-559).

1210:53. A Sturmian Theorem for Partial Differential Equations, by R. M. Redheffer, in the Proceedings of the American Mathematical Society, vol. 8, no. 3 (June 1957), p. 458-462, Contract No. DA-04-495-ORD-559).

1210:54. On Paris of Harmonic Functions, by R. M. Redheffer, in the Proceedings of the American Mathematical Society, vol. 8, no. 3 (June 1957), p. 450-457, Contract No. DA-04-495-ORD-559).

1210:55. Inversion of Matrices by Biorthogonalization and Related Results, by Magnus R. Hestenes. (Manuscript submitted to the Journal of the Society for Industrial and Applied Mathematics, Contract No. DA-04-495-ORD-559).

1210:56. Maximizing Functions of Rotations—Experiments Concerning Speed of Diagonalization of Symmetric Matrices Using Jacobi's Method, by David A. Pope and C. Tompkins, in the Journal of the Association for Computing Machinery, vol. 4, no. 4 (October 1957), p. 459-466, Contract No. DA-04-495-ORD-559.

1210:57. Solution of a Heat Equation for a Bounded Line by a Method Involving Sine Transforms, by C. Tompkins. (Manuscript submitted to the Journal of the Association for Computing Machinery, Contract No. DA-04-495-ORD-559).

1210:58. On the Behavior of the Solution of the Dirichlet Problem at Analytic Corners, by Pentti Laasonen, in Annals Academiae Scientiarum Fennicae, Series A. I. Mathematica, 241 (1957), p. 1-12, Contract No. DA-04-495-ORD-559).

G. Probability and Statistics

362:27. Effect of Expansion of the Universe on the Distribution of Images of Galaxies on Photographic Plates—A Simplified Model, by Martin Fox. (Manuscript submitted to the Astronomical Journal, Contract No. DA-04-200-ORD-171, T. O. 3).

III MATHEMATICS

G. <u>Probability and Statistics</u> (continued)

362:28. Contributions to the Statistical Theory of Cloud Chamber
Data, by Robert Richard Read. (Manuscript submitted for pub-
lication, Contract No. DA-04-200-ORD-171, T. O. 3).

362:29. A Counterexample to a Theorem of Kolmogorov, by Leo Breiman,
in the Annals of Mathematical Statistics, vol. 28, no. 3
(September 1957), p. 811-814, Contract No. DA-04-200-ORD-171,
T. O. 3).

362:30. Densities for Stochastic Processes, by Charlotte T. Striebel.
(Manuscript submitted to the Annals of Mathematical Statistics,
Contract No. DA-04-200-ORD-171, T. O. 3).

362:31. On a Locally Most Powerful Similar Test for the Independence
of Two Poisson Variables, by Mohamed Salahuddin Ahmed. Not
Dated, 73 p. (University of California, PhD Thesis; also sub-
to the Annals of Mathematical Statistics under the title "On
a Locally Most Powerful Boundary Randomized Similar Test for
the Independence of Two Poisson Variables," Contract No. DA-
04-200-ORD-171, T. O. 3).

832:19. Some Results on the Probability Distribution of the Latent
Roots of a Symmetric Matrix of Continuously Distributed Ele-
ments, and Some Applications to the Theory of Response Sur-
face Estimation, by H. R. van der Vaart. January 1958, 40 p.
(University of North Carolina, Technical Report No. 18, Con-
tract No. DA-36-034-ORD-1517).

832:20. The Comparison of Regression Variables, by Evan J. Williams.
April 1958, 13 p. (University of North Carolina, Technical Re-
port No. 19, Contract No. DA-36-034-ORD-1517).

1166:37. Lectures on the Theory of Least Squares, by R. Lowell Wine
and William A. Glenn. December 1957, 176 p. (Virginia
Polytechnic Institute, Technical Report No. 35, Contract No.
DA-36-034-ORD-1527).

1175:9. Research in Unbiased Estimation, Integral Equations with Un-
known Distribution Functions, and Non-Parametric Methods, by
Julius R. Blum. 1 February 1958, 12 p. (Indiana University
Foundation Research Division, Technical Report No. 8, Con-
tract No. DA-33-008-ORD-965).

1715:9. The Propagation of Errors, Fluctuations and Tolerances -
Supplementary Formulas, by John W. Tukey. Not Dated, 14 p.,
tables. (Princeton University, Department of Mathematics,
Technical Report No. 11, Contract No. DA-36-034-ORD-2297).

III MATHEMATICS

G. Probability and Statistics (continued)

1715:10. The Propagation of Errors, Fluctuations and Tolerances. 3 - An Exercise in Partial Differentiation, by John Tukey. Not Dated, 72 p., figures, tables. (Princeton University, Department of Mathematics, Technical Report No. 12, Contract No. DA-36-034-ORD-2297).

1715:11. The Propagation of Errors, Fluctuations and Tolerances-Basic Generalized Formulas, by John W. Tukey. Not Dated, Various paging. (Princeton University, Department of Mathematics, Technical Report No. 10, Contract No. DA-36-034-ORD-2297).

1715:12. Some General Considerations in Process Optimisation, by G. E. P. Box. Not Dated, 28 p., figures. (Princeton University, Department of Mathematics, Technical Report No. 13, Contract No. DA-36-034-ORD-2297).

1840:2. A Characterization of the Normal Distribution, by S. G. Ghurye and I. Olkin. 15 October 1957, 6 p. (Michigan State University, Technical Report No. 8, Contract No. DA-20-018-ORD-14735).

1840:3. An Inequality Satisfied by the Gamma Function, by Ingram Olkin. 9 December 1957, 4 p. (Michigan State University, Technical Report No. 9, Contract No. DA-20-018-ORD-14735).

1840:4. A Class of Integral Identities with Matrix Argument, by Ingram Olkin. 5 February 1958, 12 p. (Michigan State University, Technical Report No. 10, Contract No. DA-20-018-ORD-14735).

I-88:1. A Statistical Distribution Applicable to Certain Redundant Systems, by Helen J. Coon and Frank E. Grubbs. September 1957, 22 p., figures, tables. (Ballistic Research Laboratories, Report No. 1099).

H. Operations Analysis

968:15. Calculation of Non-Stationary Queuing Probabilities for Landing Congestion of Aircraft, by Clyde Wheeler and Herbert P. Galliher. (Manuscript submitted to the Journal of the Operations Research Society of America, Contract No. DA-19-020-ORD-2684).

968:16. Monte Carlo Simulation Studies, by Herbert P. Galliher. (Manuscript submitted to the Proceedings of the Symposium on System Simulation, Contract No. DA-19-020-ORD-2684).

III MATHEMATICS

H. <u>Operations Analysis</u> (continued)

968:17. A High-Speed Computer Technique for the Transportation Problem, by Jack B. Dennis. (Manuscript submitted to the Journal of the Association for Computing Machinery, Contract No. DA-19-020-ORD-2684).

IV ENGINEERING

A. Combustion and Fuels

B. Fluid Mechanics

1074:5. Flow Behavior of Concentrated (Dilatant) Suspensions, by A. B. Metzner and Malcolm Whitlock. (Manuscript submitted to the Society of Rheology, Contract No. DA-36-034-ORD-1495).

1074:6. Turbulent Heat Transfer Inside Tubes, by W. L. Friend and A. B. Metzner. (Manuscript submitted to the American Institute of Chemical Engineers Journal, Contract No. DA-36-034-ORD-1495).

C. Friction and Lubrication

D. Heat and Mass Transfer

1366:3. Heat Transfer to Boiling Liquids under Conditions of High Temperature Difference and Forced Convection, by S. Rankin. 20 February 1958, 80 p., figures, tables. (University of Delaware, Department of Chemical Engineering, Final Report UD-FB-13, Contract No. DA-36-034-ORD-1797).

1540:3. Results of Oil Quenching Experiments, by Victor Paschkis. Not Dated, 7 p., figures, tables. (Columbia University, Technical Report No. 6, Contract No. DA-30-069-ORD-1621).

1540:4. Numerical Evaluation Techniques, by Victor Paschkis. 15 November 1957, 22 p., figures, tables. (Columbia University, Technical Report No. 5, Contract No. DA-30-069-ORD-1621).

E. Human Engineering

1492:5. Controlled Contact Cutting Tools, by B. T. Chao and K. J. Trigger. (Manuscript submitted to the American Society of Mechanical Engineers, Contract No. DA-11-022-ORD-1980).

F. Measurement and Control

1538:4. Compensation of Nonlinear Feedback Systems by Means of An Inexact Model, by Kenneth R. Kaplan and John G. Truxal. 8 January 1958, 9 p., figures. (Polytechnic Institute of Brooklyn, Contract No. DA-30-069-ORD-1560).

1586:1. Some Topological Considerations in Electrical Circuit Theory, by F. M. Reza. September 1957, 54 p., figures. (Syracuse University Research Institute, Technical Report No. 1, Contract No. DA-30-115-ORD-722).

IV ENGINEERING

G. Materials and Material Processing

1282:6.   Curved Bar and Related Problems Involving Plastic Flow, by
Bernard W. Shaffer. February 1958, 7 p. (New York University:
Final Report, Contract No. DA-30-069-ORD-1398).

1282:7.   Mechanics of the Sheet-Bending Process, by Bernard W. Shaffer
and Eric E. Ungar. January 1958, 19 p., figures. (New York
University, Technical Report No. 6, Contract No. DA-30-069-ORD
-1398).

H. Solid Mechanics

1235:4.   The Transition Temperature in a Notched Bar Impact Test, by
J. A. Hendrickson, D. S. Wood, and D. S. Clark. March 1958,
35 p., figures. (California Institute of Technology, Tech-
nical Report No. 4; also submitted to the American Society
for Metals, Contract No. DA-04-495-ORD-171).

1253:11. Problems of Spherical Stress Waves in Materials, by Donald E.
Dawson. 15 September 1957, 36 p., figures, tables. (The
Pennsylvania State University, Technical Report No. 11,
Contract No. DA-36-061-ORD-465).

1253:12. Stress Waves of Penetration in Plates, by Norman Davids. 1
February 1958, 20 p., figures. (Pennsylvania State University,
Technical Report No. 12, Contract No. DA-36-061-ORD-465).

1253:13. Scabbing in Bars and Plates—Further Studies, by Sudhir Kumar.
1 March 1958, 19 p., figures. (Pennsylvania State University,
Technical Report No. 13, Contract No. DA-36-061-ORD-465).

1283:5.   Studies in Photoplasticity, by M. M. Frocht and R. A. Thomson.
December 1957, 15 p., figures. (Illinois Institute of Tech-
nology, Technical Report No. 5, Contract No. DA-11-022-ORD-
1609).

1283:6.   A Non-Destructive Method for Three-Dimensional Photoelastic-
ity, by M. M. Frocht and L. S. Srinath. December 1957, 12 p.,
figures. (Illinois Institute of Technology, Technical Re-
port No. 6, Contract No. DA-11-022-ORD-1609).

1348:6.   A Statistical Method for Determining Fatigue Strengths with
a Limited Number of Specimens, by J. J. Coleman and W. N.
Findley. June 1957, 21 p., figures. (Brown University,
Technical Report No. 5, Contract No. DA-19-020-ORD-3520).

IV ENGINEERING

H. Solid Mechanics (continued)

1563:1. The Elasticity Solution of a Long Circular Cylindrical Shell Subjected to a Uniform Circumferential Radial Line Load, by Jerome M. Klosner and Frederick V. Pohle. July 1957, 42 p., figures, tables. (Polytechnic Institute of Brooklyn, Final Report, Contract No. DA-30-069-ORD-1723).

1969:1. Analysis of Shells of Revolution Composed of Work-Hardening Material, by E. T. Onat. January 1958, 34 p., figures. (Brown University, Technical Report No. 1, Contract No. DA-19-020-ORD-4564).

I-1:1. Terrain Evaluation in Automotive Off-The-Road Operations, by M. G. Bekker. March 1957, 23 p., figures. (Ordnance Tank Automotive Command, Report No. 13).

I-1:2. Mobility on Land, Challenge and Invitation, by M. G. Bekker. May 1957, 12 p., figures. (Ordnance Tank Automotive Command, Report No. 15).

I-1:3. Study of Snow Values Related to Vehicle Performance, by William L. Harrison, Jr. December 1957, 32 p., figures. (Ordnance Tank Automotive Command, Technical Report No. 23).

I-71:1. Singularities in the Plane Theory of Elasticity. Part I. by Oscar L. Bowie. March 1958, 44 p. (Watertown Arsenal Laboratories, WAL TR 893/203).

I. Symposia and Conferences

J. Vibration and Acoustics

K. Field Operations

L. Aerodynamics

1600:18. Measurement of Turbulent Heat Transfer Rates on the Aft Portion and Blunt Base of a Hemisphere-Cylinder in the Shock Tube, by Josef Rabinowicz. 1 November 1957, 24 p., figures. (California Institute of Technology, Memorandum No. 41; also submitted to Jet Propulsion, Contract No. DA-04-495-ORD-19).

V METALLURGICAL SCIENCES

A. Solid State Metallurgy

157:17. A Study of Reversion Phenomena in the Carbon-Alpha-Iron System, by Donald Keefer and Charles Wert. (Manuscript submitted to Transactions of the AIME, Contract No. DA-11-022-ORD-1731).

906:7. Liquid Tin Solution Calorimeter for Measuring Heats of Formation of Alloys, by Raymond L. Orr, Alfred Goldberg and Ralph Hultgren, in the Review of Scientific Instruments, vol. 28, no. 10 (October 1957), p. 767-773. (Technical Report No. 5, Contract No. DA-04-200-ORD-171, T. O. 8).

B. Metallography and Structure

C. Mechanical and Thermal Metallurgy

D. Chemical Metallurgy

1425:9. On the Thermodynamics of the III-V Compounds InSb, GaSb and InAs, by W. F. Schottky and M. B. Bever. 23 p., figures, tables. (Massachusetts Institute of Technology, Report No. 9: 1 August 1956 - 31 July 1957, Contract No. DA-19-020-ORD-3661).

1425:10. Phase Relations in the System Ag-Sb-S at 400°C, by Jan Barstad. 10 p., figures, tables. (Massachusetts Institute of Technology, Report No. 10: 1 October 1956 - 31 May 1957, Contract No. DA-19-020-ORD-3661).

1425:11. The Formation of Ag_3SbS_3 and $AgSbS_2$ from Ag_2S and Sb_2S_3 by Solid State Reactions at 400°C, by A. G. Verduch and Carl Wagner. 10 p., figures, tables. (Massachusetts Institute of Technology, Report No. 11: 1 January 1956 - 30 June 1957, Contract No. DA-19-020-ORD-3661).

1425:12. Outline of Investigations on the Reaction of Silver-Antimony Alloys with Sulfur, by Carl Wagner. 21 p., figures. (Massachusetts Institute of Technology, Report No. 12: 1 April 1957 - 31 July 1957, Contract No. DA-19-020-ORD-3661).

1425:13. Determination of the Electronic Conductivity in Silver Halides by Means of Polarization Measurements, by Bernhard Ilschner. 13 p., figures, tables. (Massachusetts Institute of Technology, Report No. 13: 15 January 1957 - 15 December 1957, Contract No. DA-19-020-ORD-3661).

V METALLURGICAL SCIENCES

D. Chemical Metallurgy (continued)

1425:14.   Electrical Conductivity of Liquid Magnesium-Bismuth Alloys,
by Bernhard Ilschner and Carl Wagner. 4 p., figures.
(Massachusetts Institute of Technology, Department of Metal-
lurgy, Report No. 14: 1 July 1957 – 31 December 1957, Con-
tract No. DA-19-020-ORD-3661).

E. Process Metallurgy

1472:2.   Micrographic Study of the Growth of Crystals by Condensation
from the Vapor Phase In the Case of Cadmium, by André Accary
and Robert F. Mehl, in The Proceedings of Academie des
Sciences, t. 244 (May 1957), p. 2713-2716, Contract No. DA-
36-061-ORD-530.

1567:1.   Investigation of the Kinetics and Mechanism Involved in the
Hydrogen Reduction of Metal Halide Vapors, by H. S. Spacil
and J. Wulff. 31 January 1958, 55 p., figures. (Massa-
chusetts Institute of Technology, Final Report, Contract
No. DA-19-020-ORD-3760).

1657:2.   The Measurement of Grain Contiguity in Two-Phase Alloys, by
J. Gurland. November 1957, 14 p., figures. (Brown Univer-
sity, Technical Report No. 2, Contract No. DA-19-020-ORD-
3976).

F. Symposia and Conferences

CSCRD-1

A - Proc
B - Ly, Cir

ANNUAL CONSOLIDATED REPORT ON
RESEARCH AND DEVELOPMENT PROJECTS

Office of the Chief of Ordnance
Research and Development Division

STAT

DEPARTMENT OF THE ARMY

PROJECT 599-01-004

ORDNANCE BASIC RESEARCH

VOLUME II, PART 2
TERMINATED CONTRACTS, 1957

OFFICE OF ORDNANCE RESEARCH, U. S. ARMY
BOX CM, DUKE STATION
DURHAM, NORTH CAROLINA

CSCRD-1

ANNUAL CONSOLIDATED REPORT ON

RESEARCH AND DEVELOPMENT PROJECTS

Office of the Chief of Ordnance

Research and Development Division

DEPARTMENT OF THE ARMY

PROJECT 599-01-004

ORDNANCE BASIC RESEARCH

Volume II, Part 2

Terminated Contracts, 1957

OFFICE OF ORDNANCE RESEARCH, U. S. ARMY

Box CM, Duke Station

DURHAM, NORTH CAROLINA

F O R E W O R D

Volume II Part 2 of the Annual Report of the Office of
Ordnance Research contains progress summaries and technical
report listings for contracts terminating during Calendar
Year 1957. This publication is a continuation of Volume II
of the Annual Report for 1956, which listed contracts termi-
nating during the period 1951-1956, and is paged consecutive-
ly with that report. The indexes provided in the rear of this
part of the 1957 Annual Report are complete indexes of all
terminated projects from 1951 through 1957.

It is hoped that indexes, progress summaries, and list-
ings of technical reports may be of assistance in the con-
tinued retrieval of the scientific information produced under
the Ordnance Basic Research Program.

GEORGE F. LEIST
Colonel, Ordnance Corps
Commanding

15 April 1958

TABLE OF CONTENTS

I PHYSICS

A. Astronomy and Geophysics

1072 SEARCH FOR SMALL SATELLITES OF THE EARTH WITH A NEW OPTICAL
INSTRUMENTATION TECHNIQUE

> Contractor: Lowell Observatory
> Flagstaff, Arizona
>
> Chief Investigator: C. W. Tombaugh
>
> Contract No. DA-04-495-ORD-521
> Duration: 29 December 1953 - 30 June 1956
> Amount: $ 26,375.16
> Type of Contract: Cost
>
> Primary Scientific Liaison: Office of Ordnance Research

Scope: Research will be conducted, in cooperation with White Sands
Proving Ground, which will have as its objective the development of
object-following devices and techniques. The devices developed or
assembled will be used to conduct a complete systematic search of
the space about the earth for satellites. Suspects will be checked
to ascertain if they are real or only film defects. An equatorial
mount will be used with due allowances for parallax. Star trails
will be used as reference marks for positions of satellite suspects.
Wherever possible, the techniques developed will be further tried out
through observance of other objects (small planetoids, small comets,
and flare stars).

Progress (to 30 June 1956): A large number of photographs have been
taken of several zones of the sky, with the direction and tracking
rate of the telescope adjusted for each exposure to a reasonable sat-
ellite orbit. Suggestive images were recorded and some zones were
rephotographed in an attempt to recover the satellite suspects. How-
ever, none of the suspects have been confirmed as a satellite. A new
type of observational science has evolved in the course of the work,
and results to date point out possible applications of new methods
and knowledge to artificial satellites. Search equipment used in this
study has been transferred to Quito, Ecuador, where the proximity of
the equator will simplify the geometrical problems. The final report
has been received and the contract has been terminated.

Technical Reports:

1. Proposed Geodetic Triangulation from an Unmanned Orbital Vehicle
   by Means of Satellite Search Technique, by Clyde W. Tombaugh.
   Not dated, 5 p. (Lowell Observatory).

2. Search for Small Earth Satellites, by Clyde W. Tombaugh. 29 p.
   (New Mexico College, Final Report: 1953 - 1956).

I PHYSICS

B. Atomic and Molecular Physics

1016 DETERMINATION OF MOLECULAR CONSTANTS BY MICROWAVE AND RADIO
FREQUENCY SPECTROSCOPY

   Contractor: Georgia Tech Research Institute
        Engineering Experiment Station
        Research Building, Institute of Technology
        Atlanta, Georgia

   Chief Investigators: T. L. Weatherly
           J. Q. Williams

   Contract No. DA-01-009-ORD-353 Renewed: DA-01-009-ORD-465
   Duration: 1 Oct 53 - 31 Dec 55   1 Jan 1956 - 31 May 1957
   Amount: $ 33,438.88 $ 21,888.08
   Type of Contract: Fixed Price   Cost

   Primary Scientific Liaison: Office of Ordnance Research
   Scientific Cognizance: Ballistic Research Laboratories; Picatinny
               Arsenal

Scope: Research will be conducted on the rotational constants, inter-
nuclear distances, bond angles, dipole moments, and nuclear quadrupole
coupling of various molecules by several methods of microwave and
radio-frequency spectroscopy. Study will in particular be made of ni-
trosyl bromide and nitryl chloride, and if possible, also of nitro-
methane, methyl nitrite, and nitroethane.

Progress (to 31 May 1957): A large number of chlorine compounds have
been investigated for pure nuclear quadrupole resonance in the fre-
quency region 20 to 45 mc, and resonance absorption lines were found
in 14 of these. The work on microwave spectroscopy included the study
of the microwave spectrum of NOBr and NO_2Cl in the region 20,000 to
40,000 mc. A complete analysis has been made of the $J = 2 \rightarrow 3$ transi-
tion for NOBr and the $J = 2 \rightarrow 3$ and $J = 3 \rightarrow 4$ transitions for NO_2Cl.
The Stark effect for both molecules has also been studied. Calcula-
tions from the spectra give the rotational constants, moments of in-
ertia, internuclear distances, bond angles, quadrupole coupling con-
stants and dipole moments. The Stark effect for the $J = 2 \rightarrow 3$ transi-
tion of $CClF_3$ has also been observed and preliminary calculations have
been made. Complete results are set forth in the technical reports
listed below. The final report has been received and the project has
been terminated.

Technical Reports:

1. Nuclear Quadrupole Resonances in Some Chlorine Compounds, by J.
  Q. Williams and T. L. Weatherly, in Journal of Chemical Physics,
  vol. 22, no. 3 (March 1954), p. 572.

I PHYSICS

B. Atomic and Molecular Physics

1016 (continued)

  2. Nuclear Quadrupole Resonance in Ethyl Chloroformate and Ethyl
   Trichloroacetate, by T. L. Weatherly and Quitman Williams, in
   Journal of Chemical Physics, vol. 22, no. 5 (May 1954), p. 958.

  3. Microwave Spectrum and Molecular Constants of Nitrosyl Bromide,
   by T. L. Weatherly and Quitman Williams. 19 September 1955, 11 p.
   (Georgia Institute of Technology, Engineering Experiment Station,
   Technical Report No. 1; also submitted to Physical Review).
   ASTIA AD-72 188

  4. The Stark Effect in the Rotational Spectrum of Nitrosyl Bromide,
   by D. F. Eagle, T. L. Weatherly and Quitman Williams. 2 October
   1956, 6 p., figures, tables. (Georgia Institute of Technology,
   Engineering Experiment Station, Technical Report No. 2). ASTIA
   AD-108 268

  5. Determination of Molecular Constants by Microwave and Radio Fre-
   quency Spectroscopy, by T. L. Weatherly, Quitman Williams and
   Lorimer Clayton, Jr. 63 p., figures, tables. (Georgia Institute
   of Technology, Engineering Experiment Station, Final Report:
   1 October 1953 - 31 May 1957).

I PHYSICS

D. Cryogenics and Liquids

674 ABSORPTION OF ULTRASONIC ENERGY IN LIQUIDS

       Contractor: Boston College
               Chestnut Hill 67, Massachusetts

       Chief Investigator: Frederick E. White

       Contract No. DA-19-020-ORD-2569
       Duration: 1 February 1953 - 1 December 1956
       Amount: $ 35,472.76
       Type of Contract: Cost

       Primary Scientific Liaison: Office of Ordnance Research

Scope: Research will be performed in the absorption of ultrasonic energy in various liquids to obtain reliable data over wide ranges of frequency and temperature and to try to fit these data to existing theories or to develop a new theory of absorption. The range of temperature will be from 0° to 100°C or more, the frequency range from 1 to 300 mc/s or greater.

Progress (to 1 December 1956): Ultrasonic absorption in various liquids was measured over wide ranges of frequency and temperature. These measurements were made using a pulse rather than some other known method in order to avoid heating effects and any difficulties which might arise due to the presence of standing waves. The experimental procedure is explained in detail in technical report #1. Several liquids were studied, with particular emphasis on ethyl acetate. Data were obtained for carbon tetrachloride, toluene, ethyl acetate and methyl acetate at frequencies between 30 and 90 mc. Extensive work was done on ethyl acetate at the constant temperature 20°C at frequencies from 30 mc to 150 mc. Other measurements were made at constant frequency 136 mc varying the temperature from 0°C to 35°C. Results indicate agreement with those of Pinkerton for ethyl acetate in the frequency range 7.5 to 66.7 mc. Complete results are set forth in the report listed below. The final report has been received and the contract has been terminated.

Technical Reports:

1. Absorption of Ultrasonic Energy in Liquids, by Frederick E. White.
    44 p., figures, tables. (Boston College, Department of Physics,
    Final Report: 2 February 1953 - 1 December 1956). ASTIA AD-118
    798

I PHYSICS

E. Gases and Gaseous Electronics

838 QUENCHING OF FLUORESCENCE BY FOREIGN GASES OR VAPORS

       Contractor: University of Minnesota
               (The Regents of the University)
               Minneapolis 14, Minnesota

       Chief Investigator: Howard G. Hanson

       Contract No. DA-11-022-ORD-1223
       Duration: 1 March 1953 - 15 November 1956
       Amount: $ 20,517.63
       Type of Contract: Cost

       Primary Scientific Liaison: Office of Ordnance Research

Scope: Continuation of a research program on the quenching fluorescence of sodium atoms by foreign gases or vapors such as H_2, N_2, CO_2, and H_2O. In particular, the work will include: (a) Completion of taking of data on the ratio of fluorescent intensities of the sodium D_1 and D_2 lines as it depends on quenching agents; (b) an extended measurement of the intensity of fluorescence of the NaI molecule as it depends on the wavelength of the exciting ultraviolet light--this in turn will be used to deduce the trend of the upper repulsive potential curve for an excited sodium atom together with an iodine atom; (c) further studies of the dependence of quenching on the relative velocity of the quenching molecule and excited sodium atom--the velocity of the excited sodium after dissociation is obtained from (b) above; and (d) development of a technique of rapid recording of fluorescent intensities as they depend on exciting wavelength of the ultraviolet light by use of an oscilloscope and recording camera.

Progress (to 15 November 1956): Necessary equipment has been set up for recording the intensity of NaI fluorescence as a function of time, and measurements have been made of the dependence of the quenching of H_2, CO_2, and HCl on the wavelength of the exciting light. The intensity distribution in the ultraviolet for the hydrogen discharge lamp and the high pressure xenon arc lamp have been determined. A method of producing a stream of NaI molecules has been devised which will permit interpreting the measurements of fluorescence as they depend on ultraviolet wavelength, and determining the repulsive potential curve for the NaI molecule along which the molecule dissociates. The intensity ratio D_2/D_1 for the Na doublet has been measured for radiation from excited Na atoms which result from the optical dissociation of NaI vapor by ultraviolet light in the 2000 to 2450A region. With shorter wavelength ultraviolet as the exciting source, the D_2/D_1 ratio was found to be approximately 1, and with the longer wavelengths the ratio was approximately 1.5. Addition of foreign gases such as argon or water vapor caused the D_2/D_1 ratio to increase to approximately 1.8. Cross sections for the transfer of excited Na atoms from the $3^2 P_{3/2}$ to the $3^2 P_{1/2}$ state and vice versa have been measured as

I   PHYSICS

E. Gases and Gaseous Electronics

838 (continued)

they depend on the relative velocity of the excited sodium atoms with respect to the foreign gas atoms or molecules. A study has been made of the effects of Doppler broadening of the D_2 and D_1 lines separately. The absorption of the D_2 and D_1 lines from the atomic fluorescence of NaI by relatively cool Na vapor was measured to test whether a significant difference in the velocity of dissociation into the $3^2 P_{3/2}$ and $3^2 P_{1/2}$ states could be detected. Both components showed the same broadening within the accuracy of the experiment. The final report has been received and the contract has been terminated.

Technical Reports:

1. The Quenching of Sodium Iodide Fluorescence by H_2, HCl, CO_2 and H_2O, by Howard G. Hanson, in Journal of Chemical Physics, vol. 23, no. 8 (August 1955), p. 1391-1397. (A part of #3).

2. D_2/D_1 Ratio of Atomic Fluorescence of NaI, by H. G. Hanson. (Manuscript submitted to the Journal of Chemical Physics). (A part of #3).

3. Quenching of Fluorescence by Foreign Gases and Vapors, by Howard G. Hanson. Various paging, figures, tables. (University of Minnesota, Final Report: 1 March 1953 - 15 November 1956, consisting of #1 and #2). ASTIA AD-118 739

I   PHYSICS

F. General Physics

1013 MATHEMATICAL THEORY OF ANTENNA RADIATION

        Contractor: Michigan State University
                     (Michigan State Board of Agriculture)
                     East Lansing, Michigan

        Chief Investigator: Charles P. Wells

        Contract No. DA-20-018-ORD-13354
        Duration: 1 February 1954 - 30 June 1957
        Amount: $ 43,618.56
        Type of Contract: Cost

        Primary Scientific Liaison: Ballistic Research Laboratories
        Scientific Cognizance: Signal Corps Engineering Laboratory

Scope: A mathematical study of the properties of unusual antennas will be continued and will include but not be limited to (a) extension of the calculations of the properties of spheroidal antennas to the case where ka = 3,4, (b) applications of the Wiener-Hopf technique to the problem of the biconical antenna, (c) computation of the radiation patterns for the case of the plane wave at normal incidence to the axis of the spheroid, and (d) study of the problem of the sleeve dipole.

Progress (to 30 June 1957): Two main projects were undertaken in the course of this investigation: (1) the study of the radiating prolate spheroidal antenna and (2) the study of the Wiener-Hopf technique and its application to radiation problems. Center and off-center gap antennas were studied during the investigation of prolate spheroidal antennas. Expansions of the field components in terms of the spheroidal functions for arbitrary gap widths and locations were obtained. Using a step function voltage over the gap, radiation patterns were determined for spheroids of several different length width ratios, for ka = 1,2,3 and for various gap locations. It was found that for far field calculations, the small gap theory is adequate and that more refined calculations are unnecessary. The behavior of the integral equation for antennas was studied in detail using the prolate spheroid as the model. The integral equation was solved, but results on convergence of successive approximations were inconclusive. The problem of a plane wave normally incident on a prolate spheroid with its electric vector parallel to the axis of the spheroid was studied. In the investigation of problems in antenna radiation, work was begun by considering three scalar radiation problems where the mathematical techniques were the same as in vector radiation problems. The Wiener-Hopf method was applied together with the Lebedev integral transform and was successful in obtaining solutions in explicit form for the first of the three problems studied. In the second and third, however, the method was unsuccessful in obtaining explicit solutions.

I   PHYSICS

F. General Physics

1013 (continued)

The Wiener-Hopf complex function method was again applied to the problem of the biconical antenna of arbitrary apex angle. The method led to an infinite linear system which has not been analyzed in detail. An expression for the input impedance has been formulated. The final report has been received and the contract has been terminated.

Technical Reports:

1. On the Radiation by Disks and Conical Structures, by A. Leitner and C. P. Wells. August 1955, 40 p. (Michigan State University, Departments of Mathematics and Physics, Technical Report No. 1; also submitted to Institute of Radio Engineers). ASTIA AD-68 753 (mc)

2. The Integral Equation for the Prolate Spheroidal Antenna, by P. J. Wells and A. Leitner. September 1955, 29 p. (Michigan State University, Departments of Mathematics and Physics, Technical Report No. 2; also submitted to the Quarterly of Applied Mathematics). ASTIA AD-71 881

3. Radiation Patterns of Unsymmetrically Fed Prolate Spheroidal Antennas, by H. A. Myers, in I. R. E. Transactions on Antennas and Propagation, vol. AP-4, no. 1 (January 1956), p. 58-64. (Technical Report No. 3). ASTIA AD-101 084

4. The Prolate Spheroidal Antenna: Current and Impedance, by C. P. Wells. January 1957, various paging, figures, tables. (Michigan State University, Department of Mathematics, Technical Report No. 4; also submitted to the Institute of Radio Engineers Transactions). ASTIA AD-119 534

5. Diffraction of a Plane Electromagnetic Wave by a Thin Prolate Spheroid. Radiation Patterns, by C. P. Wells. April 1957, 10 p., figures. (Michigan State University, Technical Report No. 5).

6. Mathematical Theory of Antenna Radiation, by Charles P. Wells. 30 June 1957, 12 p., tables. (Michigan State University, Final Report).

7. Biconical Antenna, by J. A. Meier and A. Leitner. June 1957, 28 p. (Michigan State University, Departments of Mathematics and Physics, Technical Report No. 6).

I   PHYSICS

F. General Physics

1201 PENETRATION OF BALLISTIC PROJECTILES

Contractor: University of South Carolina, Columbia 1, South Carolina

Chief Investigator: A. P. French

Contract No. DA-36-034-ORD-1531
Duration: 1 February 1954 - 30 September 1957
Amount: $ 5,976.90
Type of Contract: Fixed Price

Primary Scientific Liaison: Ballistic Research Laboratories

Scope: Research on the penetration of ballistic projectiles into unconsolidated targets will be continued, and will include tests of penetration into additional types of soil-simulating materials under controlled conditions, and analysis of these tests in the light of theoretical work already accomplished.

Progress (to 30 September 1957): Studies to date have indicated that the penetration of non-deforming projectiles into glass spheres targets can, over the range of velocities studies, be described in terms of (a) a momentum transfer proportional to the projectile velocity, (b) a production of comminution proportional to the square of the projectile velocity and (less certainly) to the initial particle diameter, and (c) an effective lower limiting velocity at which the residual penetration presumably becomes negligible. The final report has been received and the contract has been terminated.

Technical Reports:

1. Calculations on Ballistic Penetration into an Unconsolidated Aggregate of Brittle Spheres, by F. T. Rogers, Jr. 31 August 1954, 26 p. (University of South Carolina, Technical Note No. 10-54-P3). ASTIA AD-52 107 (mc)

2. On R. M. S. and R. M. C. Diameters of Glass Particles before and after Ballistic Comminution, by D. F. Kiper and others. 31 October 1954, 15 p., figures, tables. (University of South Carolina, Department of Physics, Technical Note No. 11-54-P3). ASTIA AD-53 265 (mc)

3. On Some Special Stopping-Power Laws, by F. T. Rogers, Jr., and Marguerite M. Rogers. (Manuscript submitted to Physical Review).

4. On Testing a Formula for Ballistic Penetration, by F. T. Rogers, Jr. 31 January 1955, 25 p., tables. (University of South Carolina, Department of Physics, Technical Note No. 3-55-P3). ASTIA AD-59 663

I   PHYSICS

F. General Physics

1201 (continued)

5. Improved Measurements on Ballistic Comminution of Glass Spheres,
    by R. L. Kernell, P. A. Teel, and others. Not dated, 24 p.,
    tables. (University of South Carolina, Department of Physics,
    Technical Note No. 9-55-P3). ASTIA AD-78 394 (mc)

6. Experiments on Penetration of .22-Caliber Projectiles into Glass
    Spheres Targets, by Marguerite M. Rogers, L. G. Barre, and
    others. Not dated, 30 p., tables. (The University of South
    Carolina, Department of Physics, Technical Note No. 9-55-P4:
    1 May 1955 - 30 September 1955). ASTIA AD-78 395

7. On an Improved Formula for Ballistic Penetration into Brittle
    Targets, by A. P. French. Not dated, 25 p., figures, tables.
    (The University of South Carolina, Department of Physics, Tech-
    nical Note No. 7-56-P3). ASTIA AD-103 477 (mc)

8. Measurements of the Penetration of a Non-Deforming .22-Caliber
    Steel Projectile into Targets Consisting of Aggregates of Dis-
    crete Particles, by Marguerite M. Rogers, R. I. Turbeville, and
    A. R. Lowrey. 40 p., figures, tables. (University of South
    Carolina, Department of Physics, Technical Note No. 8-56-P3:
    1 April 1956 - 31 July 1956). ASTIA AD-110 965

9. Statistical Significance of a Body of Penetration Data, by D. F.
    Kiper, 23 p., figures, tables. (University of South Carolina,
    Department of Physics, Technical Note No. 6-55-P2: 1 February
    1955 - 31 May 1955).

10. Ballistic Penetration Into Glass-Spheres Targets: Theory Versus
    Experiment, by F. T. Rogers, Jr. 21 p., figures, tables. (Uni-
    versity of South Carolina, Department of Physics, Technical Note
    No. 11-55-P3: 1 October 1955 - 15 November 1955). (C)

11. Further Measurements on Ballistic Comminution of Glass Spheres,
    by B. T. Fogle, A. P. French and R. L. Kernell. Not dated, 14
    p., figures, tables. (University of South Carolina, Department
    of Physics, Technical Note No. 12-56-P3). ASTIA AD-120 253

12. Penetration of Ballistic Projectiles, by A. P. French. 40 p.,
    figures, tables. (University of South Carolina, Department of
    Physics, Final Report: 1 February 1954 - 30 September 1957).

I   PHYSICS

H. Nuclear Physics

408 ISOMERIC TRANSITIONS IN NUCLEI

        Contractor: University of Pennsylvania
                     (The Trustees of the University)
                     Philadelphia 4, Pennsylvania

        Chief Investigator: S. Frankel

        Contract No. DA-36-034-ORD-938   Renewed: DA-36-034-ORD-1351
        Duration: 20 May 52 - 19 May 53   19 May 1953 - 1 January 1957
        Amount: $ 16,335.00 $ 53,694.50
        Type of Contract: Fixed Price   Cost

        Primary Scientific Liaison: Office of Ordnance Research

Scope: The program of basic research in low-energy nuclear spectros-
copy will be extended and will include: (a) Making additional meas-
urements aimed to gain an understanding of electric transitions in
odd-neutron nuclei and to determine angular correlation phases, (b)
gaining more experimental information on nuclear phases in an odd-
proton nucleus, (c) extending theoretical work on nuclear phases, (d)
finishing investigations on Ag^{105} and Hf^{181}; and (e) measuring experi-
mentally magnetic moments of excited states of nuclei, by using the
strong magnetic fields existing in atoms.

Progress (to 1 January 1957): Experimental work completed under this
project is described in the technical reports listed below. The decay
of Hf^{181} to Ta^{181} was studied by angular correlation measurements,
conversion coefficient measurements, K/L ratios, and coincidence meas-
urements. The spin assignments were found to be in agreement with the
calculations of Nilsson on the strong coupling model. The results of
this study have been submitted for publication. Studies on related
phases of competing nuclear matrix elements on the single particle
model have been completed. Angular correlation measurements in the
decay of Hg^{197+} were made, and the results have been prepared for
publication. An investigation has been made of the decay of Ag^{105}.
The final report has been received and the project has been termina-
ted.

Technical Reports:

1. The Decay Scheme of Krypton[79], by Joseph E. Lannutti and Sherman
    Frankel.

2. Methods for the Detection of Nuclear Resonant Scattering and Their
    Connection with Angular Correlation Measurements, by Sherman
    Frankel.

408 (continued)

3. Geometrical Corrections in Angular Correlation Measurements, by
    Arnold M. Feingold and Sherman Frankel: Angular Correlation
    Measurements in Te^{121} and Te^{123}, by Norman Goldber. 1 May 1954,
    various paging, figures, tables. (University of Pennsylvania,
    Department of Physics, Technical Report No. 1). ASTIA AD-36 838

4. The Effect of Spin-Orbit Interaction on Nuclear Electric Dipole
    Absorption, by Sherman Frankel, in the Physical Review, vol. 99,
    no. 1 (July 1955), p. 169. (A part of #11).

5. Angular Correlation Measurements in Sn^{117}, by R. Golden and S.
    Frankel. 15 April 1955, 45 p., figures. (University of Pennsyl-
    vania, Department of Physics, Technical Report No. 2). ASTIA
    AD-60 542 (mc); ASTIA AD-63 940 (mc)

6. Geometrical Corrections in Angular Correlation Measurements, by
    Arnold M. Feingold and Sherman Frankel, in the Physical Review,
    vol. 97, no. 4 (February 1955), p. 1025-1030. (A part of #11).

7. Angular Correlation Measurements on Te^{121} and Te^{123}, by Norman
    Goldberg and Sherman Frankel, in the Physical Review, vol. 100,
    no. 5 (December 1955), p. 1350-1354. (A part of #11).

8. Electron Scattering in the K-Electron-Gamma Angular Correlation
    in Sn^{117}, by R. K. Golden and S. Frankel, in the Physical Review,
    vol. 102, no. 4 (May 1956), p. 1053-1057. (A part of #11).

9. Angular Correlation Measurements in the Decay of Hg^{197+}, by H. H.
    Coburn, J. V. Kane and Sherman Frankel. (Manuscript submitted
    to the Physical Review). (A part of #11).

10. The Decay of Hf^{181}, by Evan Snyder and Sherman Frankel. (Manu-
    script submitted to the Physical Review). (A part of #11).

11. Isomeric Transition in Nuclei, by Sherman Frankel. Various
    paging, figures. (University of Pennsylvania, Final Report:
    20 May 1953 - 31 December 1956, containing #4, #6, #7, #8, #9,
    and #10).

920 STUDY OF NUCLEAR DISINTEGRATION

Contractor: Tulane University
             New Orleans 18, Louisiana

Chief Investigator: Charles L. Peacock

Contract No. DA-01-009-ORD-344   Renewed: DA-01-009-ORD-458
Duration: 1 July 53 - 30 Nov 55   1 Dec 1955 - 31 May 1957
Amount: $ 17,143.49 $ 11,226.00
Type of Contract: Fixed Price   Cost

Primary Scientific Liaison: Office of Ordnance Research
Scientific Cognizance: Ballistic Research Laboratories; Watertown
                        Arsenal

Scope: Continuation of basic research in nuclear physics, in parti-
cular, study of the radiations from selected radioactive nuclei by
means of magnetic and scintillation spectrometers, and if possible,
by means of a photographic β-ray spectrometer. Attempts will be made
to formulate, (a) energies of the radiations, (b) energy levels, (c)
gamma ray intensities, (d) internal conversion coefficients, and (e)
spins.

Progress (to 31 May 1957): Investigations were made of the following
radioisotopes: Ag^{110}, Sb^{124}, Ce^{134}, Br^{82}, Ba^{140}, and Sc^{46}. It was
determined that the β-spectrum of Ag^{110} is composed of three component
groups, and the photoelectron and internal conversion electron studies
indicate fourteen γ-rays. Studies of Sb^{124} revealed that the β-spec-
trum is very complex and can be resolved into five component groups.
Photoelectron, internal conversion and scintillation studies indicate
seven γ-rays for this radioisotope. The β-spectrum of Ce^{134} was found
to be much more complex than that previously reported. Gamma rays of
seven different intensities were found with some evidence in the β-
spectrum of an eighth γ-ray with energy of 200 kev. From these data it
was possible to construct a consistent decay scheme. The β-rays from
Br^{82} were simple with a maximum energy of 444 kev. The γ-spectrum in-
dicated eight γ-rays. The principal result in the study of Ba^{140} was
the confirmation of the previously postulated group of β-rays whose
maximum energy is 586 kev. The study of Sc^{46} was concerned only with
the high energy group of β-rays which has a maximum energy of 1250
kev. The final report has been received and the project has been
terminated.

Technical Reports:

1. Study of Nuclear Disintegrations, by Charles L. Peacock. Various
    paging, figures, tables. (Tulane University, Final Report: 1 July
    1953 - 31 May 1957).

I. PHYSICS

J. Solid State Physics

392 ABSOLUTE PHOTOELECTRIC YIELD OF SURFACES FOR RADIATION IN THE EXTREME ULTRAVIOLET

Contractor: University of Southern California
3518 University Avenue
Los Angeles, California

Chief Investigator: G. L. Weissler

Contract No. DA-04-495-ORD-323
Duration: 16 June 1952 - 31 October 1956
Amount: $ 39,464.92
Type of Contract: Cost

Primary Scientific Liaison: Office of Ordnance Research

Scope: Research will be continued on the measurement of the number of electrons released from the clean or oxide-coated surfaces of various metals as a result of irradiation by monochromatic light in the ultraviolet wavelength range, between 450 and 1400A. Observation will be made of the effects of purposeful surface contamination by exposure to gases and vapors, and measurements will be taken of the energy distribution of the emitted photoelectrons as a function of the angle of incidence of the radiation. The investigation will include: (a) Yield studies of metals subjected to various surface treatments, (b) securing of representative energy distributions at various wavelengths for some of the above surfaces, (c) yield studies of some characteristic N and P type semiconductors, (d) electron energy distribution measurements for these semiconductors, (e) yields from insulators, (f) optical transmission of thin metallic films as a function of wavelength in the far ultraviolet, and (g) front and back yield and energy distributions of the above films, if possible, determined as a function of angle incidence and film thickness. This work is being continued under Contract No. DA-04-495-ORD-846, Research Proposal 1722.

Progress (to 31 October 1956): The experimental procedures used in the investigation of absolute photoelectric yield of surfaces for radiation of the extreme ultraviolet is discussed in detail in Technical Report #1. A large number of surfaces were investigated in this manner and were subjected to the following treatment: exposure to a variety of gases, thus encouraging the formation of certain cathode surface films either by adsorption, absorption or by the formation of oxides; and then the removal of such films by positive ion bombardment or by glowing the surfaces in the highest vacuum available in the apparatus. The yields from these surfaces are discussed in Technical Report #4. The significance of the results obtained is indicated by the appearance of a volume photoelectric effect with a threshold wavelength in the neighborhood of 1200A or 10 ev. This volume effect is characterized by much higher yields than those which were measured for similar surfaces near the photoelectric threshold.

I PHYSICS

J. Solid State Physics

392 (continued)

The highest yields occurred in the case of non-outgassed photocathodes such as tungsten or nickel. In all gases the volume yields were surprisingly reproducible. They became apparent at approximately 1200A and rose monotonically to a maximum 900A and 600A. In the case of impure metals the yields decreased noticeably towards shorter wavelengths, whereas in the case of outgassed metals the yields remained constant to 480A. The final report has been received and the contract has been terminated.

Technical Reports:

1. Preliminary Results on Photoelectric Yields of Pt and Ta and on Photoionization in O_2 and N_2 in the Vacuum Ultraviolet, by N. Wainfan and others, in Journal of Applied Physics, vol. 24, no. 10 (October 1953), p. 1318-1321. (Technical Report No. 1). ASTIA AD-50 823

2. The Photoelectric Yield of Platinum in the Vacuum Ultraviolet, by W. C. Walker and N. Wainfan, in Bulletin of the American Physical Society, vol. 27, no. 6 (December 1952).

3. Energy Distributions of Photoelectrons for Au and Ge in the Far Ultraviolet, by W. C. Walker and G. L. Weissler, in the Physical Review, vol. 97, no. 4 (February 1955), p. 1178-1179. (Technical Report No. 2).

4. Photoelectric Yields in the Vacuum Ultraviolet, by W. C. Walker and others, in Journal of Applied Physics, vol. 26, no. 11 (November 1955), p. 1366-1371. (Technical Report No. 3).

5. Absolute Photoelectric Yield of Surfaces for Radiation of the Extreme Ultraviolet, by G. L. Weissler. 31 October 1956, 6 p. (University of Southern California, Department of Physics, Final Report). ASTIA AD-117 994

I PHYSICS

J. Solid State Physics

667 INTERACTION OF THERMAL ATOMS WITH SURFACES

Contractor: Syracuse University
Syracuse, New York

Chief Investigator: Henry Levinstein

Contract No. DA-30-115-ORD-420
Duration: 1 February 1953 - 30 January 1957
Amount: $ 33,691.00
Type of Contract: Fixed Price

Primary Scientific Liaison: Office of Ordnance Research
Scientific Cognizance: Ordnance Materials Research Office;
Ballistic Research Laboratories

Scope: Through measurement of the length of time of contact, research
will be done on the interaction of gas molecules with surfaces against
which they collide. This will include a study of relationships between
"sitting time" and (1) the type of vapor, type of surface, the surface
temperature, and surface treatment, (2) heat of absorption, (3) the
phenomena of corrosion, oxidation, and formation of surface films, and
(4) the effects of various gases on the electrical properties of sec-
tions of single crystals having a thickness of several microns.

Progress (to 30 January 1957): Work on this contract has been divided
into two parts. The first is concerned with the interaction of alkali
atoms with a hot tungsten surface; the second is concerned with study-
ing the effects of oxygen on crystal surfaces which cannot be heated.
In order to investigate hot tungsten surfaces, methods have been de-
veloped for forming single crystal tungsten wire from a polycrystal-
line array of randomly oriented crystallites. By exposing the tungsten
wire to a pulsed atom beam and observing the pulse shape of the reevap-
orated ions, it has been possible to measure the time during which the
atoms are adsorbed on the wire. Both the magnitude of the adsorption
time and its temperature variation have been found to be dependent on
surface conditions. Measurements on single crystal wire surfaces con-
taining less than .001 monolayer of oxygen as well as on contaminated
surfaces have been made. In the second part of the project, the effect
of oxygen on a semiconductor surface was investigated. It was found
that SnSe which is first grown into single crystals may be cleaved into
sections less than 10 microns thick. Electrical conductivity, carrier
mobility, and concentration and band gap have been determined from
electrical, optical absorption, and photoconductivity measurements. A
study is underway to determine the effect of different ambients on the
surface. For subsequent progress, see Research Proposal No. 1844,
this report.

I PHYSICS

J. Solid State Physics

667 (continued)

Technical Reports:

1. Interaction of Thermal Atoms with Surfaces, by F. Hughes. 1 Sep-
tember 1956, 16 p., figures. (Syracuse University Research Insti-
tute). ASTIA AD-104 520

I   PHYSICS

J. Solid State Physics

718 ELECTRICAL PROPERTIES OF THORIUM OXIDE AND SIMILAR MATERIAL AT
HIGH TEMPERATURES

        Contractor: Bartol Research Foundation of the
                     Franklin Institute
                     20th and Parkway
                     Philadelphia 3, Pennsylvania

        Chief Investigator: W. E. Danforth

        Contract No. DA-36-034-ORD-1487
        Duration: 1 November 1953 - 31 January 1957
        Amount: $ 45,605.00
        Type of Contract: Cost

        Primary Scientific Liaison: Frankford Arsenal
        Scientific Cognizance: Redstone Arsenal

Scope: Research will be continued in high-temperature solid-state
physics on the properties of thorium oxide, in particular: (a) Experi-
mental study of polarization and conductivity, as a function of tem-
perature, with a view toward establishment of a new method for deter-
mining ionic densities and mobilities; (b) study of long-time polari-
zation to determine more precisely the electron transport number, its
temperature dependence, and the activation energy of electronic con-
ductivity; (c) study of high-field effects and their bearing upon the
mechanism of electrolysis; (d) studies of ionic polarization effects
in materials other than thorium oxide, particularly sodium chloride
and barium oxide; and (e) mathematical problems regarding phenomena
in mixed conductors, particularly perturbing effects of small numbers
of electrons.

Progress (to 31 January 1957): Investigations were carried out and
results were obtained on the following topics: (a) Polarization phe-
nomena in thorium oxide and associated theoretical considerations, (b)
Hall effect in thorium metal, and (c) thermoelectric power of thorium
vs. platinum. The polarization studies led to the conclusion that
conduction in fresh thorium oxide crystals is more than 99 percent
ionic. Optical absorption spectra in single crystals of ThO_2 have
been studied extensively. The polarization effects in sodium chloride
and in silver chloride were also studied. Complete results are set
forth in the technical reports listed below. The final report has
been received and the contract has been terminated.

Technical Reports:

1. Studies in Mixed Conduction in Solids, by W. E. Danforth. 31
    August 1956, 62 p., figures, tables. (Bartol Research Foundation
    of the Franklin Institute, Technical Report No. 3). ASTIA AD-110
    902 (mc)

I   PHYSICS

J. Solid State Physics

718 (continued)

2. Hall Coefficient and Thermoelectric Power of Thorium Metal, by J.
    H. Bodine, in The Physical Review, vol. 102, no. 6 (June 1956),
    p. 1459. (Technical Report No. 4). ASTIA AD-112 063

3. Polarization in Thorium Oxide Crystals, by W. E. Danforth, in The
    Journal of Chemical Physics, vol. 23, no. 3 (March 1955), p. 591-
    592. (Technical Report No. 1).

4. Polarization in Thorium Oxide Crystals, by W. E. Danforth and J.
    H. Bodine, in The Journal of the Franklin Institute, vol. 260,
    no. 6 (December 1955), p. 467-483. (Technical Report No. 2).

5. Electrical Properties of Thorium Oxide and Similar Materials at
    High Temperature, by W. E. Danforth. 15 February 1957, 12 p.
    (Bartol Research Foundation of the Franklin Institute, Final
    Report). ASTIA AD-122 411

II   C H E M I S T R Y

A.   Chemical Engineering and Materials

544   RESEARCH ON STRUCTURE OF CELLULOSE

Contractor: University of Minnesota
(Regents of the University)
Minneapolis, Minnesota

Chief Investigator: Fred Smith

Contract No. DA-11-022-ORD-999
Duration: 24 June 1952 - 30 June 1957
Amount: $ 39,287.00
Type of Contract: Cost

Primary Scientific Liaison: Office of Ordnance Research

Scope: Research will be continued in the structure of cellulose, and
experiments will be designed and conducted (a) to permit a close ex-
amination of cleavage products of cellulose polyalcohol, to verify the
structural possibilities indicated by the present identification of
glycerol and glucose, (b) to extend these studies to hemicellulose,
and (c) to clarify further the fine structural details required to
supplement these findings by appropriate methods.

Progress (to 30 June 1957): Work has been directed toward developing
a new method for the structural characterization of polysaccharides
which will permit a closer examination of the fine structure of cellu-
lose. An approach has been developed and is set forth in report #7
below. Some experimental data collected during this investigation
have led to the speculation that there are some anomalous chemical
features in the long-accepted linear or homogeneous nature of cellu-
lose. Complete results of this investigation are reflected in the
technical reports below. The final report has been received and the
contract has been terminated.

Technical Reports:

1. Reduction of the Products of Periodate Oxidation of Carbohydrates.
   IV. Hydrogenation with Palladium--Charcoal of the Dialdehydes
   from Methyl Glycosides, by J. E. Cadotte, F. Smith, and others,
   in the Journal of the American Chemical Society, vol. 79 (February
   1957), p. 691-695. (A part of #7).

2. Synthesis of D-3,4-Di-o-Methyl Erythritol, by Irwin J. Goldstein
   and F. Smith, in the Journal of the American Chemical Society,
   vol. 79 (March 1957), p. 1188-1190. (A part of #7).

3. Synthesis of D- and L-α-o-Methyl Glycerol, by Irwin J. Goldstein,
   J. K. Hamilton and F. Smith, in the Journal of the American Chemi-
   cal Society, vol. 79 (March 1957), p. 1190-1193. (A part of #7).

II C H E M I S T R Y

A. Chemical Engineering and Materials

544 (continued)

4. Reduction of the Products of Periodate Oxidation of Carbohydrates.
    V. The Constitution of Cellulose, by Irwin J. Goldstein, F.
    Smith and others. (Manuscript submitted to the Journal of the
    American Chemical Society).

5. The Structure of Dialdehydes Formed by Periodate Oxidation of
    Sugar Glycosides, by Irwin J. Goldstein, Bertha A. Lewis and F.
    Smith. (Manuscript submitted to the Journal of the American Chemi-
    cal Society). (A part of #7).

6. Nature of a Hemicellulose Extracted from Cellulose with Water, by
    G. W. Huffman, F. Smith and others, in Nature, vol. 175 (June
    1955), p. 990-992. (A part of #7).

7. The Constitution of Cellulose and Related Substances, by I. J.
    Goldstein and F. Smith. 24 July 1957, various paging, figures,
    tables. (University of Minnesota, Final Report containing #1, #2,
    #3, #5, and #6).

8. The Steric Inhibition of Periodate Oxidation, by E. F. Garner,
    Irwin J. Goldstein and Fred Smith. (Manuscript submitted to the
    Journal of the American Chemical Society).

II C H E M I S T R Y

A. Chemical Engineering and Materials

574 EFFECT OF PRESSURE ON PHYSICAL PROPERTIES OF GASES AND ON PROPERTIES
     OF CHEMICALLY REACTING SYSTEMS

        Contractor: Yale University
                     New Haven, Connecticut

        Chief Investigator: Barnett F. Dodge

        Contract No. DA-19-059-ORD-971   Renewed: DA-19-059-ORD-1500
        Duration: 17 June 52 - 10 June 53 11 June 1953 - 31 Dec 1956
        Amount: $ 18,691.26 $ 47,670.00
        Type of Contract: Fixed Price   Cost

        Primary Scientific Liaison: Office of Ordnance Research

Scope: Study of (1) the effect of pressure on physical properties
such as compressibility, viscosity, thermal conductivity, composition
of coexisting liquid and vapor phases and the like, (2) the effect of
pressure on the equilibrium and rate of chemical reactions, (3) cata-
lytic reactions of carbon monoxide at high pressure, (4) effect of
pressure on the rate and equilibrium of the water-gas reaction, and
(5) pressure-volume-temperature relationships in binary and ternary
gas mixtures at high pressure.

Progress (to 31 December 1956): Work under this project has been
confined to a study of the following phases, (1) catalytic reactions
of carbon monoxide at high pressure, (2) reactions of butadiene in
the liquid phase, (3) effect of high pressure on the equilibrium in the
water-gas reaction, (4) compressibilities of nitrogen, hydrogen, and
ammonia in the gas phase, and (5) equilibrium in the heterogeneous
system ethanol-ethyl ether-ethylene-water at elevated pressures.
Results of these phases appear in report #2 listed below. The final
report has been received and the contract has been terminated.

Technical Reports:

1. Equilibrium of the Water-Gas Shift Reaction at High Pressures.
    Equipment Design, by Kaoru Iwasaki. June 1955, 67 p., figures,
    tables. (Yale University, M.S. thesis).

2. Effect of Pressure on the Physical Properties of Gases and on the
    Properties of Chemically Reacting Systems, by Barnett F. Dodge,
    Randolph H. Bretton and others. 22 February 1957, 18 p. (Yale
    University, Final Report). ASTIA AD-123 694

II C H E M I S T R Y

A. Chemical Engineering and Materials

887 MASS TRANSFER INTO GAS STREAMS AT LOW PRESSURES AND HIGH VELOCITIES

Contractor: Massachusetts Institute of Technology
Memorial Drive
Cambridge 39, Massachusetts

Chief Investigator: Thomas K. Sherwood

Contract No. DA-19-020-ORD-3244
Duration: 30 December 1953 - 31 December 1956
Amount: $ 26,142.00
Type of Contract: Cost

Primary Scientific Liaison: Office of Ordnance Research
Scientific Cognizance: Ballistic Research Laboratories; Redstone
Arsenal

Scope: An investigation will be made of mass transfer from solid sur-
faces to gas streams by a study of (a) the rate of sublimation of a
solid into air streams at high Mach numbers, and (b) the rate of sub-
limation into air at very low pressures. The results are expected to
contribute significantly to current development of understanding the
nature of turbulent flow over surfaces, and the relationships between
mass, heat, and momentum transfer.

Progress (to 31 December 1956): Basic information has been obtained
regarding the rate of sublimation of materials at sub-atmospheric
pressures in both stagnant and flowing systems, using various gases as
the surrounding atmosphere. Small spheres of solid naphthalene were
sublimed into air, helium, carbon dioxide, and freon-12, and the rate
of sublimation was measured as a function of pressure. Studies have
been made to determine and correlate mass transfer rates of materials
at air velocities up to twice the speed of sound in air. Rates of
sublimation of naphthalene, camphor, and thymol from cone cylinders
of these materials were determined by insertion of the cylinders into
various wind tunnels. Average coefficients of mass transfer over the
entire area of the subliming solid were determined by weight loss;
local coefficients at various locations along the model were deter-
mined by measuring the decrease in the diameter of the cylinder. A
turbulent boundary layer was used exclusively in this work. Addition-
al work has been directed toward obtaining an insight into the nature
and relationship of the factors by which changes in concentration of
the diffusing compound affect the rates of mass transfer between a gas
and a wet surface. For this purpose the evaporation of water into
steam-air mixtures was used. The experimental program included the
study of a wetted-wall tower, and the evaporation of water from a
porous wet cylinder. In all the runs, turbulent conditions were main-
tained in the gas phase. The results obtained in both the wetted-wall
tower and the wet cylinders indicated that concentration changes af-
fect the turbulent and molecular transfer process in a similar way and

II C H E M I S T R Y

A. Chemical Engineering and Materials

887 (continued)

confirm the inverse proportionality between the mass transfer coeffi-
cient and the mean partial pressure of the non-diffusing gas. Complete
results of the above studies appear in the reports listed below. The
final report has been received and the contract has been terminated.

Technical Reports:

1. Mass Transfer into Gas Streams at Low Pressures: The Effect of
Pressure on the Rate of Sublimation, by N. E. Cooke and T. K.
Sherwood. 1 May 1955, 10 p., figures. (Massachusetts Institute
of Technology, Technical Report No. 1). ASTIA AD-62 353 (mc)

2. Mass Transfer at Low Pressures, by T. K. Sherwood and N. E. Cooke.
1 December 1955, 214 p., figures, tables. (Massachusetts Insti-
tute of Technology, Part I of the Final Report). ASTIA AD-80 230
(mc)

3. Mass Transfer through Compressible Turbulent Boundary Layers, by
Thomas K. Sherwood and Howard S. Bryant, Jr. 1 April 1956, 199 p.,
figures, tables. (Massachusetts Institute of Technology, Part II
of the Final Report; also published in the Canadian Journal of
Chemical Engineering, vol. 35, no. 2 (August 1957), p. 51-93).
ASTIA AD-90 353 (mc)

4. The Evaporation of Water at High Humidities, by Thomas K. Sherwood
and Oliverio Phillips. 15 April 1957, 215 p., figures, tables.
(Massachusetts Institute of Technology, Part III of the Final
Report).

II CHEMISTRY

A. Chemical Engineering and Materials

1562 APPLICATION OF THE TRACER DISPLACEMENT TECHNIQUE TO THE MEASUREMENT OF MASS TRANSFER AND DIFFUSION COEFFICIENTS

        Contractor: North Carolina State College
                   Raleigh, North Carolina

        Chief Investigator: Frances M. Richardson

        Contract No. DA-36-034-ORD-2199
        Duration: 1 January 1956 - 30 April 1957
        Amount: $ 12,361.00
        Type of Contract: Cost

        Primary Scientific Liaison: Office of Ordnance Research

Scope: Research will be performed on (1) the adaptation of the tracer displacement technique to the measurement of coefficients of molecular diffusion, and (2) the possibility of adapting the tracer displacement technique to measurements of mass transfer of dissolved materials in liquids flowing in turbulent flow.

Progress (1 January 1956 - 31 January 1958): The tracer displacement technique has been applied to the evaluation of the study of diffusion in dilute aqueous solutions of Pontamine blue dye and potassium permanganate. The differential equation describing the transfer of mass by diffusion and convection in the particular system has been formulated and various attempts at its solution have been made. Experimental results have been obtained in terms of an empirical correlation, and despite the somewhat inconclusive nature of the data, these results are encouraging. The final report has been received and the contract has been terminated.

Technical Reports:

1. Application of the Tracer Displacement Technique to the Measurement of Mass Transfer and Diffusion Coefficients, by James K. Ferrell and F. M. Richardson. 75 p., figures, tables. (North Carolina State College, Final Report: 1 February 1956 - 31 January 1958).

II CHEMISTRY

B. Combustion and Fuel Chemistry

664 DEVELOPMENT OF EQUATION OF STATE AND TRANSPORT PROPERTIES OF LIQUIDS AND GASES AT HIGH DENSITIES

        Contractor: University of Wisconsin
                   (The Regents of the University)
                   Madison 6, Wisconsin

        Chief Investigator: J. O. Hirschfelder

        Contract No. DA-11-022-ORD-994
        Duration: 23 June 1952 - 22 June 1957
        Amount: $ 100,246.60
        Type of Contract: Cost

        Primary Sceintific Liaison: Office of Ordnance Research
        Scientific Cognizance: Redstone Arsenal

Scope: Theoretical treatments will be made of the following problems: Use of a pseudolattice theory to improve the equation of state of liquids and of dense gases; use of a conventional equation of state for mixtures of chemical species; improvement of the existing corresponding-states relationships for properties of gases and liquids; and development of the theory of transport properties at high temperatures.

Progress (30 September 1956 - 30 June 1957): An equation of state for pure substances has been derived and it covers the full range of gases and liquids. The standard form of the equation is based on a generalized principle of corresponding states which includes two additional experimental parameters, the critical compressibility factor, and a parameter determined from the vapor pressure. The equation for liquids also includes experimental densities at saturation. Considerable flexibility exists since the equations can be used when experimental parameter values are missing, and the standard form can be improved when extensive data are available. Based on the above equation of state, explicit expressions have been derived for the thermodynamic functions. A complete description of the above work appears in reports #16 and #17 below. Additional work has been directed toward developing a perturbation method for treating mixtures. In this connection, the work of Zwanzig and Kirkwood is being extended. This extension considers the molecules in a mixture to interact with an average potential and then considers as the perturbation, the difference between the actual intermolecular forces and the averaged potential. Further work along this line is in progress. Future studies will include the theoretical development of Henry's law constants. For subsequent progress see Research Proposal No. 1898, this report.

B.   Combustion and Fuel Chemistry

664 (continued)

Technical Reports:

1. Theory of Phase Transition in Anisotropic Colloidal Solutions, by
   Taro Kihara. 4 October 1952. (University of Wisconsin, Depart-
   ment of Chemistry, Technical Report Wis-OOR-1). ATI 172 451

2. The Separation of the Rotational Coordinates from the N-Particle
   Schroedinger Equation. II, by C. F. Curtiss. 4 December 1952,
   53 p. (University of Wisconsin, Department of Chemistry, Techni-
   cal Report Wis-OOR-2; also published in the Journal of Chemical
   Physics, vol. 21 (July 1953), p. 1199). ASTIA AD-5 838 (mc)

3. The Kinetic Theory of Dense Gases, by C. F. Curtiss. 28 January
   1953. (University of Wisconsin, Department of Chemistry, Techni-
   cal Report Wis-OOR-3). ASTIA AD-6 699 (mc)

4. The Quantum Mechanics of Collisions between Diatomic Molecules,
   by C. F. Curtiss. 30 January 1953, 23 p. (University of Wiscon-
   sin, Department of Chemistry, Technical Report Wis-OOR-4; also
   published in the Journal of Chemical Physics, vol. 21 (November
   1953), p. 2045). ASTIA AD-13 252

5. The Mathematical Theory of Electrical Discharges in Gases. B.
   Velocity-Distribution of Positive Ions in a Static Field, by
   Taro Kihara. 25 March 1953, 24 p. (University of Wisconsin,
   Department of Chemistry, Technical Report No. Wis-OOR-5; also
   published in Reviews of Modern Physics, vol. 25, no. 4 (October
   1953), p. 844-852). ASTIA AD-7 754 (mc)

6. Theoretical Treatment of Adiabatic Chemical Reactions, by E. F.
   Haugh and others. 15 April 1953, 20 p. (University of Wiscon-
   sin, Technical Report Wis-OOR-6). ASTIA AD-7 753 (mc)

7. Virial Coefficients and Models of Molecules in Gases, by Taro
   Kihara. 5 June 1953, 49 p., figures, tables. (University of
   Wisconsin, Department of Chemistry, Technical Report Wis-OOR-7;
   also published in Reviews of Modern Physics, vol. 25 (1953),
   p. 831). ASTIA AD-13 251

8. The Quantum Mechanics of Collisions between Rigid Axially Sym-
   metric Molecules, by George Gioumousis and C. F. Curtiss. 10
   June 1953, 21 p. (University of Wisconsin, Department of Chem-
   istry, Technical Report Wis-OOR-8). ASTIA AD-13 252

9. The Effects of Concentration Dependence of Diffusion Coefficients,
   by Robert F. Snider and C. F. Curtiss. 17 February 1954, 28 p.,
   tables. (University of Wisconsin, Department of Chemistry, Tech-
   nical Report Wis-OOR-9). ASTIA AD-30 142 (mc)

B.   Combustion and Fuel Chemistry

664 (continued)

10. The Kinetic Theory of Moderately Dense Gases, by C. F. Curtiss
    and R. F. Snider. 20 May 1954, 55 p. (University of Wisconsin,
    Department of Chemistry, Technical Report Wis-OOR-10). ASTIA
    AD-33 203

11. The Theory of Rotational-Vibrational Interaction in Polyatomic
    Molecules, by Lewis J. Bodi. 30 August 1954, 133 p. (University
    of Wisconsin, Department of Chemistry, Technical Report Wis-OOR-
    11). ASTIA AD-41 542 (mc)

12. The Theory of Rotational-Vibrational Interaction in Polyatomic
    Molecules, by Lewis J. Bodi and C. F. Curtiss. 4 January 1956,
    20 p. (University of Wisconsin, Department of Chemistry, Tech-
    nical Report Wis-OOR-11a). ASTIA AD-83 153 (mc)

13. A Generalized Equation of State for Both Gases and Liquids, by
    J. O. Hirschfelder, R. J. Buehler, and others. 22 March 1956,
    47 p., figures, tables. (University of Wisconsin, Department of
    Chemistry, Technical Report Wis-OOR-12). ASTIA AD-93 093 (mc)

14. Properties of Gaseous and Liquid Mixtures, by Walter K. Tang.
    9 August 1956, 198 p., tables. (University of Wisconsin, Depart-
    ment of Chemistry, Technical Report Wis-OOR-13). ASTIA AD-109
    594 (mc)

15. The Permutation Group and Electron Quantum Mechanics, by F. A.
    Matsen. 28 August 1956, 30 p. (University of Wisconsin, Depart-
    ment of Chemistry, Technical Report Wis-OOR-14). ASTIA AD-109
    595 (mc)

16. A Generalized Equation of State for Both Gases and Liquids, I.,
    by J. O. Hirschfelder, R. J. Buehler, H. A. McGee, Jr., and J. R.
    Sutton. 5 October 1956, 67 p., figures, tables. (University
    of Wisconsin, Department of Chemistry, Technical Report Wis-OOR-
    15; also submitted to Industrial and Engineering Chemistry).
    ASTIA AD-116 764

17. Generalized Thermodynamical Excess Functions for Gases and Liq-
    uids, II., by J. O. Hirschfelder and others. 7 November 1956,
    19 p., figures, tables. (University of Wisconsin, Department of
    Chemistry, Technical Report Wis-OOR-16; also submitted to Indus-
    trial and Engineering Chemistry).

18. The Properties of a Gaseous or Liquid Mixture, by J. O. Hirsch-
    felder and R. J. Buehler. 9 January 1957, 13 p., tables. (Uni-
    versity of Wisconsin, Department of Chemistry, Technical Report
    Wis-OOR-17). ASTIA AD-119 723

II CHEMISTRY

D. Electrochemistry and Corrosion

485 KINETICS OF ANODE FILMS

        Contractor: University of Illinois
                      (Trustees of the University)
                      Urbana, Illinois

        Chief Investigator: J. H. Bartlett

        Contract No. DA-11-022-ORD-939
        Duration: 1 June 1952 - 31 August 1957
        Amount: $ 36,871.00
        Type of Contract: Cost

        Primary Scientific Liaison: Rock Island Arsenal
        Scientific Cognizance: Frankford Arsenal

Scope: The investigation in the general field of the kinetics of
electrode films will be continued, and will be extended to electrodes
other than Cu. Present techniques will be applied to a study of the
build-up of diffusion layers at the cathode and to a study of the
mechanisms of electropolishing. These studies will include (a) cal-
culation of the temporal behavior of the concentrations in the diffu-
sion layers, and (b) a study of the mechanism of layer growth.

Progress (to 30 September 1957): Studies have been made of the
Cu-HCl system and the following results have been obtained: (1) ob-
servation of the growth of the solid anode film, (2) identification
of the reaction products and potentials, (3) development of quantita-
tive kinetics for the current transient behavior, and (4) observa-
tion of the effect of natural convection on the steady state, over-
shoot, and oscillations. A schlieren microscope was developed to
observe complicated diffusion and convection phenomena. Concentra-
tion gradients were measured in the anolyte and the parabolic concen-
tration distribution in the convection layer was confirmed. The
Cu-H$_3$PO$_4$ system was studied to some extent and resulted in the de-
termination of polishing conditions. Complete results of this in-
vestigation are reflected in the reports listed below. The final
report has been received and the contract has been terminated.

Technical Reports:

1. The Kinetics of Anodic Films with an Appendix on the Schlieren
    Microscope, by Lee Stephenson and James H. Bartlett. 30 Septem-
    ber 1953, 122 p., figures. (University of Illinois, Department
    of Physics, Technical Report No. 1). ASTIA AD-18 651 (mc)

2. Anodic Behavior of Copper in HCl, by Lee Stephenson and J. H.
    Bartlett, in Journal of the Electrochemical Society, vol. 101,
    no. 11 (November 1954), p. 571-581.

II CHEMISTRY

D. Electrochemistry and Corrosion

485 (continued)

3. Dissolution and Electropolishing of Copper in Phosphoric Acid, by
    Frederick H. Giles and James H. Bartlett. 15 June 1955, 138 p.,
    figures. (University of Illinois, Department of Physics, Techni-
    cal Report No. 2). ASTIA AD-75 996

4. Anodic Transients of Copper in Hydrochloric Acid, by Ralph S.
    Cooper. 1 March 1956, 23 p., figures. (University of Illinois,
    Department of Physics, Technical Report No. 33; also published in
    the Journal of the Electrochemical Society, vol. 103, no. 6 (June
    1956), p. 307-315). ASTIA AD-93 227 (mc)

5. Anodic Behavior of Copper in Hydrochloric Acid, by Ralph S. Cooper.
    15 March 1957, 127 p., figures. (University of Illinois, Depart-
    ment of Physics, Technical Report No. 4).

6. Anodic Behavior of Copper in Hydrochloric Acid and in Phosphoric
    Acid, by J. H. Bartlett, R. S. Cooper and others. 30 September
    1957, 18 p. (University of Illinois, Department of Physics,
    Final Report).

II CHEMISTRY

E. Explosives and Propellants

613 QUALITATIVE KINETIC INVESTIGATION OF AROMATIC SUBSTITUENTS FOR
SULFINIC ACID AZIDE

Contractor: Texas Technological College
Lubbock, Texas

Chief Investigator: Samuel H. Lee, Jr.

Contract No. DA-23-072-ORD-491
Duration: 1 February 1953 - 31 August 1956
Amount: $ 9,200.00
Type of Contract: Fixed Price

Primary Scientific Liaison: Picatinny Arsenal

Scope: To continue the investigation of the decomposition of certain
sulfinic acid azides. In particular studies will continue on the
preparation and the kinetics of various substituted benzenesulfin-
azides.

Progress (31 August 1956): Benzenesulfinazide, 4-nitrobenzenesulfin-
azide, and 4-bromobenzenesulfinazide have been prepared by the re-
duction of the arylsulfonyl chloride by alkaline sodium sulfite,
acidification of the product to the arylsulfinic acid, conversion of
the acid to the sulfinyl chloride by thionyl chloride in excess, and
formation of the azide by reaction of the sulfinyl chloride with
activated sodium azide. An alternative method involving conversion
of the acid chloride to the hydrazide followed by diazotization to the
azide with nitric acid has also been explored. In the first method,
the presence of a small amount of thionyl chloride in the last step
(reaction of sulfinyl chloride with activated sodium azide) was found
to have a beneficial effect, but upon further investigation it was
found that $SOCl_2$ is unnecessary if the acid chloride is sufficiently
dispersed and the temperature is not kept too low. Additional studies
have indicated that the role of $SOCl_2$ is that of improving contact be-
tween insoluble reacting phases. An investigation of the effect of
unreacted acid chloride in sulfinazide before making kinetic measure-
ments has indicated that removal of the acid chloride is not as
essential as might have been supposed. The effect of benzene as sol-
vent has been shown as inhibiting decomposition at the lower tempera-
tures, and promoting it at higher temperatures. Approximately 150
rate determinations have been made on the three sulfinazides in three
solvents at seven temperatures, and the majority of these were based
on pressure measurements confined to one solvent, petroleum ether.
From a careful inspection of the rate constant data, especially the
averages for the three compounds at each temperature in a common sol-
vent, the following conclusions were reached: (1) 4-Nitrobenzene-
sulfinazide is definitely more stable, i.e., less rapid in its decompo-
sition than either of the others, and (2) it is very difficult, if not
impossible, to distinguish between benzenesulfinazide and its bromo
derivative according to their relative thermal stabilities. These

II CHEMISTRY

E. Explosives and Propellants

613 (continued)

conclusions have been further reinforced by considering the energies
and entropies of activation, for which the nitro compound has dis-
tinctly lower values for both quantities and the values for the other
two are virtually impossible to differentiate. The final report has
been received and the contract has been terminated.

Technical Reports:

1. Qualitative Kinetic Investigation of Aromatic Substituents for
Sulfinic Acid Azides, by Samuel H. Lee, Jr., Henry L. King and
Satya Pal Sood. 52 p., figures, tables. (Texas Technological
College, Final Report: 1 February 1953 - 31 August 1956).
ASTIA AD-121 518

II CHEMISTRY

E. Explosives and Propellants

1179 REPLACEMENT OF HALOGEN BY HYDROGEN IN NITRO ARYL HALIDES

       Contractor: Queens College
                  Flushing, New York

       Chief Investigator: A. H. Blatt

       Contract No. DA-30-069-ORD-1289
       Duration: 1 June 1954 - 31 December 1956
       Amount: $ 8,858.00
       Type of Contract: Cost

       Primary Scientific Liaison: Office of Ordnance Research
       Scientific Cognizance: Redstone Arsenal

Scope: To study the replacement of halogen by hydrogen in nitric aryl halides; specifically to determine: (a) the nature, number, and locations of the substitutes necessary in the halides, (b) the kinetics of the reaction, and (c) application of the reaction to structural and preparative problems.

Progress (to 31 December 1956): In the course of working out a procedure for preparing picryl iodide from the corresponding chloride and sodium iodide, a color test was developed for aromatic nitro compounds and the number of nitro groups they contain. The test depends upon the colors developed by aromatic nitro compounds and iodide ions when they are together in acetone solution. Attempts to secure useful kinetic data on the reaction between picryl iodide and hydriodic acid were unsuccessful since the data were not sufficiently reproducible. The difference in reactivity between sodium iodide-acetic acid and hydriodic acid-sodium acetate has been shown to be due to the hypophosphorous acid present as a stabilizer in the hydriodic acid. Hypophosphorous acid alone was found to be the most effective reagent for reducing picryl iodide to trinitrobenzene. Reduction of picryl iodide by hydriodic acid in acetone was strongly inhibited by added water. Reduction with an alkali iodide and an added acid increased the rate with the strength of the added acid. Reduction of a nitroaryl halide to a nitro aromatic compound using dilute hydriodic acid stabilized with hypophosphorous acid was found to require the presence of three nitro groups on the aromatic ring as in the picryl halides. Reduction with hydriodic acid and with hypophosphorous acid was studied in the thiophene series and it has been possible to get as far as 2,3,4-trinitro-5-bromothiophene and 2,3,4-trinitrothiophene. Attempts to prepare tetranitrothiophene from 2,3,4-trinitrothiophene were unsuccessful. The final report has been received and the contract has been terminated.

II CHEMISTRY

E. Explosives and Propellants

1179 (continued)

    Technical Reports:

    1. The Replacement of Halogen by Hydrogen in Nitro Aryl Halides, by A. H. Blatt and Norma Gross. (Manuscript submitted to the Journal of Organic Chemistry). (A part of #3).

    2. Replacement of Halogen by Hydrogen in Nitro Aryl Halides: Some Applications in the Thiophene Series, by A. H. Blatt, Norma Gross, and E. W. Tristram. (Manuscript submitted to the Journal of Organic Chemistry). (A part of #3).

    3. Replacement of Halogen by Hydrogen in Nitro Aryl Halides, by A. H. Blatt and Norma Gross. Not dated, various paging. (Queens College, Final Report containing #1 and #2).

II CHEMISTRY

F. Inorganic and Analytical Chemistry

817 THE CHEMISTRY OF THE HYDRIDES OF THE GROUP IV ELEMENTS

Contractor: Illinois Institute of Technology
3300 South Federal Street
Chicago 16, Illinois

Chief Investigator: Sei Sujishi

Contract No. DA-11-022-ORD-1264
Duration: 15 June 1953 - 30 June 1957
Amount: $ 23,632.00
Type of Contract: Cost

Primary Scientific Liaison: Office of Ordnance Research

Scope: Within the field of the Group IV hydrides, investigations
will be made in particular on the chemistry of silylphosphorus com-
pounds. Possible methods of synthesizing trisilylphosphine will be
studied by reaction with trimethylboron and by other suitable means.
Additional studies will include the possible synthesis of silylphos-
phines and their basicity, and an exploration of the possible synthe-
sis of germanyl amines and silylsulfide and to determine their basic
properties. In addition, a study of the acids containing the same
substitutes will be made.

Progress (to 30 June 1957): Work on the reactions of phosphine and
the methylphosphines with silyl bromide and iodide has been completed.
Results of this work appear in report #1 below. The reactions of sil-
oxane and disilyl sulfide with diborane, boron trifluoride, and tri-
methylaluminum have been studied as well as silicon-oxygen and silicon-
sulfur π-bonding. Studies have also been made of the reactions of
hexamethyldisilazine with trimethylborane, diborane, boron trifluo-
ride, and boron trichloride. Reactions of germanium tetrachloride
with lithium aluminohydrides, and lithium tri-t-butoxyaluminohydride
have been investigated for use as an effective reagent for the prepa-
ration of germane. The preparation of germyl isocyanide has been
studied and a comparison has been made of some of its chemical proper-
ties with those of silyl isocyanide. Reactions of germyl bromide with
amines and phosphines have also been studied. Results of the above
studies appear in report #3 listed below. The final report has been
received and the contract has been terminated.

Technical Reports:

1. Chemistry of the Group Four Hydrides, by Sei Sujishi and Samuel
Witz. 1 March 1954, 35 p., figures, tables. (Illinois Institute
of Technology, Department of Chemistry, Technical Report No. 1).
ASTIA AD-27 159 (mc)

II CHEMISTRY

F. Inorganic and Analytical Chemistry

817 (continued)

2. Effect of Replacement of Carbon by Silicon in Trimethylamine on
the Trimethylboron Addition Compounds. Estimation of the Resonance
Energy for Silicon-Nitrogen Partial Double Bond, by S. Sujishi
and S. Witz, in Journal of the American Chemical Society, vol. 76
(1954), p. 4631.

3. Chemistry of the Group Four Hydrides, by Sei Sujishi. 1 August
1957, 59 p., figures, tables. (Illinois Institute of Technology,
Department of Chemistry, Final Report).

II CHEMISTRY

F. Inorganic and Analytical Chemistry

841 DEVELOPMENT OF A NEW METHOD FOR THE SPECTROSCOPIC ANALYSIS OF MIXTURES

Contractor: Florida State University
Tallahassee, Florida

Chief Investigator: Russell J. Keirs

Contract No. DA-01-009-ORD-327   Renewed: DA-01-009-ORD-457
Duration: 1 July 53 - 30 Nov 55   30 Nov 1955 - 31 Aug 1957
Amount: $ 13,825.23 $ 8,640.00
Type of Contract: Fixed Price   Cost

Primary Scientific Liaison: Office of Ordnance Research
Scientific Cognizance: Picatinny Arsenal

Scope: A determination will be made of the upper and lower concentration limits for the detection of phosphorescence for each compound to be studied, the solubility limits will be ascertained in the solvents used, and the effects of impurities will be studied. Quantitative photometric data will be obtained on binary mixtures, relating intensity of phosphorescence to concentration, with special emphasis on reproducibility. A method and technique will be developed for the analysis of multicomponent mixtures, especially when all components absorb radiation in the same spectral region. All phosphorescence spectra studied will be catalogued.

Progress (to 31 August 1957): Work under this project has indicated that certain organic compounds can be determined by analysis of the phosphorescent emissions excited in the compounds under appropriate conditions. Where this method has been challenged by using compounds of very similar absorption or phosphorescent characteristics, initial results have been satisfactory. The average relative error found upon determining the concentrations of known solutions by this method was about 10%, excluding an unfavorable result involving benzophenone in a mixture with acetophenone, where the concentration was 3.5×10^{-6}M. Data substantiate a statement that the precision determined by running replica samples is much higher than the accuracy obtained in the initial runs, indicating that the accuracy can be improved by controlling experimental parameters more carefully. It has been found possible to analyze mixtures containing more than two phosphorescent substances, without physical separation, by the proper choice of excitation frequency, resolution time, and emission frequency. The final report has been received and the contract has been terminated.

II CHEMISTRY

F. Inorganic and Analytical Chemistry

841 (continued)

Technical Reports:

1. Phosphorimetry: A New Method of Analysis, by R. J. Keirs and others, in Analytical Chemistry, vol. 29 (February 1957), p. 202-209. (Technical Report No. 1). ASTIA AD-124 013

2. Basic Research in the General Field of Spectroscopic Analysis, by Russell J. Keirs. 52 p., figures, tables. (Florida State University, Department of Chemistry, Final Report: 1 July 1953-31 August 1957).

II CHEMISTRY

F. Inorganic and Analytical Chemistry

1111 THE BORON BASES

      Contractor: University of Houston
                    Cullen Boulevard
                    Houston 4, Texas

      Chief Investigator: George W. Campbell, Jr.

      Contract No. DA-23-072-ORD-761   Renewed: DA-23-072-ORD-964
      Duration: 1 Nov 53 - 31 Jan 56   1 Feb 1956 - 31 Jan 1957
      Amount: $ 12,803.70 $ 6,191.50
      Type of Contract: Cost   Cost

      Primary Scientific Liaison: Office of Ordnance Research
      Scientific Cognizance: Frankford Arsenal

Scope: Research will be continued in the general field of the boron bases and will include (1) a study of the chemistry of $Na_2HB(CH_3)_2$ from the standpoint of its base activity and also its hydride activity toward a variety of reagents, (2) attempts to prepare $Na_2HB(CH_3)_2$ in large quantities, (3) a study of the process of having $Na_2HB(CH_3)_2$ react with $(CH_3)_4B_2H_2$ in liquid ammonia, and (4) a study of the properties of compounds analogous to $Na_2HB(CH_3)_2$, with special emphasis on $Li_2HB(CH_3)_2$.

Progress (to 31 January 1957): The work on boron bases has reached the stage where it appears that a number of such bases are capable of existence, but their extreme reactivity makes it very difficult to prepare them in good purity except on a very small scale. However, the Na and Ca salts of the $HB(CH_3)_2^-$ ion have been studied in some detail, and evidence that the Li salt can be prepared is reasonably good. The synthesis of the dimethylborohydrides of Ca and Li has been accomplished and the ammoniate of tetramethyldiborane has been studied in an effort to learn more about the reaction of tetramethyldiborane with active metals in liquid ammonia. The final report has been received and the contract has been terminated.

Technical Reports:

1. Further Studies of Boron Bases, by G. W. Campbell, Jr., and Anton B. Burg. (Manuscript submitted to Journal of the American Chemical Society).

2. Further Studies on the Boron Bases: $CaHB(CH_3)_2$, by George W. Campbell, Jr., in the Journal of the American Chemical Society, vol. 79 (August 1957), p. 4023-4029.

3. The Boron Bases, by George W. Campbell, Jr. and Louis A. Martincheck. 1 February 1957, 34 p., figures, tables. (University of Houston, Final Report). ASTIA AD-123 238

II CHEMISTRY

G. Lubrication and Surface Phenomena

684 STUDY OF PARAFFIN-CHAIN MOLECULES

      Contractor: University of Washington
                    Board of Regents
                    Seattle 5, Washington

      Chief Investigator: E. C. Lingafelter

      Contract No. DA-04-200-ORD-236
      Duration: 1 February 1953 - 30 June 1957
      Amount: $ 41,976.00
      Type of Contract: Cost

      Primary Scientific Liaison: Frankford Arsenal

Scope: To study the structure of paraffin chain molecules by x-ray diffraction methods in solution and specifically including atoms of large scattering power within the paraffin chain; to study the crystal structures of certain paraffin chain compounds in order to study the packing requirements of the polar and ionic groups and the variations of carbon-carbon bond lengths and C-C-C bond angles; to study the properties of solutions of metalloalkane sulfonates in relation to molecular structure and micellar properties of paraffin-chain salt solutions.

Progress (31 October 1956 - 30 June 1957): Programming of the IBM 650 computer has been completed and programs are available for the following calculations: (1) Structure factors for any centrosymmetric zone on any space group, (2) Fourier, Patterson, or difference syntheses (2-dimensional) at various intervals from 25ths to 200ths, (3) overall isotropic temperature by least squares treatment, (4) overall isotropic temperature factor by Wilson's method, (5) interatomic distances and angles for crystals of monoclinic and higher symmetry, (6) hydrogen coordinates for CH_2 and CH_3 groups from carbon coordinates, and (7) best plane through any given set of atoms. The crystal structure of bis-ethylenediamine-nickel (II) thiocyanate has been essentially completed, with the discrepancy index being below 15% for all three axial projections. Since the difference syntheses showed peculiarities in the region of the Ni atom, the validity of the scattering factor, and the advisability of including the dispersion correction will be investigated. For subsequent progress see Research Proposal No. 1907, this report.

Technical Reports:

1. The X-Ray Crystallography of the Amides of the n-Aliphatic Acids, by J. D. Turner and E. C. Lingafelter. 30 October 1953, 32 p., figures, tables. (University of Washington, Department of Chemistry, Technical Report No. 1). ASTIA AD-20 725 (mc)

II C H E M I S T R Y

G. Lubrication and Surface Phenomena

684 (continued)

2. Study of Paraffin-Chain Molecules: The Effect of Gegenions on
    Micelles, by Russel F. Fogle, Jr., and E. C. Lingafelter. 31
    July 1954, 9 p. (University of Washington, Technical Report No.
    2). ASTIA AD-37 360 (mc)

3. Primary Salt Effects with Some Paraffin-Chain Salt Solutions, by
    J. A. Erikson and E. C. Lingafelter, in the Journal of Colloid
    Science, vol. 10, no. 1 (February 1955), p. 71-87. (Technical
    Report No. 3). ASTIA AD-58 621

4. X-Ray Crystallography of the Sodium n-Alkyl Sulfates, by F. F.
    Rawlings, Jr., and E. C. Lingafelter, in the Journal of the
    American Chemical Society, vol. 77 (February 1955), p. 870-872.
    (Technical Report No. 4). ASTIA AD-61 608

5. The Crystal Structure of Tetra-Decanamide, by J. D. Turner and
    E. C. Lingafelter, in Acta Crystallographica, vol. 8, no. 9
    (September 1955), p. 551-557.

6. Linear to Log Converter, by J. R. Brathovde and J. D. Breazeale,
    in Review of Scientific Instruments, vol. 26, no. 9 (September
    1955), p. 892-893. (Technical Report No. 5). ASTIA AD-81 747

7. The X-Ray Crystallography of the n-Aliphatic Amides, by J. D.
    Turner and E. C. Lingafelter, in Acta Crystallographica, vol. 8,
    no. 9 (September 1955), p. 549-550.

8. The Crystal Structure of Decanamide, by J. R. Brathovde and E. C.
    Lingafelter. (Manuscript submitted to Acta Crystallographica).

II C H E M I S T R Y

H. Molecular Structure and Physical Properties

525 STUDIES BEARING ON THE RELATION OF STRUCTURE TO PROPERTIES IN
     LIQUID SOLUTIONS

    Contractor: University of Pittsburgh
                 Pittsburgh 13, Pennsylvania

    Chief Investigators: Henry S. Frank
                          T. H. Dunkelberger

    Contract No. DA-36-061-ORD-295   Renewed: DA-36-061-ORD-472
    Duration: 1 Jan 53 - 31 Mar 55   1 April 1955 - 30 Sept 1956
    Amount: $ 22,454.99 $ 6,755.00
    Type of Contract: Fixed Price   Fixed Price

    Primary Scientific Liaison: Office of Ordnance Research

Scope: To establish and extend correlations between thermodynamic
data, kinetic data, and structural features of liquids and solutions.
This objective will be accomplished by means of research along any or
all of the lines listed below: (1) Measurement of e.m.f.'s of con-
centration cells within transference, using solutions of sodium chlo-
ride and potassium chloride in pure or nearly pure deuterium oxide
(heavy water), (2) calorimetric measurements of heats of dilution and
viscosities of aqueous solutions of additional amino acids, including
the three aminobenzoic acids and some dipeptides, and (3) further
study of the distribution of acetanilide and related compounds between
water and non-polar solvents such as benzene and carbon tetrachloride.

Progress (to 30 September 1956): An evaluation has been made of devel-
opments in electrolyte theory during 1953, and the results have been
published. An experimental study has been completed on the viscosities,
activity coefficients, and heats of dilution of taurine and 2-amino-
butane-1-sulfonic acid in aqueous solution. Results of this study re-
vealed new regularities in structural influences of amino acids. A
parallel study of cis- and trans-1,4-aminocyclohexanecarboxylic acids
shed additional light on structural effects. In addition a study was
made of the activity coefficient of LiCl in dilute aqueous solutions
at 25°C. Results of the above studies appear in the technical re-
ports listed below. The final report has been received and the
contract has been terminated.

Technical Reports:

1. Solutions of Electrolytes, by Henry S. Frank and Maak Sang Lsao
    in Annual Review of Physical Chemistry, vol. 5 (1954), p. 43-70.
    (Technical Report No. 1). ASTIA AD-48 611

II CHEMISTRY

H. Molecular Sturcture and Physical Properties

525 (continued)

2. Some Thermodynamic and Flow Properties of Aqueous Solutions of Two Amino Sulfonic Acids, by Wilbert Eugene Keder. 1956, 65 p., figures, tables. (University of Pittsburgh, Technical Report No. 2, Ph.D. thesis). ASTIA AD-106 722(mc)

3. Some Thermodynamic and Flow Properties of Aqueous Solutions of cis and trans-1,4-Aminocyclohexanecarboxylic Acids, by William Allan Plummer. 1956, 89 p., figures, tables. (University of Pittsburgh, Technical Report No. 3, Ph.D. thesis). ASTIA AD-106 723(mc)

4. The Activity Coefficient of LiCl in Dilute Aqueous Solutions at 25°C, by Henry S. Frank, T. H. Dunkelberger and others. 1956, 75 p., figures, tables. (University of Pittsburgh, Department of Chemistry, Technical Report No. 4, Ph.D. thesis).

5. Structure and Properties in Liquid Solutions, by Henry S. Frank and T. H. Dunkelberger. Not Dated, 10 p. (University of Pittsburgh, Department of Chemistry, Final Report).

II CHEMISTRY

H. Molecular Structure and Physical Properties

670 FACTORS INFLUENCING THE FORMATION AND PROPERTIES OF CHELATE COMPLEXES OF METAL IONS WITH VARIOUS SUBSTITUTED HYDROXAMIC ACIDS

Contractor: Purdue Research Foundation
Lafayette, Indiana

Chief Investigator: W. W. Brandt

Contract No. DA-33-008-ORD-607
Duration: 1 February 1953 - 31 August 1956
Amount: $ 18,000.00
Type of Contract: Fixed Price

Primary Scientific Liaison: Frankford Arsenal

Scope: Basic research will be carried out involving factors influencing the formation and properties of chelate complexes of metal ions with various substituted hydroxamic acids.

Progress (to 31 August 1956): Work has been directed toward developing and understanding reactions of metals with hydroxamic acids, particularly of the iron-, vanadium-, and uranium-benzohydroxamic acid systems. Several new species have been identified, and the influence of structural variations in the reagent upon the properties of the complexes has been evaluated. The analytical applications of three metal systems have been demonstrated and evaluated to permit a better understanding of the variables influencing these methods. The final report has been received and the contract has been terminated.

Technical Reports:

1. The Spectrophotometric Determination of Vanadium in Crude and Residual Oils, by Warren M. Wise and Warren B. Brandt, in Journal of American Chemical Society, vol. 27, no. 9 (September 1955). p. 1392-1395. (A part of #4). ASTIA AD-119 400

2. An Investigation of Some Hydroxamic Acids, by Warren M. Wise and Warren W. Brandt in the Journal of the American Chemical Society vol. 77 (20 February 1955), p. 1058-1059. (A part of #4). ASTIA AD-119 399

3. Extraction Studies of Metal-Hydroxamic Acid Complexes, by Warren W. Brandt and others. (Manuscript submitted to Journal of the American Chemical Society).

4. Factors Influencing the Formation and Properties of Chelate Complexes of Metal Ions with Various Substituted Hydroxamic Acids, by Warren W. Brandt, Warren M. Wise and others. 15 December 1956, 41 p., figures, tables. (Purdue Research Foundation, Department of Chemistry, Final Report, containing #1 and #2). ASTIA AD-119 398

II   CHEMISTRY

H.   Molecular Structure and Physical Properties

695   STUDIES OF SALT EFFECTS ON SOLUBILITY AND ION-PAIR EQUILIBRIA IN
      SOLVENTS OF LOW DIELECTRIC CONSTANT

            Contractor: University of Kansas
                          Lawrence, Kansas

            Chief Investigator: Ernest Griswold

            Contract No. DA-23-072-ORD-493   Renewed: DA-23-072-ORD-965
            Duration: 1 Feb 53 - 31 Jan 56   1 Feb 1956 - 31 July 1957
            Amount: $ 19,440.00 $ 6,775.00
            Type of Contract: Fixed Price   Cost

            Primary Scientific Liaison: Office of Ordnance Research

      Scope: In the field of solvents of low dielectric constant, investi-
      gation concerning solubility phenomena involving electrolytes will be
      carried out by (a) determining the solvent effect of different soluble
      salts upon one or more slightly soluble salts in such a solvent, and
      (b) measuring the conductances of the individual salts in the solvents.
      Evaluation and appropriate interpretation of the results will be made.

      Progress (to 31 July 1957): The solubility of silver acetate has been
      determined at 30° in acetic acid alone and in the presence of sodium
      acetate, silver nitrate, and lithium nitrate, each at several con-
      centrations. Also the solubility of silver nitrate has been measured
      in acetic acid solutions of silver acetate, lithium nitrate, and
      sodium acetate at the same temperature. It has been determined that
      the solubility of ammonium bromide in acetic acid at 30° is roughly
      tripled in the presence of 0.1 molal lithium acetate, potassium ace-
      tate or sodium acetate. Ammonium acetate produced about a 30% increase
      at this concentration. The solubility of KBr has been determined in
      fourteen different mixtures of acetic acid and acetonitrile with each
      mixture containing various concentrations of sodium acetate. Similar
      measurements were made using potassium acetate as added salt in nine
      different acetic acid-acetonitrile mixtures. Conductance measurements
      have been made at 25° and 30° on potassium bromide, sodium bromide,
      potassium acetate, and sodium acetate over a range of concentrations
      in acetic acid and in three acetic acid-acetonitrile mixtures. These
      results have been used to calculate ion pair dissociation constants
      and limiting equivalent conductances for the salts. Studies have
      indicated that ion-pair metathesis in solvents of the kind used in
      this investigation plays an important role in salt effect on solu-
      bility. The final report has been received and the contract has been
      terminated.

II   CHEMISTRY

H.   Molecular Structure and Physical Properties

695   (continued)

      Technical Reports:

      1. The Effect of Some Salts on the Solubility of Silver Acetate and
          of Silver Nitrate in Acetic Acid at 30°, by Ralph K. Birdwhistell
          and Ernest Griswold. Not Dated, 11 p., tables. (University of
          Kansas, Department of Chemistry, Technical Report No. 1; also
          published in the Journal of the American Chemical Society, vol.
          77 (February 1955), p. 873-875). ASTIA AD-50 489 (mc)

      2. Studies of Salt Effects on Solubility and Ion-Pair Equilibria in
          Solvents of Low Dielectric Constant, by Ernest Griswold. 42 p.,
          figures, tables. (University of Kansas, Department of Chemistry,
          Final Report: 1 February 1953 - 31 July 1957).

II CHEMISTRY

H. Molecular Structure and Physical Properties

967 ABSORPTION INTENSITIES IN THE POLARIZED SPECTRA OF SIMPLE MOLECULAR
CRYSTALS

        Contractor: Cornell University
             ·Ithaca, New York

        Chief Investigator: R. M. Hexter

        Contract No. DA-30-115-ORD-513   Renewed: DA-30-115-ORD-704
        Duration: 15 Oct 53 - 14 Dec 55   15 Dec 1955 - 30 June 1957
        Amount: $ 14,263.76 $ 8,437.18
        Type of Contract: Fixed Price   Cost

        Primary Scientific Liaison: Office of Ordnance Research
        Scientific Cognizance: Redstone Arsenal

Scope: The investigation will be concerned with the use of polarized
infrared spectroscopic techniques in the study of crystal and molecular
structure. In particular, it is intended to study iodine monobromide
and several "pseudo-diatomic" molecular systems. Two such cases are
hexachloroethane and symmetric tribromo-trichloroethane. In addition,
the infrared techniques will be supplemented by an investigation of
the Raman spectra.

Progress (to 30 June 1957): The polarized infrared spectrum of
crystalline iodoform has been obtained. A complete assignment of all
fundamentals was possible including at least two of the lattice fre-
quencies of the crystal. A study has been made of the effect of
liberations of molecules about axes perpendicular to those of the
transition moments of molecular vibrations upon the dichroic ratios
associated with such vibrations in the infrared spectra of molecular
crystals. It has been demonstrated that if such librations are
harmonic and of small amplitude, the root-mean-square deviation of the
molecular orientation from its equilibrium orientation is sufficient
to account for the deviation of observed dichroic ratios from those
predicted by the "oriented gas model". An analysis was made of the
spectrum of $Mg(OH)_2$ and $Ca(OH)_2$, based upon the use of energy level
diagrams for restricted rotators in a potential field of the appro-
priate symmetry for such crystals, and it has been concluded that this
development constitutes a valuable ·new approach toward the under-
standing of the notion of molecules in solids. Studies have also been
made of the high resolution, temperature dependent spectra of calcite
and of sodium nitrate, and preliminary·results have been obtained on
the spectra of $LiOH$, $NaBH_4$, KBH_4 and SiH_4. Complete results of the
above studies appear in report #5 listed below. The final report has
been received and the contract has been terminated.

II CHEMISTRY

H. Molecular Structure and Physical Properties

967 (continued)

Technical Reports:

1. The Infrared Absorption Anisotropy of Crystalline Iodoform, by
R. M. Hexter and H. Cheung. Not dated, 16 p., figures. (Cornell
University, Technical Report No. 1: June 1954 - June 1955; also
published in the Journal of Chemical Physics, vol. 24, no. 6
(June 1956), p. 1186-1195)

2. Absorption Intensities in the Polarized Spectra of Simple Molec-
ular Crystals, by R. M. Hexter. 21 p., tables. (Cornell Univer-
sity, Technical Report No. 2: June 1955 - January 1956). ASTIA
AD-80 828

3. High Resolution, Temperature Dependent Spectra of Calcite, by
R. M. Hexter. 22 p., figures, tables. (Cornell University,
Technical Report No. 3: 15 December 1955 - 14 June 1956).

4. Low-Frequency Liberations and the Vibrational Spectra of Molecular
Crystals, by R. M. Hexter and D. A. Dows, in Journal of Chemical
Physics, vol. 25, no. 3 (September 1956), p. 504-509.

5. Absorption Intensities in the Polarized Spectra of Simple Molecular
Crystals, by R. M. Hexter. 31 p., figures, tables. (Cornell
University, Final Report: 15 October 1953 - 15 June 1957).

II C H E M I S T R Y

H. Molecular Structure and Physical Properties

1087 DIELECTRIC PROPERTIES OF HYDROGEN BONDING LIQUIDS AND SOLIDS

Contractor: Brown University
             Providence 12, Rhode Island

Chief Investigators: Donald F. Hornig
                      Robert H. Cole

Contract No. DA-19-020-ORD-3177
Duration: 30 October 1953 - 30 October 1956
Amount: $ 26,000.00
Type of Contract: Cost

Primary Scientific Liaison: Office of Ordnance Research
Scientific Cognizance: Redstone Arsenal

Scope: One or more of the following topics will be treated in this
investigation: (a) Measuring dielectric dispersion and loss in
representative liquids, (b) measuring the effect of pressure on di-
electric relaxation at low temperatures, and (c) investigating the
dielectric properties of several inorganic acids.

Progress (to 30 October 1956): The dielectric properties of the solid
phases of three hydrogen and deuterium halides have been measured from
63°K to the melting points in the frequency range 20 c/sec to 2 mc/sec.
The static and dynamic electrical properties of five of the lower mono-
hydric aliphatic alcohols have been investigated. In addition, various
compositions of a solution of two of the alcohols were studied in the
frequency range from 0.1 c/sec to 2 mc/sec with the temperature range
such that dispersion was characterized both above and below the melt-
ing point. The effect of pressures to 1000 atmospheres on the dielec-
tric constant and loss of 1-propanol and glycerol has been studied and
liquid equation of state data have been obtained for interpreting the
dielectric results as a function of pressure. Techniques for measur-
ing dielectric properties of liquids in the 1-250 mc/sec range have
been developed, and a special test cell which can be thermostatted
adequately down to -78°C has been designed and used successfully.
Additional work has included a critical study of previous measurements
on liquid alkali halides, and of equimolar mixtures of i-butyl bromide
and i-butyl chloride and of a mixture of i-amyl bromide and 1-propanol.
Attempts have been made to measure the dielectric constant and loss of
sulfuric acid. Further work is necessary before any conclusions can
be made as to the accuracy of the measurements. The final report has
been received and the contract has been terminated.

Technical Reports:

1. The Design and Construction of Two Low Temperature Thermostats, by
    Andrew Gilchrist, in the Review of Scientific Instruments, vol. 26,
    no. 8 (August 1955), p. 773-775. (A part of #6).

II C H E M I S T R Y

H. Molecular Structure and Physical Properties

1087 (continued)

2. On the Analysis of Dielectric Relaxation Measurements, by R. H.
    Cole, in Journal of Chemical Physics, vol. 23, no. 3, (March 1955),
    p. 493-499. (A part of #6).

3. Dielectric Properties of Methanol and Methanol 1-Propanol Solu-
    tions, by Donald J. Denny and R. H. Cole, in The Journal of Chemi-
    cal Physics, vol. 23, no. 10 (October 1955), p. 1767-1772. (A
    part of #6).

4. Dielectric Properties of Liquid Butyl Alcohols, by Walter Dann-
    houser and R. H. Cole, in Journal of Chemical Physics, vol. 23,
    no. 10 (October 1955) p. 1762-1766. (A part of #6).

5. On Dielectric Properties of Solid Hydrogen and Deuterium Halides,
    by S. Havriliak, Jr. and R. H. Cole, in Journal of Chemical
    Physics, vol. 23, no. 12 (December 1955) p. 2455-2456. (A part of
    #6).

6. Dielectric Properties of Hydrogen Bonding in Liquids and Solids,
    by R. H. Cole, 16 March 1956, various paging, figures, tables.
    (Brown University, Metcalf Research Laboratory, Technical Report
    No. 1, containing #1 through #5). ASTIA AD 107-142

7. Effect of Pressure on Dielectric Properties and Volume of 1-
    Propanol and Glycerol, by A. Gilchrist and others. (Manuscript
    submitted to the Journal of Chemical Physics). (A part of #11).

8. Dielectric Properties of Some Liquid Alkyl Halides, by Donald J.
    Denny. (Manuscript submitted to the Journal of Chemical Physics).
    (A part of #11).

9. A Coaxial Dielectric Cell for Liquids, by R. H. Cole and S. E.
    Lovell. (Manuscript submitted to The Review of Scientific
    Instruments).

10. Dielectric Relaxation in Solid Hydrogen Halides, by R. H. Cole
    and S. Havriliak, Jr. (Manuscript submitted to Discussions of the
    Faraday Society). (A part of #11).

11. Dielectric Properties of Hydrogen Bonding Liquids and Solids, by
    R. H. Cole and others. 15 April 1957, various paging, figures,
    tables. (Brown University, Metcalf Research Laboratory, Final
    Report containing #7, #8, #9 and #10).

II C H E M I S T R Y

H. Molecular Structure and Physical Properties

1173 PROPOSAL TO FURNISH FURTHER STRUCTURAL INFORMATION REGARDING OXIDES,
OXYACIDS, AND OXYHALIDES OF NITROGEN

        Contractor: Stanford University
                (Board of Trustees of the
                  Leland Stanford Junior University)
                Palo Alto, California

        Chief Investigator: Richard A. Ogg, Jr.

        Contract No. DA-04-200-ORD-318
        Duration: 1 June 1954 - 31 May 1957
        Amount: $ 31,586.64
        Type of Contract: Cost

        Primary Scientific Liaison: Office of Ordnance Research
        Scientific Cognizance: Picatinny Arsenal

Scope: Research will be conducted to furnish further structural in-
formation regarding oxides, oxyacids and oxyhalides of nitrogen. The
problem will be attacked by studying nuclear magnetic resonance in
nitrogen compounds. In particular such compounds as NO, N_2O_4 and
$NClO_2$ will be studied.

Progress (to 31 May 1957): The following studies have been completed
and the results are in various stages of publication: (1) Quadrupole
relaxation and structures in nitrogen magnetic resonances of ammonia
and ammonium salts, (2) quadrupole relaxation broadening of the mag-
netic resonance spectrum of methylammonium ion, (3) proton and nitro-
gen magnetic resonance spectra and structure of nitramide and nitro-
urethane, (4) proton magnetic resonance spectra of some alkyl nitrites,
(5) nuclear magnetic N^{14} resonance spectra, molecular structures and
exchange reactions in the system N_2O_5—NO_2^+—NO_3^-—H_2O, (6) prepara-
tion and proton magnetic resonance studies of anhydrous ammonia, and
(7) molecular structure determination from nitrogen magnetic resonance
spectra. The final report has been received and the contract has been
terminated.

Technical Reports:

1. Proton Magnetic Resonance Spectra of Some Alkyl Nitrites, by L.
    H. Piette, James D. Ray, and R. A. Ogg, Jr., in the Journal of
    Chemical Physics (1957). (A part of #7).

2. Nuclear Magnetic H^1 and N^{14} Resonance Spectra of Nitramide and
    Nitrourethane, by James D. Ray and R. A. Ogg, Jr., in the Journal
    of Chemical Physics (1957). (A part of #7).

II C H E M I S T R Y

H. Molecular Structure and Physical Properties

1173 (continued)

3. Nuclear Magnetic N^{14} Resonance Spectra, Molecular Structures and
    Exchange Reactions in the System N_2O_5—NO_2^+—NO_3^-—H_2O, by James
    D. Ray and R. A. Ogg, Jr., in the Journal of Chemical Physics,
    vol. 25, no. 6 (December 1956), p. 1285-1286. (A part of #7).

4. Quadrupole Relaxation and Structures in Nitrogen Magnetic Reso-
    nances of Ammonia and Ammonium Salts, by R. A. Ogg, Jr., and James
    D. Ray, in the Journal of Chemical Physics (1957). (A part of #7).

5. Quadrupole Relaxation Broadening of the Magnetic Resonance Spec-
    trum of Methylammonium Ion, by R. A. Ogg, Jr., and James D. Ray,
    in the Journal of Chemical Physics, vol. 26, no. 5 (May 1957),
    p. 1340-1341. (A part of #7).

6. Preparation and Proton Magnetic Resonance Studies of Anhydrous
    Ammonia, by James D. Ray and R. A. Ogg, in the Journal of Chemical
    Physics (1957). (A part of #7).

7. Study to Furnish Further Structural Data on Oxides, Oxyacids, and
    Oxyhalides of Nitrogen, by R. A. Ogg., Jr., James D. Ray, and L.
    H. Piette. Various paging, figures. (Stanford University, Final
    Report containing #1, #2, #3, #4, #5, #6, and #8: 1 June 1954 -
    31 May 1957).

8. Molecular Structure Determination from Nitrogen Magnetic Resonance
    Spectra, by James D. Ray and R. A. Ogg, Jr. (Manuscript submitted
    to the Journal of Chemical Physics). (A part of #7).

II   CHEMISTRY

H. ·Molecular Structure and Physical Properties

1277 HYBRIDIZATION STUDIES AND THE STRUCTURE AND BOND TYPE IN MOLECULAR
COMPLEXES WITH PARTICULAR EMPHASIS ON THE METAL CARBONYLS

      Contractor: Florida State University
               (The Board of Control of the University)
               Tallahassee, Florida

      Chief Investigators: R. E. Johnson
                    Richard Wolfgang

      Contract No. DA-01-009-ORD-406   Renewed: DA-01-009-ORD-461
      Duration: 1 Feb 55 - 31 Jan 56   1 Feb 1956 - 30 June 1957
      Amount: $ 6,243.00 $ 7,952.50
      Type of Contract: Fixed Price   Cost

      Primary Scientific Liaison: Office of Ordnance Research
      Scientific Cognizance: Frankford Arsenal

Scope: A number of metal cyanides, carbonyls, and hydrocarbonyls will
be synthesized and studied by infrared spectroscopy. These will in-
clude but not be limited to mixed and individual cyanides, carbonyls
and hydrocarbonyls of ruthenium, osmium, iron, nickel, and cobalt.
Particular emphasis will be placed upon the normal coordinate analysis
of representative compounds.

Progress (to 30 June 1957): Attempts have been made to analyze the
structure and bond types in molecular complexes by spectroscopic
methods and by isotopic exchange reactions, and the following results
have been obtained: (1) The infrared spectra of cobalt tricarbonyl
was determined and a tentative assignment of absorption peaks was
made, (2) the infrared spectra of two nickel cyanides, $K_4Ni_2(CN)_6$ and
$K_4Ni(CN)_4$, were determined and their structure was predicted, (3) a
normal coordinate analysis of the $Fe(CO)_5$ molecule was made and a
tetragonal pyramid structure was assigned, (4) the thermochemistry of
some metal carbonyls was investigated, and (5) the isotopic rates of
exchange of carbon monoxide with $Fe(CO)_5$, $Co_2(CO)_8$, $Ni (CO)_4$,
$Co_2(CO)_6 \cdot C_6H_5C \equiv C_6H_5$ and $Mn_2(CO)_{10}$ were measured. The final re-
port has been received and the contract has been terminated.

Technical Reports:

1. Bond Hybridization and Structure in the Metal Carbonyls, by J. W.
    Cable and R. K. Sheline. 68 p., figures, tables. (Florida State
    University, Technical Report No. 1: 1 February 1955 - 1 August
    1955; also submitted to Chemical Reviews). ASTIA AD-69 715 (mc)

2. The Structure and Bond Type in Molecular Complexes, by Raymond K.
    Sheline, Richard W. Wolfgang and Rowland E. Johnson. 14 p.
    (Florida State University, Final Report: 1 February 1955 - 30
    June 1957).

II   CHEMISTRY

H. Molecular Structure and Physical Properties

1394 A STUDY OF SYSTEMS OF WATER, HYDROGEN PEROXIDE, AND SALTS

      Contractor: University of Virginia
               Charlottesville, Virginia

      Chief Investigator: Paul Gross, Jr.

      Contract No. DA-36-034-ORD-2019
      Duration: 1 July 1955 - 15 September 1957
      Amount: $ 17,710.44
      Type of Contract: Cost

      Primary Scientific Liaison: Office of Ordnance Research

Scope: To investigate systems of hydrogen peroxide/water containing
salts with the broad objective of obtaining quantitative thermodynamic
data that could lead to a quantitative evaluation of the solvation of
the ions. Some of the methods used may be vapor pressure determina-
tions, solubility determinations, conductivity measurements, and dis-
tribution measurements.

Progress (1 July 1955 - 15 September 1957): A series of vapor pres-
sure and vapor composition measurements have been made of water-
hydrogen peroxide solutions. These mixtures had previously shown
interesting solvation effects in salt systems. In addition, a series
of partial molal volume determinations, a number of experiments
characterizing the solid phases in equilibrium with saturated
solutions, and a limited number of solubility determinations have been
made to explain the properties of the salt solutions. Complete
results of these studies appear in the report listed below. The final
report has been received and the contract has been terminated.

Technical Reports:

1. A Study of Systems of Water, Hydrogen Peroxide, and Salts, by
    Paul M. Gross, Jr. 23 p., figures. (University of Virginia,
    Final Report: 1 July 1955 - 15 September 1957).

II CHEMISTRY

I. Organic Chemistry

735 ACYLATION OF ALICYCLIC KETONES AND RELATED COMPOUNDS WITH ESTERS,
AND OF ACTIVE HYDROGEN COMPOUNDS WITH LACTONES

        Contractor: University of Massachusetts
                 Amherst, Massachusetts

        Chief Investigator: G. W. Cannon

        Contract No. DA-19-059-ORD-1317   Renewed: DA-19-059-ORD-2196
        Duration: 11 May 53 - 31 May 55   1 June 1955 - 10 June 1957
        Amount: $ 8,983.91 $ 9,598.00
        Type of Contract: Fixed Price   Fixed Price

        Primary Scientific Liaison: Office of Ordnance Research

Scope: Research will be continued on, but not limited to, the follow-
ing topics: (a) Acylation and alkylation of alicyclic compounds with
esters and active hydrogen compounds with lactones including the pos-
sible evolution of useful synthetic methods; and (b) to study substi-
tuted cyclopropane structures in an effort to determine if hyperconju-
gation exists sufficiently to activate neighboring positions analogous
to the effects produced by the inclusion of unsaturation, carbonyl
groups, etc. This can involve alkylations, acylations, or whatever
other reactions are relevant toward the attainment of the above cited
objectives.

Progress (to 10 June 1957): A study was made of the transmission of
conjugative effects in certain cyclopropanes. Cyclopropyl esters,
ketones, and nitriles were synthesized and the acylation, alkylation,
aldolization, and cyanoethylation at the contiguous methyl group was
investigated. Studies were also made of the ultraviolet and infrared
absorption spectra of the cyclopropanes. Acylation studies of active
hydrogen compounds with lactones have been completed. γ-Butyrolactone,
γ-valerolactone, and δ-valerolactone were studied in this connection.
Studies were made of the structure of the condensation products, of
the infrared and ultraviolet absorption spectra, and of the reaction
of the products with ammonia and hydrazine. The infrared and ultra-
violet spectra of certain β-alkoxy-α,β-unsaturated ketones were in-
vestigated for use in interpreting the spectra and elucidating the
structure of the products obtained from the condensation of lactones
with ketones. Complete results of the above studies appear in the
reports listed below. The final report has been received and the con-
tract has been terminated.

II CHEMISTRY

I. Organic Chemistry

735 (continued)

Technical Reports:

1. Acylation of Alicyclic Ketones and Related Compounds with Esters,
and of Active Hydrogen Compounds with Lactones, I. Acylation of
Active Hydrogen Compounds with Lactones, II. The Infrared and
Ultraviolet Spectra of Certain β-Alkoxy-α,β-Unsaturated Ketones,
and III. A Study of the Transmission of Conjugative Effects in
Certain Cyclopropanes, by George W. Cannon and others. June 1957,
63 p., tables. (University of Massachusetts, Final Report).

II CHEMISTRY

I. Organic Chemistry

1252 A QUANTITATIVE STUDY OF THE RELATIVE INFLUENCE OF POLAR SUBSTITUENTS
AND HYPERCONJUGATION ON THREE-CARBON TAUTOMERISM

      Contractor: Columbia University
                 (Trustees of Columbia University)
                 Broadway at 116th Street
                 New York 27, New York

      Chief Investigator: Fausto Ramirez

      Contract No. DA-30-069-ORD-1316
      Duration: 1 September 1954 - 31 August 1956
      Amount: $ 20,206.00
      Type of Contract: Cost

      Primary Scientific Liaison: Office of Ordnance Research

Scope: A quantitative study will be made of the effects which polar
substituents (such as para and meta NO_2, NH_2, OH, and Cl) and alkyl
groups (such as methyl, ethyl, isopropyl) exert on the position of the
equilibria of certain tautomeric systems. Also, a study will be made
of the rate of equilibration of the butenolides including the position
of equilibrium and rate constants of the system, and an examination
will be made of the mechanism of formation of lactones from ketoacids.

Progress (to 31 August 1956): A study was made of the mechanism of the
conversion of γ-ketoacids to butenolides. Racemic and optically active
α-alkyl-β-aroylpropionic acids were converted into racemic and optical-
ly active, crystalline, symmetrical anhydrides by treatment with acetic
anhydride. The decomposition of the anhydrides was studied under a
variety of conditions. It was shown that the product obtained when an
optically active symmetrical anhydride is heated for 30 minutes at
100° in the absence of solvents, consists of optically active ketoacid
and a mixture of mostly racemic butenolides. It was shown that the
product obtained when a symmetrical anhydride is heated for 100 min-
utes at 100° in acetonitrile, consists of a clean mixture of ketoacid
and β-γ-butenolide. Kinetic runs revealed that a symmetrical anhy-
dride decomposes at 100° in dioxane to ketoacid anion and an intermed-
iate which slowly generates β-γ-butenolide. In acetonitrile, at 100°,
the anhydride decomposition was somewhat faster and the subsequent
transformation of the intermediate to β,γ-butenolide was considerably
accelerated. The above results were compared with those obtained when
the reaction of the ketoacids with acetic anhydride was allowed to
proceed to the butenolide stage without isolation of intermediates,
and a probable over-all mechanism was formulated. The information ob-
tained was utilized in attempts to prepare optically active α-alkyl-γ-
aryl-β,γ-butenolides, and it has been concluded that the preparation
is feasible when the para-substituent in the γ-aryl ring is bromo,
methoxy, and hydrogen, if proper conditions are selected. Preparation
of the butenolides was desired in order to study hydrogen mobility in

II CHEMISTRY

I. Organic Chemistry

1252 (continued)

three-carbon tautomerism and to ascertain the effect of alkyl groups
on the hydrogen mobility by measuring the rates of racemizations. It
was concluded that rate measurements on optically active butenolides
by polarimetric techniques was the best method to determine hydrogen
mobility. The final report has been received and the contract has been
terminated.

Technical Reports:

1. A Quantitative Study of Relative Influence of Polar Substituents
   and Hyperconjugation on Three-Carbon Tautomerism, by Fausto
   Ramirez, Charles E. Dills and Samuel Dershowitz. 62 p., tables.
   (Columbia University, Final Report: 1 October 1954 - 30 July
   1956).

II   C H E M I S T R Y

I.   Organic Chemistry

1258 RESEARCH IN ORGANIC SULFUR COMPOUNDS

       Contractor: Wayne University
                   (Board of Education of the City of Detroit)
                   4841 Cass Avenue
                   Detroit 1, Michigan

       Chief Investigator: Carl Djerassi

       Contract No. DA-20-018-ORD-13474
       Duration: 1 September 1954 - 1 December 1956
       Amount: $ 13,411.62
       Type of Contract: Cost

       Primary Scientific Liaison: Office of Ordnance Research
       Scientific Cognizance: Redstone Arsenal; Picatinny Arsenal

Scope: To perform basic research in the area of organic sulfur chem-
istry, investigating in particular: (a) Chemistry of beta-ketosulfon-
ic acids, (b) the synthesis of substituted beta-mercaptoethanols, their
condensation with carbonyl compounds to hemithioketals and the behav-
ior of such hemithioketals as well as their corresponding sulfoxides
and sulfones.

Progress (to 1 December 1956): The desulfurization of β-mercaptoetha-
nols with Raney nickel in acetone solution yielded mainly the alcohol.
Desulfurization of the corresponding hemithioketals (1,3-oxathiolanes)
under the same conditions involved introduction of oxygen from an out-
side source. Acid cleavage of spiro-(5-diphenylmethyl-1,3-oxathiolane-
2,3'-cholestane) (I) followed by lithium aluminum hydride reduction of
the resulting disulfide led to optically pure 1,1-diphenyl-3-mercapto-
propan-2-ol. Raney nickel desulfurization of this β-mercaptoethanol
or of its O,S-dibenzoate furnished 1,1-diphenyl-propan-2-ol, yielded
benzoates. The rotations of this alcohol and its derivatives were
identical to those of the earlier prepared desulfurization product of
the hemithioketal I. The results have indicated that no racemization
occurs in the formation of alcohols by Raney nickel desulfurization of
hemithioketals or of β-mercaptoethanols. The final report has been
received and the contract has been terminated.

Technical Reports:

1. Studies in Organic Sulfur Compounds. VIII. Introduction of
     Oxygen in the Raney Nickel Desulfurization of Hemithioketals, by
     Carl Djerassi and others, in Journal of the American Chemical
     Society, vol. 77 (1955), p. 4647-4651.

II   C H E M I S T R Y

I.   Organic Chemistry

1258 (continued)

2. Studies in Organic Sulfur Compounds. IX. Preparation and Desul-
     furization of Optically Active 1,1-Diphenyl-3-Mercaptopropan-2-ol,
     by Carl Djerassi and J. Grossman. (Manuscript submitted to the
     Journal of the American Chemical Society). (A part of #3).

3. Research in Organic Sulfur Compounds, by Carl Djerassi. Various
     paging, figures. (Wayne State University, Final Report: 1 Sep-
     tember 1954 - 30 November 1956, consisting of #1 and #2). ASTIA
     AD-117 617

II CHEMISTRY

I. Organic Chemistry

1464 PREPARATION AND PROPERTIES OF TRIALKYLFLUOROSILANES

        Contractor: Duquesne University
                 Pittsburgh 19, Pennsylvania

        Chief Investigators: H. H. Szmant
                       Kurt C. Schrieber

        Contract No. DA-36-061-ORD-489   Renewed: DA-36-061-ORD-544
        Duration: 15 June 55 - 14 June 56   15 June 1956 - 31 July 1957
        Amount: $ 4,900.00 $ 4,680.00
        Type of Contract: Fixed Price   Fixed Price

        Primary Scientific Liaison: Frankford Arsenal
        Scientific Cognizance: Rock Island Arsenal

Scope: Basic research will be performed in the area of substituted
fluorosilanes and will include but not be limited to: (1) Synthesis
of trialkylfluorosilanes in which the alkyl groups are identical,
(2) synthesis of trialkylfluorosilanes containing dissimilar alkyl
groups, (3) a study of the physical properties of the above described
compounds and mixtures, and (4) synthesis of branched alkylfluorosi-
lanes and a study of their susceptibility to atmospheric oxidation.

Progress (to 31 July 1957): A series of trialkylfluorosilanes has
been prepared. Analyses have been made and the physical constants
have been determined. Samples of tri-dodecylfluorosilane and
tri-(3,5,5-trimethylhexyl) fluorosilane have been submitted to Frank-
ford Arsenal for testing as lubricant constituents. A number of
unsymmetrical trialkylfluorosilanes have been synthesized, and samples
of amyl-di-dodecylfluorosilane and of 3,5,5-trimethylhexyl-di-
dodecylfluorosilane have also been sent to Frankford Arsenal for test-
ing purposes. The branched chain compounds, in general, have appeared
most promising; e.g., 3,5,5-trimethylhexylfluorosilane compared well
with petroleum for lubricity and showed a viscosity of 10,000 centi-
stokes at -40°. The final report has been received and the contract
has been terminated.

Technical Reports:

1. Trialkylfluorosilanes, by H. Harry Szmant and Gerald W. Miller.
    October 1955, 4 p., tables. (Duquesne University, Technical Re-
    port No. 1). ASTIA AD-79 534

2. Preparation and Properties of Trialkylfluorosilanes, by H. H.
    Szmant, Kurt C. Schrieber and others. August 1957, 11 p.,
    tables. (Duquesne University, Final Report).

II CHEMISTRY

K. Reaction Kinetics and Equilibria

403 TRANSPORT PROPERTIES IN LIQUID SYSTEMS

        Contractor: University of Southern California
                 3518 University Avenue
                 Los Angeles 7, California

        Chief Investigator: Arthur W. Adamson

        Contract No. DA-04-495-ORD-364
        Duration: 27 June 1952 - 1 November 1956
        Amount: $ 25,855.00
        Type of Contract: Cost

        Primary Scientific Liaison: Office of Ordnance Research

Scope: The investigation of certain transport properties in liquids
and liquid solutions will be continued, and will include (a) a theo-
retical and experimental investigation of the parameter dependence of
self-diffusion coefficients, (b) extension of measurements of ion
self-diffusion coefficients to salt solutions and to concentration
ranges not previously studied, (c) a study of self-diffusion of ions
of polyvalent metal salts as a means of obtaining information of the
physical state of these ions in solution, (d) a study of the mechanisms
of proton transfer in water, and (e) if time permits, a comparison will
be made of the self-diffusional mobility of small charged and uncharged
species in aqueous media.

Progress (to 15 January 1957): Studies have been made of the dif-
fusional behavior of ions and of neutral molecules in liquid systems
in order to (1) obtain fairly complete information about the diffusion-
al and other properties of selected systems so that existing theories
could be checked, (2) develop more structurally detailed diffusion
treatments, and (3) explain the serious discrepancies that existed be-
tween various laboratories as to the actual values of the self-
diffusion coefficients of ions in electrolyte solutions, and to de-
termine why different experimental methods seemed to yield different
results. The sources of the experimental difficulties have been found
to lie partly in the method of calibrating the diaphragm cells and
partly in the stirring procedure used in the open-end capillary method.
These findings have been published. In addition, a complete set of
physical data has been obtained for the sucrose-water system and for
water itself. This work has involved measuring or supplementing ex-
isting data on the binary and the two self-diffusion coefficients over
the entire concentration range of sucrose concentrations in the first
system, and of H_2O-D_2O composition in the second system, as well as
filling in viscosity, density, and activity coefficient data. In addi-
tion a partially successful effort was made to obtain a measure of
the nature of coupling between the components of a binary system,
through the use of inert markers. The results which were obtained in
the above studies were used to test the various theories of binary

II CHEMISTRY

K. Reaction Kinetics and Equilibria

403 (continued)

diffusion and it was concluded that they were not at all adequate. However, some progress has been made towards developing a theory which will have more general utility. This phase of the investigation is discussed in report #5 listed below. The final report has been received and the contract has been terminated.

Technical Reports:

1. Diffusion and Self-Diffusion of Electrolytes and Hydration Effects, by Arthur W. Adamson. June 1953, 28 p., figures. (Department of Chemistry, University of Southern California; also published in the Journal of Physical Chemistry, vol. 58 (July 1954), p. 514-523). ASTIA AD-52 920 ASTIA AD-13 441 (mc)

2. A Proposed Approach to the "Chelate Effect", by Arthur W. Adamson, 4 p., tables. (University of Southern California, Department of Chemistry). ASTIA AD-24 370 (mc)

3. The Measurement of Self-Diffusion in Liquid Media, by Arthur W. Adamson and R. G. Mills. February 1954, 15 p., figures, tables. (University of Southern California, Department of Chemistry). ASTIA AD-42 259

4. A Modified Equation of State for Monolayers of Linear Macromolecules, by H. L. Frisch.

5. Transport Processes in Liquid Systems, by Arthur W. Adamson. 31 p., figures, tables. (University of Southern California, Department of Chemistry, Final Report: 27 June 1952 - 15 January 1957).

III MATHEMATICS

A. Algebra and Number Theory

1194 INVESTIGATIONS OF LINEAR ALGEBRAS AND OPERATOR ALGEBRAS

Contractor: University of Chicago
5801 Ellis Avenue
Chicago 37, Illinois

Chief Investigators: A. A. Albert
Irving Kaplansky

Contract No. DA-11-022-ORD-1571
Duration: 1 October 1954 - 31 March 1957
Amount: $ 28,040.20
Type of Contract: Cost

Primary Scientific Liaison: Office of Ordnance Research

Scope: A. A. Albert has studied a number of cases of power-associative algebras and has obtained a quite complete theory for the commutative case. There are a number of open questions still to be studied in the commutative case, and the non-commutative cases are still in a chaotic state. A recent contribution along this line is Albert's work on right alternative algebras. The algebras called Lie algebras are also power-associative algebras which are non-commutative. The theory of Lie algebras is connected with the theory of continuous groups and the new theory of Lie algebras of characteristic p is of great importance in the study of finite groups. Both Albert and Kaplansky will investigate the latter theory. The structure theory of linear algebras forms a model for the structure theory of operator algebras on Banach and Hilbert space. Kaplansky will continue his studies of such algebras.

Progress (to 31 March 1957): Studies completed by A. A. Albert include (1) new classes of simple Lie algebras of characteristic p in which the results represent a major break-through for the theory of Lie algebras of characteristic p , (2) the consideration of a property of associative involutorial algebras which has provided a new and very simple proof of some properties used in the theory of abelian varieties, (3) a study of ordered rings satisfying a polynomial identity, (4) a study of the structure of partially stable simple commutative power-associative algebras, (5) a study of certain trinomial equations in finite fields, and (6) a proof that the conjecture of Nathan Jacobson that every Jordan algebra is the homorphic image of a special Jordan algebra A is false when A is finite dimensional. I. Kaplansky obtained a proof that any orthocomplemented complete modular lattice is a continuous geometry. He also wrote a short book which contains many new results, especially on algebraic groups. He made a study of the multiplicative group of a C* algebra in which it has been shown that certain groups proved by Kadison to be topologically simple are simple. He also developed a new algebraic approach to the theory of rings of operators. R. Block completed a study of new classes of simple Lie algebras of characteristic p in which he showed that certain algebras

III MATHEMATICS

A. Algebra and Number Theory

1194 (continued)

considered by A. A. Albert and M. S. Frank were restricted while
others were not. G. Weiss obtained a theorem on interpolation of sub-
linear operators in H_p spaces. E. C. Posner completed a study concern-
ing the connection between commutative differential rings and simple
rings. D. Hertzig made a study of the cohomology of a group with co-
efficients in an algebra. He filled a gap in the structure theory of
Lie algebra caused by the existence of Cartan's spin automorphism, and
extended to degree two Kolchin's classification of strongly normal
fields. G. Kolettis studied and extended the theory of primary abelian
groups beyond its previous limits. The final report has been received
and the project has been terminated.

Technical Reports:

1. On Involutorial Algebras, by A. A. Albert, in Proceedings of the
    National Academy of Sciences, vol. 41, no. 7 (July 1955), p. 480-
    482. ASTIA AD-99 217

2. Simple Lie Algebras of Characteristic p , by A. A. Albert and
    M. S. Frank, in Rendiconti del Seminario Matematico dell' Univer-
    sita e Politecnico di Torino, vol. 14 (1954-1955). ASTIA AD-112
    600

3. A Property of Ordered Rings, by A. A. Albert, in Proceedings of
    the American Mathematical Society, vol. 8, no. 1 (February 1957),
    p. 128-129.

4. On Partially Stable Algebras, by A. A. Albert, in Transactions of
    the American Mathematical Society, vol. 84, no. 2 (March 1957),
    p. 430-443.

5. On Matrices of Trace Zero, by A. A. Albert and B. Muckenhaupt, in
    Michigan Mathematical Journal, vol. 4 (1957). ASTIA AD-123 676

6. A Property of Special Jordan Algebras, by A. A. Albert, in Proceed-
    ings of the National Academy of Sciences, vol. 42, no. 9 (Septem-
    ber 1956), p. 624-625.

7. On Certain Trinomial Equations in Finite Fields, by A. A. Albert,
    in Annals of Mathematics, vol. 66, no. 1 (July 1957), p. 170-178.

8. Investigations of Linear Algebras and Operator Algebras, by A. A.
    Albert. 11 p. (University of Chicago, Department of Mathematics,
    Final Report: 1 October 1954 - 30 September 1956). ASTIA AD-106
    973

III MATHEMATICS

A. Algebra and Number Theory

1194 (continued)

9. Any Orthocomplemented Complete Modular Lattice is a Continuous
    Geometry, by Irving Kaplansky. 17 p. (University of Chicago,
    Department of Mathematics; also published in Annals of Mathemat-
    ics, vol. 61, no. 3 (May 1955), p. 524-541. ASTIA AD-111 692

10. An Interpolation Theorem for Sublinear Operators on H_p Spaces, by
     Guido Weiss, in Proceedings of the American Mathematical Society,
     vol. 8, no. 1 (February 1957), p. 92-99.

11. Derivations in Prime Rings, by Edward C. Posner. Not dated, 13 p.
     (University of Chicago, Department of Mathematics).

III M A T H E M A T I C S

B. Analysis

888 EXPANSION OF ANALYTIC FUNCTIONS BY A SERIES OF POWERS OF A POLYNOMIAL

Contractor: Illinois Institute of Technology
3300 South Federal Street
Chicago 16, Illinois

Chief Investigator: Gordon Pall

Contract No. DA-11-022-ORD-1494
Duration: 2 October 1953 - 19 April 1957
Amount: $ 40,523.65
Type of Contract: Cost

Primary Scientific Liaison: Office of Ordnance Research

Scope: In research on the expansion of analytic functions in series of powers of polynomials, one or more of the following areas will be included: (1) Properties of these expansions analogous to those of ordinary power series, (2) conformal mapping, (3) function theoretic problems such as Tauberian problems, and (4) applications to eigenvalue problems in the theory of differential equations.

Progress (to 19 April 1957): Investigations have been conducted which show that the Jacobi expansion of a function f in powers of a polynomial h of degree n (the coefficients polynomials of lower degree) can be characterized in terms of a kind of generalized derivative, with the Taylor series and the ordinary derivative as a special case. This has led to new expansions and applications. The concepts of bi-derivative and bi-integral have been clarified, giving direct definitions of these at point pairs relative to j^2 and other functions. Geometrical illustrations have been given and the bi-derivatives of certain functions have been computed. An explicit formula for $D_h f$ has been derived. A thesis concerned with the application of Jacobi series to the computation of eigenvalues in Sturm-Liouville systems has been written. The partial sums of a Jacobi series were used as trial functions in the collocation and least squares methods. The method seems to give rapid convergence, but the proof of convergence was carried through only in special cases. One advantage of this method is that it leads to the study of a determinant of a fixed order rather than one of increasing order as in the classical treatments. It has been proved that the zeros of certain determinants whose limits are the desired real eigenvalues are never real themselves except in a specific case, and actually occur in conjugate complex pairs. The calculus of operators of J. Mikusinski has been extended to bi-derivatives. Work has also been concerned with matrix operators and matrix functions, and necessary and sufficient conditions for a matrix operator to reduce to a classical matrix function have been found. A solution of Van der Pol's equation has been obtained which has proved valid not only for small values of the parameter, but quite generally. The final report has been received and the contract has been terminated.

III M A T H E M A T I C S

B. Analysis

888 (continued)

Technical Reports:

1. A Simple Definition of Analytic Functions and General Multifunctions, by Karl Menger, in the Proceedings of the National Academy of Sciences, vol. 40, no. 9 (September 1954), p. 819-821.

2. The Behavior of a Complex Function at Infinity, by Karl Menger, in Proceedings of the National Academy of Sciences, vol. 41, no. 7 (July 1955), p. 512-513.

3. Generalized Derivatives and Expansions, by Karl Menger and S. S. Shii, in Proceedings of the National Academy of Sciences, vol. 41, no. 8 (August 1955), p. 591-595.

4. Expansion of Analytic Functions by Series of Powers of a Polynomial, by Gordon Pall. 21 October 1955, 4 p. (Illinois Institute of Technology, Department of Mathematics, Second Annual Report).

5. A Symmetric Generalization of the Lagrange Interpolation Formula, by Berthold Schweizer, in Journal of Mathematics and Physics, vol. 34, no. 3 (October 1955), p. 157-159.

6. Jacobi Series and the Numerical Solution of Eigenvalue Problems, by Berthold Schweizer. June 1956, 55 p. (Illinois Institute of Technology, Ph.D. thesis).

7. Expansion of Analytic Functions by Series of Powers of a Polynomial, by Gordon Pall. 7 p. (Illinois Institute of Technology, Final Report: October 1953 - May 1957).

8. Multiderivatives and Multiintegrals, by Karl Menger. (Manuscript submitted to the Slaught Memorials of the Mathematical Association of America).

9. Generalized Jacobi Expansions and Corresponding Derivatives, by Gordon Pall. (Manuscript submitted to the Slaught Memorials of the Mathematical Association of America).

10. On Approximate Eigenvalues Obtained by the Method of Least Squares, by Berthold Schweizer. (Manuscript submitted to the Massachusetts Institute of Technology Journal of Mathematics and Physics).

III MATHEMATICS

B. Analysis

1045 EXISTENCE AND NATURE OF SOLUTIONS IN THE CALCULUS OF VARIATIONS WITH SPECIAL REFERENCE TO PARAMETRIC DOUBLE INTEGRAL PROBLEMS

      Contractor: University of Wisconsin
                (The Regents of the University)
                Madison 6, Wisconsin

      Chief Investigator: L. C. Young

      Contract No. DA-11-022-ORD-1511
      Duration: 12 November 1953 - 30 June 1957
      Amount: $ 26,949.00
      Type of Contract: Cost

      Primary Scientific Liaison: Office of Ordnance Research
      Scientific Cognizance: Redstone Arsenal

Scope: The primary objective of the work will be to continue to obtain results on the existence and of solutions in the calculus of variations, especially for parametric double integral problems. By means of the method of generalized surfaces employed in the present research project, a very complete existence theory and certain basic information on the nature of solutions is being obtained for those parametric double integral problems which concern surfaces of preassigned topological type. The work depends partly on new inequalities connecting the area of a surface S with the product of the lengths of two suitable cycles on S. It is desirable to obtain more complete information on the nature of solutions and to make a corresponding study for problems in which the topological type is not prescribed.

Progress (to 30 June 1957): The results obtained in this investigation were based on the following methods: (a) Elementary methods which were concerned with inequalities between area and a product of two lengths. In this connection it was found that the area of a polyhedron is not less than half the product of a pair of lengths, a result connected with a minimal property of the hemisphere. It was also found that closed polyhedra whose areas are bounded and whose "pinching constants" have a positive lower bound are equivalent (by slitting) to discs whose perimeters have bounded lengths. (b) Banach methods, i.e., methods based on the techniques of general linear spaces and in particular of Banach spaces. In this connection it was found that even the problem of least area, with a single rectifiable rim, requires for its solution surfaces of infinitely many handles. An algorithm was provided which turns out to be necessary and sufficient for an absolute minimum irrespective of topological type. A solution of a variational problem was made up from pieces which possess Lipschitzian tracks and satisfy roughly the classical differential equations. More complete results are set forth in the technical reports listed below. The final report has been received and the project has been terminated.

III MATHEMATICS

B. Analysis

1045 (continued)

  Technical Reports:

1. An Example in the Problem of Least Area, by Wendell H. Fleming. (Manuscript submitted to the Proceedings of the American Mathematical Society).

2. A Variational Algorithm, by L. C. Young, in the Rivista di Mathematica del Universita di Parma, vol. 5 (1954), p. 255-268. ASTIA AD-84 733.

3. Some New Methods in Two-Dimensional Variational Problems with Special Reference to Minimal Surfaces, by L. C. Young. December 1955, 12 p. (University of Wisconsin, Department of Mathematics, Technical Report No. 1). ASTIA AD-80 914 (mc)

4. Representations of Generalized Surfaces as Mixtures, by W. H. Fleming and L. C. Young. (Manuscript submitted to Rendiconti del Circulo Matematico di Palermo).

5. Fields of Vectors Attached To A Plane Measure, by Lawrence C. Young. October 1956, 19 p. (University of Wisconsin, Technical Report No. 2; also submitted to the Journal de Mathematiques). ASTIA AD-109 984

6. Estimates for the Lengths of Certain Closed Geodesics on a Polyhedron, by L. Young. November 1956, 9 p. (University of Wisconsin, Department of Mathematics, Technical Report No. 3). ASTIA AD-116 915

7. Minimal Perimeter of a Disc Equivalent To A Closed Polyhedron, by L. Young. November 1956, 8 p. (University of Wisconsin, Department of Mathematics, Technical Report No. 4). ASTIA AD-116 917

8. A Proposition of Rigid Statics Related to Area and to the Calculus of Variations, by L. Young. December 1956, 17 p. (University of Wisconsin, Department of Mathematics, Technical Report No. 5). ASTIA AD-116 919

9. Generalized Surfaces with Prescribed Elementary Boundary, by W. H. Fleming and L. C. Young, in Rendiconti del Circolo Matematico di Palermo, serie 2 (1956), tomo 5, p. 1-211

10. Existence and Nature of Solutions in the Calculus of Variations with Special Reference to Parametric Double Integral Problems, by L. Young. 5 p. (University of Wisconsin, Department of Mathematics, Final Report).

III MATHEMATICS

B. Analysis

1239 RESEARCH IN ANALYSIS AND GEOMETRY

Contractor: The Institute for Advanced Study
Olden Lane
Princeton, New Jersey

Chief Investigators: Deane Montgomery
Atle Selberg

Contract No. DA-36-034-ORD-1622
Duration: 1 September 1954 - 31 August 1957
Amount: $ 68,125.00
Type of Contract: Cost

Primary Scientific Liaison: Office of Ordnance Research

Scope: Research in analysis and geometry will be continued and attempts will be made to (a) give transcendental proofs of arithmetic theorems by means of recursive propositions, (b) study generalizations of classical LP spaces, (c) investigate the nature of the set of limits of Riemann sums of vector value functions, (d) investigate periodic transformations on an infinite dimensional space, and (e) investigate the problem of imbedding an n-complex in Euclidean space.

Progress (to 31 August 1957): Principal results obtained under this contract are reflected in the technical reports listed below. A study was made of groups of transformations with special emphasis on finite groups and toral groups. Definite results were obtained by using spectral sequences in the study of transformation groups. Considerable information was obtained on the set of fixed points for a toral group on a manifold and about the base space. These results indicate that so far as cohomology is concerned the fixed points and the base space resemble these sets in the case where the group acts linearly. The investigation on Banach spaces was completed, and a paper describing the study has been written. The final point has been received and the contract has been terminated.

Technical Reports:

1. A Universal Covering Semigroup for Groups with Abelian Commutator Subgroups, by Eugene Schenkman. March 1955, 24 p. (Institute for Advanced Study). ASTIA AD-56 469

2. On Abelian Varieties over Function Fields, by Wei-Liang Chow. (Manuscript submitted to Proceedings of the National Academy of Sciences). ASTIA AD-61 981

3. Uniformly Bounded Representations of Groups, by L. Ehrenpreis and F. I. Mautner, in Proceedings of the National Academy of Sciences, vol. 41 (1955), p. 231-233.

III MATHEMATICS

B. Analysis

1239 (continued)

4. Some Properties of the Fourier Transform on Semi-Simple Lie Groups, Part II, by L. Ehrenpreis and F. I. Mautner. Not dated, various paging. (Institute for Advanced Study). ASTIA AD-66 587

5. On the Engle Condition of Order 2 for Groups, by Eugene Schenkman. August 1955, 3 p. (Institute for Advanced Study). ASTIA AD-68 525

6. The Principal Ideal Theorem for Some Infinitely Generated Groups, by Eugene Schenkman. August 1955, 5 p. (Institute for Advanced Study). ASTIA AD-68 524 (mc)

7. Algebraic Varieties with Rational Dissections, by Wei-Liang Chow. July 1955, 8 p. (Institute for Advanced Study). ASTIA AD-68 526 (mc)

8. Approaches to the Theory of Distributions, by J. C. Burkill. January 1956, 16 p. (Institute for Advanced Study). ASTIA AD-88 538 (mc)

9. Geodesic Flows on Symmetric Riemann Space, by F. I. Mautner. December 1955, 29 p. (Institute for Advanced Study; also submitted to Annals of Mathematics). ASTIA AD-88 533 (mc)

10. Some Properties of the Fourier Transform Semi-Simple Lie Groups III, by L. Ehrenpreis and F. I. Mautner. April 1956, various paging. (Institute for Advanced Study). ASTIA AD-93 037

11. On the Action of a Finite Group on S^n x S^n, by P. E. Conner. November 1956, 3 p. (Institute for Advanced Study). ASTIA AD-115 455

12. A Note on Banach Function Spaces, by H. W. Ellis, December 1956, 10 p. (Institute for Advanced Study). ASTIA AD-118 603

13. Eine Unableitbarkeitsbeweismethode Für Den Intuitionistischen Aussagenkalkul, by G. Kreisel and H. Putnam. January 1957, 7 p. (Institute for Advanced Study).

14. Mathematical Significance of Consistency Proofs, by G. Kreisel. March 1957, 37 p. (Institute for Advanced Study).

15. Orbit Spaces of Circle Groups of Transformations, by P. E. Conner and E. E. Floyd. March 1957, 12 p. (Institute for Advanced Study).

16. Theorie Des Fonctions - Fonctionnelles Recursivement Definissables et Fonctionelles Recursives, by Georg Kreisel, Daniel Lacombe and Joseph R. Shoenfield. August 1957, 4 p. (Institute for Advanced Study).

III M A T H E M A T I C S

   B. Analysis

1239 (continued)

    17. Concerning the Action of a Torus on the Euclidean Space, by P.
        E. Conner, Jr. August 1957, 5 p. (Institute for Advanced
        Study).

    18. Research in Analysis and Geometry, by Pierre E. Conner, Jr.,
        H. W. Ellis and others. 3 p. (Institute for Advanced Study,
        Final Report: 1 September 1956 - 31 May 1957).

III M A T H E M A T I C S

   D. Geometry and Topology

1014 THE THEORY OF CONVEX SETS

      Contractor: University of Washington
                   Seattle 5, Washington

      Chief Investigator: V. L. Klee

      Contract No. DA-04-200-ORD-292
      Duration: 2 October 1953 - 1 October 1957
      Amount: $ 37,062.67
      Type of Contract: Cost

      Primary Scientific Liaison: Ballistic Research Laboratories

Scope: This investigation will deal with (a) basic questions relating
to convex sets in infinite-dimensional linear spaces, and (b) inter-
section properties of convex sets in Euclidean space. Typical ques-
tions to be considered in (a) are represented by the following: (1)
Is the Tychonoff theorem valid that a compact convex subset of a local-
ly convex linear topological space has the fixed point property, with-
out the hypothesis of local convexity? (2) Must a closed convex of a
Banach space be supported by a hyperplane at one of its points? With
reference to (b), an attempt will be made to initiate a careful and
complete investigation with a view toward obtaining unifying results
and toward answering the following question of Barsuk: Can every
bounded subset of Euclidean n-space be covered by (n + 1) sets of
smaller diameter?

Progress (to 1 October 1957): Complete results obtained under this
project are set forth in the technical reports listed below. The
final report has been received and the contract has been terminated.

Technical Reports:

1. Common Secants for Plane Convex Sets, by V. L. Klee, Jr., in Pro-
    ceedings of the American Mathematical Society, vol. 5, no. 4
    (August 1954), p. 639-641.

2. A Characterization of Reflexivity by the Lattice of Closed Sub-
    Spaces, by E. E. Floyd and V. L. Klee. January 1954, 13 p. (Uni-
    versity of Washington, Technical Report No. 1; also published in
    Proceedings of the American Mathematical Society, vol. 5, no. 4
    (August 1954), p. 655-661). ASTIA AD-25 304 (mc)

3. A Characterization of Extreme Points, by V. L. Klee, Jr. January
    1954, 4 p. (University of Washington, Technical Report No. 2).
    ASTIA AD-25 305 (mc)

III MATHEMATICS

D. Geometry and Topology

1014 (continued)

4. Boundedness and Continuity of Linear Functionals, by V. L. Klee. Not dated, various paging. (University of Washington, Technical Report No. 3; also published in Duke Mathematical Journal, vol. 22 (1955), p. 263-270). ASTIA AD-26 238 (mc)

5. Separation Properties of Convex Cones, by V. L. Klee, Jr. 30 June 1954, 9 p. (University of Washington, Technical Report No. 4; also published in Proceedings of the American Mathematical Society, vol. 6, no. 2 (April 1955), p. 313-318). ASTIA AD-34 592

6. On Metric Independence and Linear Independence, by V. L. Klee and L. M. Blumenthal, in Proceedings of the American Mathematical Society, vol. 6, no. 5 (October 1955), p. 732-734. (A part of #8).

7. Solution of a Problem of E. M. Wright on Convex Functions, by V. L. Klee, Jr., in American Mathematical Monthly, vol. 63, no. 2 (February 1956), p. 106-107. (A part of #8).

8. Convex Sets, by V. L. Klee, Jr. 1 December 1954, various paging. (University of Washington, Technical Report No. 5, containing #6 and #7). ASTIA AD-52 561

9. Remarks on a Previous Paper (Convex Bodies and Periodic Homeomorphisms in Hilbert Space, by V. L. Klee, Jr., in Transactions of the American Mathematical Society, vol. 74, 1953, p. 10-43). (Manuscript submitted to Transactions of the American Mathematical Society). (A part of #11).

10. Strict Separation of Convex Sets, by V. L. Klee, Jr., in Proceedings of the American Mathematical Society, vol. 7, no. 4 (August 1956), p. 735-737. (A part of #11).

11. Convex Sets, by V. L. Klee, Jr. 15 January 1955, various paging. (University of Washington, Technical Report No. 6, containing #9 and #10). ASTIA AD-53 013 (mc)

12. Some Intersection Properties of Infinite Families of Convex Sets, by V. L. Klee, Jr. Not dated, 9 p. (University of Washington, Technical Report No. 7: 16 January 1955 - 15 July 1955; also submitted to Mathematica Scandinavica). ASTIA AD-71 473 (mc)

13. A Note on Extreme Points, by V. L. Klee, Jr., in American Mathematical Monthly, vol. 62, no. 1 (January 1955), p. 30-32.

14. Some Topological Properties of Convex Sets, by V. L. Klee, Jr., in Transactions of the American Mathematical Society, vol. 78, no. 1 (January 1955), p. 30-45.

III MATHEMATICS

D. Geometry and Topology

1014 (continued)

15. Fixed-Point Sets of Periodic Homeomorphisms of Hilbert Space, by V. L. Klee, Jr. (Manuscript submitted to Annals of Mathematics). (A part of #19).

16. Iteration of the "Lin" Operation for Convex Sets, by V. L. Klee, Jr. (Manuscript submitted to Mathematica Scandinavica). (A part of #19).

17. Homogeneity of Infinite-Dimensional Parallelotopes, by V. L. Klee, Jr. (Manuscript submitted to the Annals of Mathematics). (A part of #19).

18. An Example in the Theory of Topological Linear Spaces, by V. L. Klee, Jr. (Manuscript submitted to the Archivader Mathematik). (A part of #19).

19. The Theory of Convex Sets, by V. L. Klee, Jr. Various paging. (University of Washington, Technical Report No. 8: 16 July 1955 - 15 July 1956 consisting of #15 through #18). ASTIA AD-99 981

20. A Note on Topological Properties of Normed Linear Spaces, by V. L. Klee, Jr., in the Proceedings of the American Mathematical Society, vol. 7, no. 4 (August 1956), p. 673-674.

21. Convex Sets and Nearest Points, by R. R. Phelps. 21 p. (University of Washington, Technical Report No. 9: 16 July 1956 - 31 October 1956; also submitted to the Proceedings of the American Mathematical Society). ASTIA AD-112 464

22. The Structure of Semispaces, by V. L. Klee, Jr. (Manuscript submitted to Scandinavica Mathematica).

23. Extremal Structure of Convex Sets. I, by V. L. Klee, Jr. (Manuscript submitted to Archiv der Mathematik). (A part of #29).

24. Convex Sets and Nearest Points. II, by R. R. Phelps. (Manuscript submitted to the Proceedings of the American Mathematical Society). (A part of #29).

25. Extremal Structure of Convex Sets. II, by V. L. Klee, Jr. (Manuscript submitted to Mathematische Zeitschrift). (A part of #29).

26. Semi-Convexity and Locally Bounded Spaces, by Robert Trull Ives. (Manuscript submitted to the Duke Mathematical Journal).

III MATHEMATICS

D. Geometry and Topology

1014 (continued)

27. On a Method of Mapping Due to Kadec and Bernstein, by V. L. Klee,
     Jr. and R. G. Long. (Manuscript submitted to Archiv der Mathe-
     matik). (A part of #29).

28. Some Characterizations of Convex Polyhedra, by V. L. Klee, Jr.
     (Manuscript submitted to Acta Mathematica). (A part of #29).

29. Convex Sets, by V. L. Klee, Jr., R. R. Phelps and R. G. Long.
     Various paging. (University of Washington, Technical Report No.
     9: 1 November 1956 - 15 August 1957, containing #23, #24, #25,
     #27, and #28).

30. Convex Sets, by V. L. Klee, Jr. 4 p. (University of Washington,
     Final Report: 1 October 1953 - 30 September 1957).

III MATHEMATICS

D. Geometry and Topology

1503 DIFFERENTIAL GEOMETRIC STRUCTURES AND THEIR RELATED SYSTEMS OF
     DIFFERENTIAL EQUATIONS

          Contractor: University of California
                       (The Regents of the University)
                       Berkeley 4, California

          Chief Investigator: Harley Flanders

          Contract No. DA-04-200-ORD-456
          Duration: 1 September 1955 - 16 September 1957
          Amount: $ 19,375.95
          Type of Contract: Cost

          Primary Scientific Liaison: Office of Ordnance Research
          Scientific Cognizance: Ballistic Research Laboratories

     Scope: A program of research will be conducted on differential geo-
     metric structure and differential equations, and will include one or
     more of the following areas: (1) Geometric entities and operators
     of affine connection theory, (2) the topological nature of the in-
     variant of the curvature operator on an affinely connected manifold,
     (3) a geometric interpretation of a parallel curvature tensor,
     (4) application of operator algebras to Hermitian manifolds, Lie
     groups, and harmonic integrals, and (5) invariant integrals and com-
     pletely integrable systems of exterior differential forms.

     Progress (to 16 September 1957): A weekly seminar on advanced dif-
     ferential geometry was conducted during the period September 1955 -
     June 1956. The material presented at this seminar has been incor-
     parated into a technical report. Considerable progress was made in
     the study of differential geometry on complex varieties. A study of
     the theory of prolongations has been completed. The theory of complex
     structures and Kähler manifolds and their applications to differential
     manifolds was studied. The techniques of modern differential geometry
     were applied to the classical theory of contact and canonical trans-
     formations and some interesting results were obtained. The final report
     has been received and the contract has been terminated.

III M A T H E M A T I C S

   D. Geometry and Topology

1503 (continued)

   Technical Reports:

   1. Seminar on Exterior Differential Forms, by Harley Flanders. June
       1957, 58 p. (University of California, Technical Report No. 1).

   2. Systems of Differential Forms, Including Kuranishi's Theory of
       Total Prolongations, by Harold H. Johnson. Not Dated, 80 p.
       (University of California, Technical Report No. 2).

   3. Prolongations of Differential Systems, by Harold H. Johnson.
       July 1957, 38 p. (University of California, Technical Report
       No. 3).

   4. Differential Geometry, by Harley Flanders. Various paging.
       (University of California, Department of Mathematics, Final Report.
       1 September 1955 - 16 September 1957).

III M A T H E M A T I C S

   E. Mechanics

1823 SUMMER SEMINAR IN APPLIED MATHEMATICS

          Contractor: American Mathematical Society
                       University of Colorado
                       Boulder, Colorado

          Chief Investigator: J. H. Curtiss

          Contract No. DA-19-020-ORD-4373
          Duration: 28 January 1957 - 27 January 1958
          Amount: $ 9,775.00
          Type of Contract: Fixed Price

          Primary Scientific Liaison: Office of Ordnance Research

   Scope: The contractor, under the direction of Dr. J. H. Curtiss, will
   plan, make arrangements for, administer, and conduct a seminar in
   applied mathematics to be held at the University of Colorado from the
   period on or about 24 June 1957 to on or about 20 July 1957. The
   symposium will be jointly sponsored by the Office of Ordnance Research,
   the Office of Naval Research, the Office of Scientific Research (ARDC),
   the National Science Foundation, and the Atomic Energy Commission.
   The seminar will consist of lectures to be made by lecturers selected
   by the contractor, informal seminars, and discussion groups, and will
   include 2 main lecturers and approximately 8 supplementary lecturers.

   Progress: The Summer Seminar in Applied Mathematics was held from 23
   June 1957 to 19 July 1957 at Boulder, Colorado. Among the subjects
   treated were solid mechanics, fluid dynamics, probability theory, mag-
   neto gas dynamics, and partial differential equations. Manuscripts of
   the presentations have been received and the contract has been
   terminated.

III MATHEMATICS

F. Numerical and Graphical Methods

1089 RESEARCH IN THE FIELD OF PROBABILITY, STATISTICS, AND NUMERICAL
ANALYSIS

Contractor: New York University
Washington Square
New York 53, New York

Chief Investigator: John H. Curtiss

Contract No. DA-30-069-ORD-1257
Duration: 1 September 1953 - 31 March 1957
Amount: $18,219.30
Type of Contract: Cost

Primary Scientific Liaison: Office of Ordnance Research

Scope: The primary objective will be to evaluate the so-called "Monte
Carlo" method with reference to the estimation of the eigenvalues of
linear partial differential equations and several independent varia-
bles. The particular goal will be an evaluation of the usefulness of
this method for the Schrodinger equation in the case of reasonably
complicated potentials. The eigenvalue problem will be approached
via discrete Markov processes and matrix methods. Various methods for
cutting down sample size will be tried, the central ones being the
techniques of "importance sampling" and "sampling with probabilities
proportional to size", the main idea being to utilize a priori knowledge
of the solution of the problem as fully as possible. It is hoped that
useful answers relative to the computation of matrix eigenvalues and
eigenvalues of elliptic partial differential equations will be ob-
tained, whether a final evaluation of the applicability to the
Schrodinger case can be made or not. Beyond the eigenvalue problem
the investigator will consider the whole question of interrelation
between partial differential equations and stochastic processes from
a theoretical point of view, as well as from the point of view of
numerical analysis.

Progress (to 31 March 1957): Work under this contract proceeded a-
long two main lines: (a) Numerical analysis, with particular re-
ference to linear computations, and (b) statistical inference. Re-
sults obtained under (a) are contained in technical reports #1, #2, #4
and #6. The work under (b) consisted in organizing facts already
known and existing in scattered forms in the literature. The results
of this study may be found in technical reports #2, #3 and #5. The
terminal report has been received and the contract has been terminated.

III MATHEMATICS

F. Numerical and Graphical Methods

1089 (continued)

Technical Reports:

1. Methods for Matrix Inversion and for the Solution of Simultaneous
Linear Algebraic Equations, by J. H. Curtiss. March 1954, 22 p.
(New York University, Institute of Mathematical Sciences, Techni-
cal Report No. 1). ASTIA AD-32 481 (mc)

2. A Theoretical Comparison of the Efficiencies of Two Classical
Methods, and a Monte Carlo Method for Computing One Component
of the Solution of a Set of Linear Algebraic Equations, by J. H.
Curtiss. May 1954, 56 p., tables. (New York University, Insti-
tute of Mathematical Sciences, Technical Report No. 3) ASTIA
AD-40 173 (mc)

3. Lectures on the Theory of Industrial Sampling, by J. H. Curtiss.
April 1955, 134 p. (New York University, Institute of Mathemati-
cal Sciences, Technical Report No. 4). ASTIA AD-60 618 (mc)

4. A Generalization of the Method of Conjugate Gradients for Solving
Systems of Linear Algebraic Equations, by J. H. Curtiss, in
Mathematical Tables and Other Aids to Computation, vol. 8, no. 48
(October 1954), p. 189-193.

5. Lectures on the Theory of Industrial Sampling: Preface and
Summary of the Text, by J. H. Curtiss. March 1954, 18 p. (New
York University, Institute of Mathematical Sciences, Technical
Report No. 2).

6. Matrix Inversion and the Solution of Linear Equations, by J. H.
Curtiss. August 1955, 85 p. (New York University, Technical
Report No. 5). ASTIA AD-115 793

7. Research in the Field of Probability, Statistics, and Numerical
Analysis, by J. H. Curtiss. April 1957, 3 p. (New York Univer-
sity, Terminal Report).

III M A T H E M A T I C S

F. Numerical and Graphical Methods

1445 LOGICAL DESIGN COMPUTING MACHINERY

Contractor: Stanford University
(Board of Trustees of the Leland Stanford
Junior University, Palo Alto)
Stanford, California

Chief Investigator: Robert McNaughton

Contract No. DA-04-200-ORD-436
Duration: 1 July 1955 - 31 October 1957
Amount: $ 12,896.66
Type of Contract: Cost

Primary Scientific Liaison: Ballistic Research Laboratories
Scientific Cognizance: White Sands Proving Ground; Ordnance
Tank and Automotive Command

Scope: The objectives are in general to apply the methods of symbolic
logic to the task of constructing the most economical computing ma-
chine. In particular the research will be concerned with one or more
of the following problems: (1) Minimality of complete decoding nets
when the net is composed of arbitrary truth functions, (2) the deter-
mination of a mathematical function which reflects the true cost of
the complete decoding net, and (3) a coherent theory in which a wide
variety of problems concerning minimality of switching circuits could
be formulated and solved.

Progress (to 31 October 1957): The problem of complete decoding nets
with elements realizing arbitrary truth functions was studied. A
study was made of the "Don't Care" problem and the results obtained
are included in the report on rectifier nets with multiple outputs.
The concept of "prime implicant" was extended to the synthesis of
multiple output "don't care" diode nets. An attempt was made to prove
the minimality of the balanced multiplicative switch nets in the class
of all well-formed nets made up of elements realizing arbitrary truth
functions, but the results obtained have not been substantiated. The
problem of unate truth functions was studied. The final report has
been received and the contract has been terminated.

III M A T H E M A T I C S

F. Numerical and Graphical Methods

1445 (continued)

Technical Reports:

1. On the Measure of Normal Formulas, by Robert McNaughton. 28 De-
cember 1955, 31 p. (Stanford University, Applied Mathematics and
Statistics Laboratory, Technical Report No. 1; also submitted to
the Pacific Journal of Mathematics). ASTIA AD-79 833 (mc)

2. The Minimality of Rectifier Nets with Multiple Outputs Incompletely
Specified, by Robert McNaughton and Bernon Mitchell. 18 April
1957, 40 p., tables. (Stanford University, Technical Report No.
2).

3. A Proof That Addition is Not Arithmetically Definable in Terms of
a Single Unary Operator, by Robert McNaughton. 1 May 1957, 14 p.
(Stanford University, Technical Report No. 3). ASTIA AD-130 287

4. Logical Design of Computing Machinery, by Robert McNaughton. 2 p.
(Stanford University, Final Report: 1 July 1957 - 30 October
1957).

5. Unate Truth Functions, by Robert McNaughton. 21 October 1957, 18
p. (Stanford University, Technical Report No. 4).

III MATHEMATICS

G. Probability and Statistics

1550 A STUDY OF METHODS FOR DEVELOPING MISSILE RELIABILITY THROUGH ANALYSIS
OF FAILED COMPONENT PARTS

Contractor: United Geophysical Corporation
Pasadena, California

Chief Investigator: Leslie W. Ball

Contract No. DA-04-495-ORD-669
Duration: 1 July 1955 - 30 September 1956
Amount: $ 4,708.37
Type of Contract: Cost

Primary Scientific Liaison: Office of Ordnance Research

Scope: A study will be made of the extent to which failure analysis
methods are currently being used, and the degree of success that is
being achieved in complex systems which have reliability problems
similar to those encountered in Ordnance missiles. Original analyt-
ical studies of modes of failure will be performed, and with each
mode, tests will be associated that may be specified to detect them,
and quality controls specified to reduce the frequency of their
occurrence.

Progress (31 July 1956 - 30 September 1956): Delays in obtaining
failure case histories from direct component test programs resulted
in concentration on studies based on published literature and on
analyses of well-documented case histories provided by White Sands
Proving Ground Test Plan 63. The available data, particularly the re-
ported shapes of failure rate curves with time as the abscissa,
stimulated extensive and rather radical interpretation of the phe-
nomenological basis for failure in guided missiles and other complex
systems. The final report has been received and the contract has been
terminated.

Technical Reports:

1. Guided Missile Component Failures: A Study of Their Underlying
Causes and Recurrence Prevention, by Leslie W. Ball. September
1956, 37 p., figures. (United Geophysical Corporation, United
Electrodynamics, Final Report). ASTIA AD-118 534

III MATHEMATICS

G. Probability and Statistics

1599 MULTIVARIATE ANALYSIS

Contractor: University of Chicago
5801 Ellis Avenue
Chicago 37, Illinois

Chief Investigator: Ingram Olkin

Contract No. DA-11-022-ORD-1998
Duration: 1 October 1955 - 30 September 1956
Amount: $ 6,986.00
Type of Contract: Cost

Primary Scientific Liaison: White Sands Proving Ground
Scientific Cognizance: Ballistic Research Laboratories

Scope: A program in multivariate analysis will be conducted in which
either or both of the following will be considered: (a) Multivariate
tests with a priori information, and (b) nonparametric multivariate
analysis.

Progress (to 30 September 1956): A determination has been made of un-
biased estimates of (1) the ordinary bivariate correlation coefficient,
(2) the intraclass correlation coefficient, (3) the squared multiple
correlation coefficient, and (4) the partial correlation coefficient.
Tables have been prepared to facilitate the use of the estimates. A
paper has been prepared concerning Tchebycheff type inequality for the
probability that an n dimensional point falls in a certain hyper-
rectangle. The result is a generalization of a bivariate inequality
due to Berge. Studies have also been made on the extrema of quadratic
forms and applications to statistics, extrema of functions of a matrix
in terms of the eigenvalues, sequential estimation for a finite popu-
lation, multivariate ratio estimation for finite populations, and
multivariate tests on means with a priori information. Intraclass
correlation models have been considered and a number of problems of
estimating and testing have been formulated. The final report has
been received and the project has been terminated.

Technical Reports:

1. Unbiased Estimation of Certain Correlation Coefficients, by Ingram
Olkin and John W. Pratt. Not dated, 18 p., tables. (University
of Chicago, Technical Report No. 1; also submitted to Annals of
Mathematical Statistics under the title "Estimation of Certain
Correlation Coefficients").

2. On a Multivariate Tchebycheff Inequality, by Ingram Olkin and
John W. Pratt. Not dated, 8 p. (University of Chicago, Technical
Report No. 2).

III MATHEMATICS

G. Probability and Statistics

1599 (continued)

3. Extrema of Quadratic Forms With Applications to Statistics, by K. A. Bush and I. Olkin. Not dated, 10 p. (University of Chicago, Technical Report No. 3).

4. Extrema of Functions of a Matrix in Terms of the Eigenvalues, by K. A. Bush and I. Olkin. Not dated, 1 p. (University of Chicago, Technical Report No. 4).

5. Multivariate Ratio Estimation for Finite Populations, by Ingram Olkin. 24 August 1956, various paging. (University of Chicago, Technical Report No. 6). ASTIA AD-105 773

6. Sequential Estimation From a Finite Population, by Ingram Olkin and Herbert T. David. 15 September 1956, various paging. (University of Chicago, Technical Report No. 5). ASTIA AD-108 948 (mc)

7. Multivariate Analyses, by Ingram Olkin and others. 1 October 1956, 3 p. (University of Chicago, Final Report).

III MATHEMATICS

H. Operations Analysis

1529 AUTOMATION RESEARCH

Contractor: Columbia University
(Trustees of the University)
Broadway at 116th Street
New York 27, New York

Chief Investigator: Merrill M. Flood

Contract No. DA-30-069-ORD-1622
Duration: 19 December 1955 - 18 December 1956
Amount: $ 26,600.00
Type of Contract: Cost

Primary Scientific Liaison: Ordnance Weapons Command
Scientific Cognizance: Ballistic Research Laboratories; Frankford Arsenal; White Sands Proving Ground

Scope: To perform basic research on automation, a field relating to the design, operation, and management of efficient productive systems. The investigation will be limited to research on ordinary manufacturing operations yielding present types of products. Chief research aims will be (a) to determine the general nature of the productive systems and their mathematical models that are most amenable to treatment by the types of analytical and simulation techniques to be used in this investigation, and (b) to clarify the character and extent of the problems arising because of interaction between men and machines in order to better understand the extent to which various behavioral models now available can be adapted to the purposes of this automation research.

Progress (to 18 December 1956): A simple machine tool operation has been observed and analyzed in order to understand and explain mathematically the human decision-making skills that are and are not better than mechanical counterparts. This study of a simple lathe-turning operation at Watertown Arsenal was intended as an example of how some of the human decisions made in a manufacturing operations might profitably be automated, not as a practical evaluation of the methods in actual use. The methods developed in this study could be applied equally well to other manufacturing operations. Details of this study appear in Technical Report No. 2. The final report has been received and the project has been terminated.

Technical Reports:

1. The Optimal Design of Devices Requiring Positioning, by Raymond N. Auger and Richard J. Herman. November 1956, 10 p., figures. (Columbia University, Technical Report No. 1).

III MATHEMATICS

H. Operations Analysis

1529 (continued)

2. Automation Research, by Richard J. Herman and Lamont M. La
   Robardier. December 1956, various paging, figures, tables.
   (Columbia University, Final Report). ASTIA AD-115 720

3. Costwise Optimization: A Mathematical Approach to Minimizing
   Machining Cost, by Richard J. Herman and Lamont La Robardier.
   (Manuscript submitted to Business Week, to American Machinist
   and to Factory Management and Maintenance).

4. Proposed Procedure for Experiments on Machine Tool Operation at
   Watertown Arsenal, by Richard J. Herman and Lamont La Robardier.
   25 July 1956, 27 p., figures. (Columbia University).

IV ENGINEERING SCIENCES

A. Combustion and Fuels

1515 SIXTH COMBUSTION SYMPOSIUM

Contractor: The Combustion Institute
             200 Alcoa Building
             Pittsburgh 19, Pennsylvania

Chief Investigator: Bernard Lewis

Duration: 1 April 1956 - 1 December 1957
Amount: $ 4,000.00
Type of Contract: Military Interdepartmental Purchase Request

Primary Scientific Liaison: Air Force Office of Scientific Re-
                             search

Scope: Business and fiscal details will be handled for the Sixth
International Combustion Symposium to be sponsored jointly by the
Office of Naval Research, Air Force Office of Scientific Research, and
the Office of Ordnance Research. Technical papers will be solicited,
clerical functions incident to holding the actual symposium will be
performed, and the tasks of editing and correcting the manuscripts of
the papers presented at the symposium, appending the pertinent discus-
sion, and preparing a final manuscript to be used by the publishers
of the symposium volume will be carried out.

Progress (1 April 1956 - 1 December 1957): The Sixth International
Combustion Symposium was held at Yale University in August, 1956.
Up-to-date advances in the field of combustion were presented in
125 papers which are being published in one volume. Included in this
volume are papers on structure and propagation of laminar flame,
structure and propagation of turbulent flames, high speed reactions,
flame stabilization in fast streams, instability in combustion cham-
bers, ignition, combustion of solid fuels, combustion of explosives
and solid propellants, evaporation and combustion of droplets and
sprays, experimental and analytical techniques in combustion, and the
applications of combustion.

IV ENGINEERING SCIENCES

A. Combustion and Fuels

1549 MEASUREMENT OF COMPRESSION TEMPERATURES IN SPARK IGNITION ENGINES

Contractor: University of Wisconsin
(Regents of the University)
Madison 6, Wisconsin

Chief Investigators: P. S. Myers
O. A. Uyehara

Contract No. DA-11-022-ORD-1989
Duration: 1 October 1955 - 31 October 1956
Amount: $ 20,000.00
Type of Contract: Cost

Primary Scientific Liaison: Detroit Arsenal

Scope: This project will involve the measurement of compression temperatures in spark ignition engines and will include the following work: (a) to continue the development and improvement of experimental techniques for gas temperature measurements, in particular the infrared technique, and (b) to use the instrumentation and techniques developed to obtain data on an operating engine. The effect of operating variables and fuel composition will be studied. (A continuation of research conducted under Proposal No. 1320).

Progress (to 31 October 1956): Investigations were directed towards the development of two methods of measuring the compression and end gas temperatures, the iodine technique and the infrared technique. Under the iodine technique a preliminary calibration of the iodine absorption pyrometer was made, and engine data were taken primarily to check the instrument. In the infrared technique, a complete filter monochromator was designed utilizing the water vapor wavelength region between 2.6 and 2.8 microns. Other mechanical and electronic improvements were made to improve the signal-to-noise ratio and scaling accuracy. Data were taken on an engine under various operating conditions, and appear in the report listed below. The final report has been received and the project has been terminated.

Technical Reports:

1. Measurement of Compression Temperatures in Spark-Ignition Engines, by Marshall Burrows, B. K. Ghandi and Shyoski Shimiyer. 67 p., figures, tables. (University of Wisconsin, Mechanical Engineering Department, Final Report: October 1955 - November 1956). ASTIA AD-116 911

IV ENGINEERING SCIENCES

A. Combustion and Fuels

1553 DEVELOPMENT OF THE VELOCITY OF SOUND METHOD FOR MEASUREMENT OF GAS TEMPERATURES IN THE COMBUSTION CHAMBER OF AN INTERNAL COMBUSTION ENGINE

Contractor: Massachusetts Institute of Technology
Memorial Drive
Cambridge 39, Massachusetts

Chief Investigator: C. F. Taylor

Contract No. DA-19-020-ORD-3699
Duration: 1 October 1955 - 30 September 1956
Amount: $ 21,700.00
Type of Contract: Cost

Primary Scientific Liaison: Office of Ordnance Research
Scientific Cognizance: Frankford Arsenal; Redstone Arsenal

Scope: Research will be primarily concerned with development of the velocity of sound methods for measurement of gas temperatures in the combustion chamber of an internal combustion engine. In particular, the investigation will be concerned with (a) measurement of end-gas temperature in a firing engine, (b) the problem of interpreting the velocity of sound in a gas in terms of its "temperature" which will involve the molecular behavior of the gas, including the internal degree of freedom of polyatomic molecules, (c) the behavior of high frequency sound waves in a medium which contains temperature gradients (as in the case of a thermal boundary layer or in turbulent flow), and (d) the design of transducer elements for the transmission and reception of sound energy through the gas. (A continuation of research conducted under Proposal No. 1320).

Progress (to 30 September 1956): A second modified CFR engine suitable for use with the sound velocity measuring equipment has been put into operation. The combustion chamber of the existing engine was modified by providing additional access holes into the test zone. Tables of gas properties have been prepared for the fuel/air residual mixtures encountered in engine operation, and engine data using isooctane have been obtained. A new piston has been made for achieving higher compression ratios. A series of runs has been made for investigating the effects of inlet valve shrouding. Engine test data have been accumulated and analyzed in an attempt to investigate the magnitude of the effects of different values on end-gas temperature and to demonstrate the applicability of the method to the measurement of temperature in an engine combustion chamber. Results of this study appear in the report listed below. The final report has been received and the contract has been terminated.

IV   ENGINEERING   SCIENCES

A. Combustion and Fuels

1553 (continued)

Technical Reports:

1. Development of a Method of Measuring Gas Temperatures in an Inter-
    nal Combustion Engine, by J. C. Livengood, E. A. Jeffery and P.
    C. Wu. 54 p., figures, tables. (Massachusetts Institute of
    Technology, Final Report: 15 September 1955 - 30 September 1956).
    ASTIA AD-120 566

IV   ENGINEERING   SCIENCES

B. Fluid Mechanics

760 DIABATIC FLOW PHENOMENA

Contractor: Purdue Research Foundation
             Lafayette, Indiana

Chief Investigator: Harold M. DeGroff

Contract No. DA-33-008-ORD-888
Duration: 15 December 1953 - 15 September 1957
Amount: $ 47,217.00
Type of Contract: Cost

Primary Scientific Liaison: Ballistic Research Laboratories
Scientific Cognizance: Redstone Arsenal

Scope: Efforts will be devoted to studies and experimentation in
nonsteady laminar motion. Further experimentation and analysis will
be made of the interrelation of skin-friction, heat transfer, and
acoustical phenomena in nonsteady, shearing compressible, heat con-
ducting fluid motion. A compressible boundary layer literature survey
will be continued, and a new phase of the program will consist of per-
forming experiments in the turbulent region with existing apparatus.

Progress (to 16 September 1957): A study was made of the dependence of
properties of fluids on temperature. In this connection both the
equilibrium properties and transport properties of fluids were in-
vestigated. The results of this study are set forth in report #6.
The influence of nonlinear viscous dissipation on skin friction and
heat transfer was studied in detail. Steady-state hot-wire ane-
mometry was used in experimental investigations of diabatic flow and
was found to be an effective means of measuring low air velocities at
elevated temperatures. Some heat transfer data were obtained in the
range of velocities where both free convection and forced convection
contribute to the heat transfer. The study of aero-thermo-acoustic
effects for nonsteady flow between concentric rotating cylinders re-
sulted in an experimental verification that transverse velocities,
or waves, can be generated by a pure longitudinal shearing motion.
An experimental study was made of combined free and forced convection
flow between concentric rotating cylinders. Velocity and temperature
profiles were obtained for various combinations of wall temperatures
and velocities. The final report has been received and the contract
has been terminated.

IV   ENGINEERING   SCIENCES

B. Fluid Mechanics

760 (continued)

Technical Reports:

1. Calibration of a Hot Wire Anemometer for Low Velocities in Steady
    Flow with Temperature Gradients, by Leslie A. Hromas and C. P.
    Kentzer. July 1955, 30 p., figures. (Purdue University, School
    of Aeronautics). ASTIA AD-68 631 (mc)

2. Viscous Heating in Couette Flow, by Harold DeGroff. September
    1955, 25 p., figures. (Purdue University, School of Aeronautical
    Engineering, Report No. A-55-2). ASTIA AD-75 391 (mc)

3. Nonsteady Laminar Motion of a Viscous, Compressible, Heat-Con-
    ducting Fluid, by Harold DeGroff. September 1955, 19 p., figures.
    (Purdue University, School of Aeronautical Engineering, Report
    No. A-55-3). ASTIA AD-75 350 (mc)

4. On Viscous Heating, by H. M. DeGroff, in Journal of the Aero-
    nautical Sciences, vol. 23, no. 4 (April 1956), p. 395-396.
    ASTIA AD-112 645

5. Experimental Investigation of Flow with Heat Transfer between
    Concentric Rotating Cylinders, by Leslie A. Hromas and Thomas R.
    Thompson. October 1956, 84 p., figures. (Purdue University,
    School of Aeronautical Engineering, Report No. A-56-3). ASTIA
    AD-116 412

6. A Survey of Compressibility and Dissociation Effects on Steady
    Laminar Boundary Layer Flow, Part I. The Flow Without Pressure
    Gradient, by Robert J. Goulard. December 1956, 139 p., figures.
    (Purdue University, School of Aeronautical Engineering, Report
    No. A-56-4). ASTIA AD-120 312

7. Unsteady Couette Flow, by Leslie A. Hromas. June 1957, 43 p.,
    figures. (Purdue University, Report No. A-57-3).

8. A Survey of Compressibility and Dissociation Effects on Steady
    Laminar Boundary Layer Flow, Part II. The Flow with Pressure
    Gradient, by Robert J. Goulard. July 1957, 227 p., figures.
    (Purdue University, School of Aeronautical Engineering, Report No.
    A-56-4).

9. On Catalytic Recombination Rates in Hypersonic Stagnation Heat
    Transfer, by Robert J. Goulard. September 1957, 48 p., figures.
    (Purdue University, Report No. A-57-9, PhD thesis; also submitted
    to the Proceedings of the American Rocket Society).

10. A Summary of Research in Diabatic Flow, by H. M. DeGroff, R. J.
    Goulard and L. A. Hromas. September 1957, 69 p., figures. (Pur-
    due Research Foundation, Final Report, Report No. A-57-10).

IV   ENGINEERING   SCIENCES

B. Fluid Mechanics

1336 NONLINEAR PROPERTIES OF FLUID FLOW THROUGH CIRCULAR ORIFICES

Contractor: Oklahoma State University of Agriculture and Applied
             Science
             Stillwater, Oklahoma

Chief Investigator: George B. Thurston

Contract No. DA-23-072-ORD-876   Renewed: DA-23-072-ORD-583
Duration: 15 Sept 54 - 14 Oct 55   1 Oct 1955 - 31 Aug 1957
Amount: $ 11,763.84 $ 16,428.05
Type of Contract: Fixed Price   Cost

Primary Scientific Liaison: Office of Ordnance Research
Scientific Cognizance: Detroit Arsenal

Scope: (1) The pressure-flow relation as has now been determined for
circular orifices will be compared with that for rectangular orifices
to determine to what extent orifice geometry is important under the
conditions of nonlinear operation. The ability to adapt the empirical
equation to rectangular geometry will be tested. (2) Multiple orifices
and screens will be studied to determine whether or not interactions
between openings appreciably modify their behavior as compared with a
single orifice. (3) Work will be continued toward developing a suita-
ble pressure-flow relation for the single orifice from theoretical
considerations. (4) The experimentally determined flow-optic relations
for aqueous milling yellow solutions for two-dimensional fluid flow
will be applied to determine the conditions of fluid motion in the
neighborhood of a two-dimensional orifice such as a slit or elongated
rectangle. Flow-optic relations established for two-dimensional flow
will be extended to three-dimensional flow having radial symmetry as
with circular orifice.

Progress (to 31 August 1957): The details of the results and conclu-
sions of the work to date are contained in the reports listed below.
The results of an experimental study of the nonlinear fluid flow
properties of thin, square edged, circular orifices appear in report
#1 below. Results of a study of the effect of some geometrical con-
ditions on the nonlinear properties of fluid flow through orifices of
varying geometry appear in report #3 below. Work directed toward
developing a method of visually studying fluid motion in the neighbor-
hood of an orifice is summarized in reports #2 and #4 below. The final
report has been received and the contract has been terminated.

Technical Reports:

1. Nonlinear Properties of Circular Orifices, by George B. Thurston,
    Logan E. Hargrove, Jr. and Bill D. Cook. May 1957, 22 p., figures.
    (Oklahoma Agricultural and Mechanical College, Technical Report
    No. 2; also submitted to the Journal of the Acoustical Society of
    America).

IV ENGINEERING SCIENCES

B. Fluid Mechanics

1336 (continued)

2. An Optical Method for Analysis of Fluid Motion, by Logan E.
Hargrove, Jr. and George B. Thurston. May 1957, 5 p., figures.
(Oklahoma Agricultural and Mechanical College, Technical Report
No. 1; also published in the Journal of the Acoustical Society of
America, vol. 29, no. 8 (August 1957), p. 966-968).

3. Some Geometrical Effects on the Nonlinear Properties of Orifices,
by George B. Thurston and Bill D. Cook. May 1957, 7 p., figures.
(Oklahoma Agricultural and Mechanical College, Technical Report
No. 3).

4. Optical Birefringence Induced by Shear Wave Propagation in Aqueous
Milling Yellow Solutions, by George B. Thurston. June 1957, 69 p.,
figures. (Oklahoma Agricultural and Mechanical College, Technical
Report No. 4).

5. Research in Nonlinear Properties of Fluid Flow Through Circular
Orifices, by George B. Thurston. June 1957, 3 p. (Oklahoma
Agricultural and Mechanical College, Final Report).

IV ENGINEERING SCIENCES

B. Fluid Mechanics

1364 STABILITY OF STRATIFIED FLOW

Contractor: State University of Iowa
Iowa City, Iowa

Chief Investigator: C. S. Yih

Contract No. DA-11-022-ORD-1729
Duration: 29 December 1954 - 28 December 1956
Amount: $ 19,449.50
Type of Contract: Cost

Primary Scientific Liaison: Office of Ordnance Research
Scientific Cognizance: Ballistic Research Laboratories

Scope: To conduct an analytical and experimental investigation of the
characteristics of flow with density stratification.

Progress (to 28 December 1956): Efforts to achieve completely uniform
flow in a previously constructed metal water-tunnel were unsuccessful
because of end conditions which were such that an undesirable third
layer of fluid slowly but persistently developed. A lucite tunnel of
smaller size with a closed tank at one end and an open-head tank at
the other was constructed, and uniform two-layer flow has been
achieved. For a given slope, discharge measured with the latter tun-
nel and the measured depth ratio have been consistently found to have
the same functional relationship as predicted by a theoretical calcu-
lation based on the assumption of laminar flow. The hot-wire method
of measuring velocity distribution in the flow was abandoned in favor
of a photographic method in which liquid drops with approximate
gravity 1 and highly reflective surfaces are used as tracers. The
experiments on the incipient instability of stratified flow have been
concluded, and a manuscript dealing with potential flows of two fluid
layers with a common interface and with flows with continuous strati-
fication has been prepared for publication. Additional work has in-
volved a series of experiments performed with a previously constructed
concrete channel. The problems of two-dimensional flow with thermal
stratification and of thermal recirculation have been investigated
both analytically and experimentally. The analysis deals with
boundary-layer development at the interface, established stratified
flow, and the experimental determination of the form of the hot wedge
which intrudes upstream from the intake on top of the submerged cold
water. Experiments were performed both to confirm some of the results
from the analysis and to obtain information concerning the temperature
distribution and recirculation. Details of this study appear in re-
port #1 listed below. An investigation has also been made of the
three-dimensional case in which both the intake of the cooling water
and its point of outlet after use are located at one side of the main
canal. In this study, determinations have been made of the amount of
thermal recirculation that occurs because of the formation of the
wedge of heated water and its intrusion upstream. The amount of

IV ENGINEERING SCIENCES

B. Fluid Mechanics

1364 (continued)

recirculation in the three-dimensional case was found to depend directly
on the form of the hot wedge. Results of this study appear in report
#2 listed below. The final report has been received and the contract
has been terminated.

Technical Reports:

1. An Investigation of Recirculation in Stratified Flows, by Geza L.
   Bata. August 1956, 107 p., figures. (State University of Iowa,
   M.S. thesis).

2. Recirculation of Cooling Water Discharged from Thermo-Electric
   Plants, by Geza L. Bata. 1956, 61 p., figures, tables. (State
   University of Iowa, Iowa Institute of Hydraulic Research; also
   published in condensed form in the Journal of the American Society
   of Civil Engineers, paper 1265, (June 1957), under the title "Re-
   circulation of Cooling Water in Rivers and Canals").

3. Stability of Stratified Flow, by Hunter Rouse. June 1957, 11 p.
   (State University of Iowa, Iowa Institute of Hydraulic Research,
   Final Report).

4. On Stratified Flows in a Gravitational Field, by Chia-Shun Yih, in
   Sartryck ur Tellus, vol. 2, no. 9 (1957), p. 220-228.

5. Stability of Laminar Flow in Curved Channels, by Chia-Shun Yih and
   W. M. Sangster, in The Philosophical Magazine, Reprint 150 (March
   1957), p. 2-6.

IV ENGINEERING SCIENCES.

C. Friction and Lubrication

375 A FUNDAMENTAL STUDY OF THE MECHANISM OF METAL TRANSFER AND WEAR

      Contractor: Massachusetts Institute of Technology
                   Memorial Drive
                   Cambridge 39, Massachusetts

      Chief Investigator: B. G. Rightmire

      Contract No. DA-19-020-ORD-1767
      Duration: 30 April 1952 - 30 September 1956
      Amount: $ 49,300.00
      Type of Contract: Cost

      Primary Scientific Liaison: Frankford Arsenal

Scope: Continuation of research on friction and wear, with emphasis
on the experimental study of wear factors such as crystal structure,
crystallographic orientation, grain size, grain orientation, normal
load, sliding speed, bulk temperature, distance of travel, and effect
of surrounding atmosphere. In addition, attempts will be made to de-
termine the values of the various constants that appear in the wear
equation and the way in which these constants are affected by surface
film nature and thickness, normal pressure, speed, etc.

Progress (to 30 September 1956): This project was concerned with the
metal transfer and wear occurring when two identical specimens of the
same commercially pure metal are rubbed together under controlled con-
ditions of load, speed, atmosphere, and ambient temperature. Copper
and iron were chosen as the metals to be tested since they are ele-
ments of known structure and properties. Tests were made on the
effect of speed and load on the wear of copper in atmospheres of dry
air plus alcohol vapor, prepurified nitrogen, and dry air. It was
found that the wear drops with increase in velocity up to about 10
cm/sec, while at higher velocities the wear tends to remain constant.
The results obtained, while subject to modification as new evidence
becomes available, were sufficient to permit qualitative explanations
of the effects of atmosphere, speed, and load on wear. The final re-
port has been received and the contract has been terminated.

Technical Reports:

1. The Mechanism of Fretting, by I-Ming Feng and B. G. Rightmire in
   Lubrication Engineering, vol. 9, no. 3 (June 1953), p. 134-136.
   ASTIA AD-4 463

2. Effect of the Surrounding Atmosphere on Wear of Pure Copper, by
   I-Ming Feng and C. M. Chang. 15 February 1954, 23 p., figures.
   (Massachusetts Institute of Technology, Lubrication Laboratory,
   Department of Mechanical Engineering, Technical Report No. 1).
   ASTIA AD-25 819 (mc)

IV E N G I N E E R I N G   S C I E N C E S

C. Friction and Lubrication

375 (continued)

3. An Analysis of the Effect of Various Factors on Metal Transfer
    and Wear Between Specimen Pairs of Same Metal and Same Shape. I.
    The Basic Scheme of Formulation of Metal Transfer and Wear, by
    I-Ming Feng, in the Journal of Applied Physics, vol. 26, no. 1
    (January 1955), p. 24-27. ASTIA AD-13 374 (mc)

4. An Analysis of the Effect of Various Factors on Metal Transfer
    and Wear Between Specimen Pairs of Same Metal and Same Shape. II.
    Effect of the Surrounding Atmosphere, by I-Ming Feng, in the
    Journal of Applied Physics, vol. 26, no. 1 (January 1955), p. 28-
    32. ASTIA AD-10 275 (mc)

5. An Analysis of the Effect of Various Factors on Metal Transfer
    and Wear Between Specimen Pairs of Same Metal and Same Shape. III.
    Effect of the Normal Load, by I-Ming Feng. 15 November 1954,
    20 p., figures. (Massachusetts Institute of Technology, Department
    of Mechanical Engineering, Supplement C). ASTIA AD-49 531 (mc)

6. Fundamental Study of the Mechanism of Metal Transfer and Wear, by
    I-Ming Feng. 15 December 1954, 8 p., figures. (Massachusetts
    Institute of Technology, Department of Mechanical Engineering,
    Technical Report No. 2). ASTIA AD-51 025

IV E N G I N E E R I N G   S C I E N C E S

C. Friction and Lubrication

665 INVESTIGATION OF SLIDING FRICTION WITH EMPHASIS ON SURFACE PHENOMENA

   Contractor: Massachusetts Institute of Technology
                Memorial Drive
                Cambridge 39, Massachusetts

   Chief Investigator: Brandon Rightmire

   Contract No. DA-19-020-ORD-2451
   Duration: 30 December 1952 - 1 September 1955
   Amount: $ 10,700.00
   Type of Contract: Cost

   Primary Scientific Liaison: Office of Ordnance Research

Scope: Tests will be conducted on the frictional behavior of thin
films of various materials which are deposited on a very hard sub-
layer. A slider of very hard material is to be used, and particular
emphasis is to apply to the adhesive and deformation characteristics
of the deposited material. Measurements of sliding velocity will be
made as a function of tangential force and temperature. The effects
of the following parameters will be investigated; normal load, ge-
ometry and material of the sliding members, surface finish, and lubri-
cation.

Progress (to September 1955): Experiments designed to elucidate the
mechanism of sliding friction have been conducted and the following
conclusions have been drawn; (1) The low-speed sliding of rubber-like
material is a rate process in which the slowest step is the slip of
interfacial spots or islands offering more resistance to slip than their
surroundings. (2) The islands tend to increase in area as the applied
tangential force is reduced, thus leading to a rapid drop in the slid-
ing speed which was observed experimentally. (3) Two kinds of islands
are present: one for which slip occurs through the yielding of some
nonrubbery material, and a second for which slip occurs within the
highly elastic substance itself. (4) Transfer and wear can occur
through the agency of contacts of the second type, even though the rate
of sliding is controlled by those of the first type. (5) Transition
of control from one type of contact to the other may occur over such a
narrow temperature range as to justify the concept of a critical or
transition temperature. The final report has been received and the
contract has been terminated.

Technical Reports:

1. Friction Experiments on Thin Film: Low Speed Sliding of Rubber,
    by B. G. Rightmire, O. F. Hedden and Kwan-Lok So. 12 p., figures,
    tables. (Massachusetts Institute of Technology, Final Report:
    30 December 1952 - 1 September 1955).

IV ENGINEERING SCIENCES

C. Friction and Lubrication

1156 THEORETICAL STUDY OF THE HYDRODYNAMICAL THEORY OF LUBRICATION

Contractor: Carnegie Institute of Technology
Schenley Park
Pittsburgh 13, Pennsylvania

Chief Investigator: Edward Saibel

Contract No. DA-36-061-ORD-444   Renewed: DA-36-061-ORD-495
Duration: 1 Sept 54 - 30 Nov 55   1 Sept 1955 - 31 Aug 1957
Amount: $ 15,300.00 $ 28,787.55
Type of Contract: Fixed Price   · Cost

Primary Scientific Liaison: Office of Ordnance Research
Scientific Cognizance: Frankford Arsenal; Rock Island Arsenal

Scope: To investigate the mathematical and physical aspects of certain
problems in lubrication theory, specifically (a) the problem of the
finite journal bearing for any eccentricity with various boundary con-
ditions, (b) the hydrodynamical problem of gear lubrication, (c) the
problem of the elastic bearing, in particular the effect of deforma-
tion of the surfaces on lubrication, (d) some aspects of friction and
wear of metal surfaces from a theoretical point of view, (e) to apply
the findings to problems connected with the machining of metals, and
(f) to investigate theoretical aspects of solid lubrication.

Progress (to 31 August 1957): Concerning the hydrodynamic theory of
lubrication, problems were investigated and solved for the effect of
elasticity of surfaces, the effect of lubricant inertia, the effect of
heat conductance in the lubricant, the effect of heat leakage to the
surrounding surfaces and numerical methods for handling such problems.
In the field of friction and wear, work has been done on sliding fric-
tion between unlubricated metallic surfaces and on the thermal aspects
of galling. Results of these studies appear in the technical reports
listed below. The final report has been received and the contract has
been terminated.

Technical Reports:

1. Slider Bearing with Transverse Curvature: Exact Solution, by
Andrew S. C. Ying and others. 10 November 1954, 10 p., figures,
tables. (Carnegie Institute of Technology, Department of Mathe-
matics, Technical Report No. 1; also submitted to the American
Society of Mechanical Engineers). ASTIA AD-48 195 (mc)

2. The Rheodynamic Squeeze-Film, by F. Osterle and others. 1 February
1955, 8 p., figures. (Carnegie Institute of Technology, Depart-
ment of Mathematics, Technical Report No. 2; also submitted to the
American Society of Lubrication Engineers). ASTIA AD-62 706 (mc)
ASTIA AD-56 338 (mc)

IV ENGINEERING SCIENCES

C. Friction and Lubrication

1156 (continued)

3. The Rheostatic Thrust Bearing, by F. Osterle and E. Saibel.
1 April 1955, 12 p., figures. (Carnegie Institute of Technology,
Department of Mathematics, Technical Report No. 3; also submitted
to American Society of Lubrication Engineers). ASTIA AD-62 712
(mc)

4. The Spring-Supported Thrust Bearing, by E. Saibel and F. Osterle.
Not dated, 8 p., figures. (Carnegie Institute of Technology,
Department of Mathematics, Technical Report No. 4; also submitted
to American Society of Lubrication Engineers). ASTIA AD-74 112
(mc)

5. Thermal Aspects of Galling of Dry Metallic Surfaces in Sliding Con-
tact, by E. Saibel and F. F. Ling. November 1955, 15 p., figures.
(Carnegie Institute of Technology, Department of Mathematics,
Technical Report No. 5; also submitted to American Society of
Lubrication Engineers). ASTIA AD-81 191 (mc)

6. The Spring-Supported Thrust Bearing, by E. Saibel and F. Osterle.
Not dated, 8 p., figures. (Carnegie Institute of Technology, De-
partment of Mathematics, Technical Report No. 4a, corrected).
ASTIA AD-84 630

7. The Effect of Lubricant Inertia in Journal Bearing Lubrication,
by E. A. Saibel and others. Not dated, 9 p., figures, tables.
(Carnegie Institute of Technology, Department of Mathematics,
Technical Report No. 6; also published in Journal of Applied
Mathematics, Paper No. 57-APM-37). ASTIA AD-89 666 (mc)

8. Research and Development on Theoretical Study of the Hydrodynami-
cal Theory of Lubrication, by Edward Saibel. 29 February 1956,
2 p. (Carnegie Institute of Technology, Department of Mathema-
tics, Final Report under DA-444). ASTIA AD-90 567

9. On Sliding Friction Between Unlubricated Metallic Surfaces, by
F. F. Ling and Edward Saibel. Not dated, 8 p., figures. (Car-
negie Institute of Technology, Department of Mathematics, Tech-
nical Report No. 7). ASTIA AD-94 630

10. The Effect of Elastic Deformations in Slider-Bearing Lubrication,
by F. Osterle and E. Saibel. 15 June 1956, 11 p., figures.
(Carnegie Institute of Technology, Department of Mathematics,
Technical Report No. 8). ASTIA AD-99 471

IV ENGINEERING SCIENCES

C. Friction and Lubrication

1156 (continued)

11. An Extension of the Concept of the Minimum in Calculus, and the
    Calculus of Variations, by A. Bomberault and E. Saibel. Not
    dated, 20 p., figures. (Carnegie Institute of Technology, De-
    partment of Mathematics, Technical Report No. 9).

12. Numerical Methods of Solution of the Adiabatic Slider-Bearing
    Without Side Leakage, by Willis H. Guilinger and Edward Saibel.
    Not dated, 25 p., figures. (Carnegie Institute of Technology,
    Department of Mathematics, Technical Report No. 10).

13. Surface Deformations in the Hydrodynamic Slider-Bearing Problem
    and Their Effect on the Pressure Development, by F. Osterle and
    E. Saibel. 8 January 1957, 12 p., figures. (Carnegie Institute
    of Technology, Department of Mathematics, Technical Report No.
    11).

14. The Effect of Heat Conductance on Slider-Bearing Characteristics,
    by Willis H. Guilinger and Edward Saibel. February 1957, 26 p.,
    figures. (Carnegie Institute of Technology, Department of Mathe-
    matics, Technical Report No. 12).

15. The Effect of Turbulence on Slider-Bearing Lubrication, by Ye
    Tsang Chou and Edward Saibel. June 1957, 25 p., figures, tables.
    (Carnegie Institute of Technology, Department of Mathematics,
    Technical Report No. 13).

16. Theoretical Study of the Hydrodynamical Theory of Lubrication, by
    Edward Saibel. 3 p. (Carnegie Institute of Technology, Depart-
    ment of Mathematics, Final Report: 1 September 1955 - 31 August
    1957).

IV ENGINEERING SCIENCES

D. Heat and Mass Transfer

940 EXPERIMENTAL STUDY OF HEAT AND MASS TRANSFER THROUGH BOUNDARY LAYERS
     ESTABLISHED ON CYLINDERS IN FLOW PARALLEL TO CYLINDRICAL AXIS

         Contractor: Illinois Institute of Technology
                      3300 South Federal Street
                      Chicago 16, Illinois

         Chief Investigator: Stothe P. Kezios

         Contract No. DA-11-022-ORD-1508
         Duration: 1 November 1953 - 31 December 1956
         Amount: $ 23,245.82
         Type of Contract: Cost

         Primary Scientific Liaison: Frankford Arsenal
         Scientific Cognizance: Redstone Arsenal

     Scope: A continuation of the investigation will be made on the
     nature of heat and mass transfer through boundary layers established
     on cylinders in flow parallel to the cylindrical axis. Primary
     emphasis will be given to determining the possible effects of cur-
     vature on transport processes in the boundary layers. Work will be
     carried out in a wind tunnel under conditions where both laminar and
     turbulent boundary layers would be developed but where the flow would
     be essentially incompressible.

     Progress (to 31 December 1956): The construction of the wind tunnel
     has been completed, and an investigation has been made of the mass
     transfer by sublimation from the outer surfaces of hollow naphthalene
     cylinders in parallel air streams at velocities between 20 and 120
     feet per second. A profilometric technique was developed whereby the
     local mass transfer could be obtained by determining changes in the
     radius of the subliming cylinders. Turbulent boundary layers were
     obtained by artifical generation of turbulence at the leading edges
     of the cylinders, and the local mass-transfer rates measured for these
     boundary layers were found to depend greatly on the manner in which
     turbulence was induced. Pressure distributions were measured on a
     one-inch hollow cylinder having a leading edge identical to those of
     the subliming cylinders, and the results showed that the real cylinders
     behaved very nearly like the ideal model with respect to the flow
     pattern over the outer surfaces. Data for the two cylinders employed
     have indicated substantially no effect of surface curvature on the
     mass transfer through turbulent boundary layers. The final report
     has been received and the contract has been terminated.

     Technical Reports:

     1. Heat and Mass Transfer Through Boundary Layers Established on
         Cylinders in Flow Parallel to the Cylindrical Axis, by W. J.
         Christian and S. P. Kezios. Not Dated, 199 p., figures, tables.
         (Illinois Institute of Technology, Final Report).

IV ENGINEERING SCIENCES

D. Heat and Mass Transfer

1164 WETTING EFFECTS ON BOILING HEAT TRANSFER

> Contractor: Georgia Tech Research Institute
> Engineering Experiment Station
> Research Building, Institute of Technology
> Atlanta, Georgia

> Chief Investigator: William B. Harrison

> Contract No. DA-01-009-ORD-368   Renewed: DA-01-009-ORD-444
> Duration: 1 Mar 54 - 30 June 55   1 Sep 1955 - 31 Aug 1957
> Amount: $ 12,552.00 $ 21,939.00
> Type of Contract: Fixed Price   Cost

> Primary Scientific Liaison: Office of Ordnance Research

Scope: Boiling experiments will be conducted with stearic acid and single crystals of Ni. A search will be made for other liquid-solid combinations which exhibit similar effects of crystal orientation on degree of wetting. Force convection experiments will be conducted with stearic acid in a thermal entrance region having a Cu single crystal surface.

Progress (to 30 September 1957): Wetting effects on convective heat transfer have been studied with a copper-stearic acid system and with a copper-sodium system. These convective studies were each made in experimental apparatus which incorporated a thermal entrance region so as to maximize the effect of additional thermal resistance created by non-wetting conditions at the heat transfer surface. The general considerations involved in bubble formation and wetting effects were studied. The work demonstrated a significant wetting effect on boiling stearic acid from different faces of copper single crystals, but wetting effects were not observed with stearic acid in forced convection past the same crystal surfaces without boiling. The convective studies with sodium were inconclusive. The final report has been received and the contract has been terminated.

Technical Reports:

1. Wetting Effects on Boiling Heat Transfer, by W. B. Harrison and others. 62 p., figures, tables. (Georgia Institute of Technology, Engineering Experiment Station, Final Report under DA-368: 1 March 1954 - 31 May 1955). ASTIA AD-66 755 (mc)

2. Wetting Effects on Heat Transfer, by W. B. Harrison. 121 p., figures, tables. (Georgia Institute of Technology, Final Report: 1 September 1955 - 30 September 1957).

IV ENGINEERING SCIENCES

F. Measurement and Control

1581 WAVEFORM STUDIES

> Contractor: Columbia University
> (Trustees of Columbia University)
> Broadway at 116th Street
> New York, New York

> Chief Investigator: Jacob Millman

> Contract No. DA-30-069-ORD-1725
> Duration: 30 April 1956 - 29 April 1957
> Amount: $ 9,198.00
> Type of Contract: Cost

> Primary Scientific Liaison: Redstone Arsenal

Scope: Consideration will be given to the following problems: (a) A study of x-transforms of transient problems which have an especially cumbersome Laplace transformation solution, (b) an extension of the x-transforms method to the solution of partial differential equations, (c) an exploration of the possibility of time domain synthesis employing x-transforms, (d) a study of circuits containing nonlinear elements controlled by more than one variable, and (e) an examination of nonlinear circuits containing pulse transformers or delay lines.

Progress (to 29 April 1957): The x-transform method for obtaining approximate solutions of linear differential equations has been extended to systems with time varying coefficients. The approach has been compared with classical numerical methods, in particular, the Runge-Fox method. Advantages of this method when applied to higher order equations or systems of equations have been demonstrated. Correlation between the x-transform method and the difference equation method has also been obtained. A detailed comparison between the method of Boxer and Thaler and the x-transform approach has been made with respect to accuracy and the amount of labor involved. The accuracy was found to be about the same in both methods, but the Boxer-Thaler solution is usually more complicated, particularly for time varying problems. An error analysis for the x-transform method has been devised. Although it may not be practical in a complex problem, it does give some insight into the nature of the error in the x-transform. In addition, the similarity of the x-transform method and a simple Runge-Kutta method has been found. The final report has been received and the contract has been terminated.

Technical Reports:

1. Comparison of the X-Transform Method with Other Numerical Methods, by C. Heizman, J. Millman and A. Vigants. 4 September 1956, 34 p., tables. (Columbia University, Engineering Center, Technical Report No. T-81C). ASTIA AD-124 717

2. Waveform Studies, by Jacob Millman. 30 April 1957, 13 p., figures, tables. (Columbia University, Engineering Center, Final Report). •

IV ENGINEERING SCIENCES

H. Solid Mechanics

234 STRESS-STRAIN RELATIONS IN PLASTICITY AND RELATED TOPICS

        Contractor: University of Michigan
                   (The Regents of the University)
                   Ann Arbor, Michigan

        Chief Investigator: Paul M. Naghdi

        Contract No. DA-20-018-ORD-12099
        Duration: . 1 February 1952 - 31 January 1957
        Amount: $ 66,070.00
        Type of Contract: Cost

        Primary Scientific Liaison: Watertown Arsenal

Scope: Investigation and determination of the plastic deformation be-
havior of certain structures, to be carried out using the tension-
torsion machine. The experimental work will be correlated with re-
sults predicted by flow and deformation theories of plasticity. In
addition to work being continued, studies will be made of (1) the
adaptation of the tension-torsion machine to provide reverse torque,
(2) theoretical investigation of problems in conjunction with the
experimental program, (3) an experimental program at high temperatures
will be conducted, (4) certain three-dimensional problems such as the
hollow sphere and cylinder under point loading distributed over a
small area, and (5) plastic stress-strain relations, especially for
anisotropic strain hardening materials.

Progress (to 31 January 1957): Principal results are reflected in the
technical reports listed below. An experimental investigation in
plasticity has been completed in which ten tubular 24S-T4 aluminum
alloy specimens having severe initial anisotropy were tested by sub-
jecting them initially to tension and later to torsion with increasing
or decreasing tension. Twenty-seven additional specimens of aluminum
alloy were subjected to combined torsion-tension-reversed torsion with
variable loading paths in a study of initial and two subsequent yield
surfaces covering the first and the fourth quadrants of the axial
stress-shear stress plane. In addition an experiment on the load-
carrying capacities of circular plates in the plastic range was carried
out and compared with the theoretically predicted limit loads given
by Prager and Hopkins. An investigation of elastic shells of revolu-
tion has been completed in which the deformation of thin elastic el-
lipsoidal shells of revolution of uniform thickness under axisymmetric
loading was considered at length. The final report has been received
and the contract has been terminated.

Technical Reports:

1. Fundamental Experiments in Plasticity: Instrumentation and Pre-
    liminary Phases, by P. M. Naghdi and J. C. Rowley. September
    1952, 26 p., tables. (University of Michigan, Engineering

---

IV ENGINEERING SCIENCES

H. Solid Mechanics

234 (continued)

    Research Institute, Technical Report No. 1). ASTIA AD-170 183

2. An Experimental Study of Biaxial Stress-Strain Relations in
    Plasticity, by P. M. Naghdi and J. C. Rowley. December 1953, 54
    p., figures. (University of Michigan, Engineering Research
    Institute, Technical Report No. 2; also published in the Journal
    of the Mechanics and Physics of Solids, vol. 3 (1954), p. 63-80).
    ASTIA AD-25 497 (mc)

3. On the Deformation of Elastic Shells of Revolution, by P. M. Naghdi
    and C. Nevin De Silva. November 1953, 26 p., tables, figures.
    (University of Michigan, Engineering Research Institute, Technical
    Report No. 3; also published in Quarterly of Applied Mathematics,
    vol. 12, no. 4 (January 1956), p. 369-374). ASTIA AD-22 453 (mc)

4. An Experiment on Circular Plates in the Plastic Range, by R. M.
    Cooper and G. A. Shifrin. March 1954, 21 p., figures, tables.
    (University of Michigan, Engineering Research Institute, Technical
    Report No. 4; also published in Proceedings of the Second U. S.
    National Congress of Applied Mechanics, (1955), p. 527-534).
    ASTIA AD-29 050 (mc)

5. Experiments Concerning the Yield Surface and the Assumption of
    Linearity in the Stress-Strain Relations, by P. M. Naghdi and
    others. April 1954, 7 p., figures. (University of Michigan,
    Engineering Research Institute, Technical Report No. 5; also
    published in Journal of Applied Mechanics, Paper No. 55-APM-5).
    ASTIA AD-32 855 (mc)

6. On Elastic Ellipsoidal Shells of Revolution, by P. M. Naghdi and
    C. Nevin De Silva. August 1954, 12 p., figures. (University of
    Michigan, Engineering Research Institute, Technical Report No.
    6; also published in Proceedings of the Second U. S. National
    Congress of Applied Mechanics (1955), p. 333-343). ASTIA AD-40
    .115 (mc)

7. Some Remarks on a Class of Shells of Revolution of Variable Thick-
    ness, by C. Nevin De Silva and P. M. Naghdi. December 1955, 11
    p. (University of Michigan, Technical Report No. 4; also sub-
    mitted to Journal of Mathematical Physics). ASTIA AD-81 383 (mc)

8. An Experimental Study of Initial and Subsequent Yield Surfaces in
    Plasticity, by P. M. Naghdi, F. Essenburg and W. Koff. January
    1957, 14 p., figures. (University of Michigan, Technical Report
    No. 8; also submitted to the Journal of the Mechanics and Physics
    of Solids). ASTIA AD-121 839

9. Stress-Strain Relations in Plasticity and Related Topics, by P.
    M. Naghdi. June 1957, 5 p. (University of Michigan, Final
    Report).

IV ENGINEERING SCIENCES

H. Solid Mechanics

744 FATIGUE FAILURES AND BREAKING STRENGTH

Contractor: Columbia University
(Trustees of Columbia University)
Broadway at 116th Street
New York 27, New York

Chief Investigator: E. J. Gumbel

Contract No. DA-30-069-ORD-1061
Duration: 1 April 1953 - 30 June 1956
Amount: $ 59,521.60
Type of Contract: Cost

Primary Scientific Liaison: Office of Ordnance Research

Scope: (a) To develop a statistical theory of fatigue failure appro-
priate for small samples in which the following factors will be con-
sidered: dimensions of the specimen, and chance variation of stress,
and (b) to study various physical models which may lead to other sta-
tistical models for use in experimental fatigue failure data.

Progress (to 30 June 1956): Completed phases of the project are re-
flected in the technical reports listed below. This investigation is
being continued as Proposal 1716, this report page IV-66.

Technical Reports:

1. Minimum Life in Fatigue Failure, by A. M. Freudenthal and others.
14 December 1953, 45 p., figures, tables. (Columbia University,
Department of Industrial Engineering, Technical Report No. T-1A).
ASTIA AD-28 858

2. Standard Errors of Estimate of Parameters of Fatigue Failure
Survivorship Functions, by C. Derman, and others. 12 May 1954,
22 p., tables. (Columbia University, Department of Industrial
Engineering, Technical Report No. T-2A). ASTIA AD-36 681

3. Statistical Estimation of the Endurance Limit, by E. J. Gumbel.
1 April 1955, 32 p., figures, tables. (Columbia University,
Department of Industrial Engineering, Technical Report No. T-3A;
also published in Annals of Mathematical Statistics, vol. 26,
no. 1 (March 1955), p. 158). ASTIA AD-67 323

4. Minimum Life in Fatigue, by A. M. Freudenthal and E. J. Gumbel,
in Journal of the American Statistical Association, vol. 49
(September 1954), p. 575-597.

IV ENGINEERING SCIENCES

H. Solid Mechanics

744 (continued)

5. Failure and Survival in Fatigue, by A. M. Freudenthal and E. J.
Gumbel, in Journal of Applied Physics, vol. 25, no. 11 (November
1954), p. 1435.

6. Some Remarks on the Endurance Limit Problem, by Cyrus Derman.
1 August 1955, 9 p. (Columbia University, School of Engineering,
Technical Report No. T-4A). ASTIA AD-75 144

7. Some Tests for Minimal Life of Fatigue Failure Survivorship Func-
tions, by Seiji Sugihara, 31 January 1956, 15 p. (Columbia Uni-
versity, Department of Industrial Engineering; Technical Report
No. T-5A). ASTIA AD-84 867 (mc)

8. Statistiche Theorie der Ermüdungserscheinungen von Metallen, by
E. J. Gumbel and Z. Z. Freie, in Zeitschrift für angewandte
Mathematek und Mechanik, vol. 35, no. 9/10 (September - October
1955).

9. Physical and Statistical Aspects of Fatigue, by A. M. Fredenthal
and E. J. Gumbel, in Advances in Applied Mechanics, vol. 4 (1956),
p. 117-158.

10. Statistical Estimation of the Endurance Limit, by E. J. Gumbel.
1 May 1956, 28 p., figures, tables. (Columbia University, Depart-
ment of Industrial Engineering, Technical Report No. T-6A).

11. Extreme Values in Technical Problems, by E. J. Gumbel, in Indus-
trial Laboratories, vol. 7, no. 12 (December 1956). (Technical
Report No. T-7A). ASTIA AD-120 920

12. Statistical Research on Fatigue Failures and Breaking Strength,
by Sebastian B. Littauer. Various paging. (Columbia University,
Comprehensive Report No. 1, Final Report: 1 April 1953 - 30
June 1956).

IV ENGINEERING SCIENCES

H. Solid Mechanics

1086 STATIC AND DYNAMIC TESTS ON BEHAVIOR OF METAL PARTS IN THE PLASTIC
RANGE

Contractor: Brown University
             Providence 12, Rhode Island

Chief Investigator: D. C. Drucker

Contract No. DA-19-020-ORD-3172
Duration: 30 October 1953 - 30 September 1957
Amount: $ 77,905.00
Type of Contract: Cost

Primary Scientific Liaison: Watertown Arsenal
Scientific Cognizance: Frankford Arsenal

Scope: Static tests on non-circular plates will be concluded and an
interpretation of test results will be made. A test will be made on
two types of structures for limit load theories. The first structure
will be the shell subject to a band of internal pressure, the other,
the beam curved in plane. A modification of the theory will be at-
tempted if the tests so indicate. Modifications will be incorporated
in the present impact testing machine for plate tests. An evaluation
will be made of approximate methods using simple models to obtain plas-
tic deformation in structures under dynamic loads.

Progress (to 30 September 1957): An attempt has been made to assess
the physical validity of mathematical solutions to the strength and
deformation of structural metal elements. Experimental results were
obtained which led to useful refinements in the theory which in turn
were checked against experiments. Considerable work was done for
static loading and a good start made for dynamic loading. Completed
phases of the investigation appear in the reports listed below and
report #12 contains a summary of the accomplishments. The final re-
port has been received and the contract has been terminated.

Technical Reports:

1. The Deflection of Plates in the Elastic-Plastic Range, by R. M.
    Haythornthwaite. February 1954, 19 p., figures. (Brown Univer-
    sity, Division of Engineering, Technical Report No. 1; also pub-
    lished in Proceedings of Second U. S. National Congress of Ap-
    plied Mechanics (1954), p. 521-526). ASTIA AD-29 685 (mc)

2. Combined Concentrated and Distributed Load on Ideally-Plastic
    Circular Plates, by D. C. Drucker and H. G. Hopkins. February
    1954, 14 p., figures. (Brown University, Division of Engineering,
    Technical Report No. 2; also published in Proceedings of Second
    U. S. Congress of Applied Mechanics (1954), p. 517-520). ASTIA
    AD-29 686

IV ENGINEERING SCIENCES

H. Solid Mechanics

1086 (continued)

3. Tests of the Behavior of Circular Plates under Transverse Load,
    by J. Foulkes and E. T. Onat. May 1955, 13 p., figures. (Brown
    University, Division of Engineering, Technical Report No. 3).
    ASTIA AD-64 120 (mc)

4. The Load Carrying Capacity of Circular Plates at Large Deflection,
    by E. T. Onat and R. M. Haythornthwaite. December 1954, 29 p.,
    figures. (Brown University, Division of Engineering, Technical
    Report No. 4; also published in Journal of Applied Mechanics,
    Paper No. 55-A-14, p. 1-7). ASTIA AD-50 920

5. The Load Carrying Capacity of Initially Flat Circular Steel Plates
    under Reversed Loading, by R. M. Haythornthwaite and E. T. Onat.
    August 1954, 7 p., figures. (Brown University, Division of Engi-
    neering, Technical Report No. 5; also published in the Journal of
    Aeronautical Sciences, vol. 22, no. 12 (December 1955), p. 867-
    869). ASTIA AD-41 020

6. Plastic Behavior of Constrained Beams with Finite Deformation, by
    R. M. Haythornthwaite. September 1955, 9 p., figures, tables.
    (Brown University, Division of Engineering, Technical Report No.
    6). ASTIA AD-78 554 (mc)

7. The Effect of Shear on the Plastic Bending of Beams, by D. C.
    Drucker. October 1955, 16 p., figures. (Brown University,
    Division of Engineering, Technical Report No. 7; also published
    in Journal of Applied Mechanics, Paper No. 56-APM-28, p. 1-6).

8. The Plastic Deformation Due to Impact of a Cantilever Beam with
    an Attached Tip Mass, by T. J. Mentel. March 1956, 43 p., figures.
    (Brown University, Division of Engineering, Technical Report No.
    8). ASTIA AD-91 635 (mc)

9. Plastic Behavior of Beams with Elastic End Constraints, by R. M.
    Haythornthwaite. August 1956, 6 p., figures. (Brown University,
    Division of Engineering, Technical Report No. 10; also submitted
    to Proceedings of IX International Congress of Applied Mechanics).
    ASTIA AD-105 030 (mc)

10. Deformation of Circular and Annular Plastic Plates under Transverse
    Impact Loads, by Ray C. Alverson. August 1956, various paging,
    figures. (Brown University, Division of Engineering, Technical
    Report No. 9). ASTIA AD-111 601 (mc)

IV   ENGINEERING   SCIENCES

H.   Solid Mechanics

1086 (Continued)

11. Design for Minimum Weight, by D. C. Drucker and R. T. Shield.
     September 1956, 10 p., figures. (Brown University, Division of
     Engineering, Technical Report No. 11; also submitted to Proceed-
     ings of IX International Congress of Applied Mechanics). ASTIA
     AD-111 480

12. Static and Dynamic Tests on Behavior of Metal Parts in the Plastic
     Range, by Daniel C. Drucker. 31 October 1957, 5 p. (Brown Uni-
     versity, Division of Engineering, Final Report).

IV   ENGINEERING   SCIENCES

H.   Solid Mechanics

1230 CORRELATION OF THERMAL FATIGUE WITH MECHANICAL FATIGUE OF METALS

     Contractor: University of Alabama
                  University, Alabama

     Chief Investigator: Harry Majors, Jr.

     Contract No. DA-01-009-ORD-396   Renewed: DA-01-009-ORD-454
     Duration: 1 Sep 54 - 31 Aug 55   1 Sep 1955 - 31 Aug 1957
     Amount: . $ 16,542.54 $ 19,660.92
     Type of Contract: Fixed Price   Cost

     Primary Scientific Liaison: Watertown Arsenal
     Scientific Cognizance: Frankford Arsenal

Scope: Experimental data will be obtained on thermal cycling fatigue
and mechanical load fatigue employing commercially pure Ti and Ni. If
possible, present equipment will be used to determine the effect of a
higher mean temperature on thermal and mechanical load cycling fatigue
using Ti and Ni. The possibility of conducting thermal cycling tests
under combined stress conditions will be investigated. In this case,
slight modifications of existing equipment will be made so that thin-
walled tubes can be tested under internal pressure. In addition, the
magnitude of the effect of thermal cycling upon the temperature of
brittle fracture will be studied.

Progress (to 1 September 1957): Thermal cycling apparatus was con-
structed to produce a periodic stress under periodic temperature vi-
brations by means of a restraint. Experimental conditions were estab-
lished and data were taken from tests of commercially pure Ni and Ti.
Tests revealed that for the same mean temperature and life to rupture,
total plastic strain sustained under thermal cycling is very much less
than under load cycling at constant temperature. Type "A" nickel
under load cycling absorbed 21 times the total plastic strain in a
thermal cycle test; type Ti-75A titanium under load cycling absorbed
approximately 5.5 times the total plastic strain in a thermal cycle
test. Thermal cycling had a tendency to smooth the grain boundaries,
and the Ti and Ni showed no structural changes or heavy oxidation.
Thermal cycling under constant load displayed heavy intergranular oxi-
dation on the inner surfaces of the tubular specimens. No influence
on the coefficient of thermal expansion was observed with cycles of
thermal cycling under constant load. The final report has been re-
ceived and the contract has been terminated.

Technical Reports:

1. Thermal Shock and Fatigue: A Literature Survey, by Harry Majors,
    Jr. September 1956, 35 p., figures, tables. (University of
    Alabama, Bureau of Engineering Research, Technical Report No. 1).
    ASTIA AD-116 007

IV   E N G I N E E R I N G   S C I E N C E S

H. Solid Mechanics

1230 (continued)

    2. Comparison of Thermal Fatigue with Mechanical Fatigue Cycling, by
        Harry Majors, Jr. 78 p., figures, tables. (University of Alabama,
        Final Report: 1 September 1954 - 1 September 1957).

    3. Influence of Thermal Cycling on the Brittle Transition Temperature
        of Low Carbon Steel, by Harry Majors. October 1957, 22 p., figures,
        tables. (University of Alabama, Technical Report No. 2).

IV   E N G I N E E R I N G   S C I E N C E S

H. Solid Mechanics

1232 BENDING OF PLATES, USING TRIGONOMETRIC SERIES

    Contractor: Brigham Young University
               Provo, Utah

    Chief Investigator: Harvey J. Fletcher

    Contract No. DA-04-495-ORD-560
    Duration: 15 June 1954 - 14 June 1957
    Amount: $ 13,459.42
    Type of Contract: Cost

    Primary Scientific Liaison: Watertown Arsenal
    Scientific Cognizance: Ballistic Research Laboratories

Scope: Solutions will be sought to problems involving the deflection,
vibration, and stretching of thin rectangular, skew, and tapered
plates, subjected to various transverse loads and boundary conditions.
A method of attack will be used consisting of seeking approximate so-
lutions for an infinite set of equations with an infinite number of
unknowns. The convergence of the solutions and the following specific
problems will be studied: (1) deflection of a simply supported skew
plate, under a constant load, (2) deflection of a simply supported
tapered plate, (3) natural frequencies of a cantilever plate, under a
constant load, and (4) deflection of a plate due to variable end
thrusts.

Progress (to 14 June 1957): Plate studies completed to date include
isosceles right triangle plates simply supported along one edge, plates
with two adjacent edges simply supported or all four edges free, con-
vergence of the infinite set of equations involved in plate problems,
isosceles right triangular plates supported on two legs, bending of
isosceles right triangular plates, and natural frequencies of plates
with opposite edges supported. Results of these studies appear in
reports #1 through #6 listed below. Problems of the vibration of a
rectangular plate with opposite edges supported, and with every edge
clamped or supported, have been solved, and appear in reports #7 and
#8 below. The final report has been received and the contract has been
terminated.

Technical Reports:

    1. Isosceles Right Triangle Plates Simply Supported Along One Edge,
        by H. J. Fletcher. 31 December 1954, 10 p. (Brigham Young
        University, Technical Report No. 1). ASTIA AD-51 283

    2. Plates with Two Adjacent Edges Simply Supported or All Four Edges
        Free, by K. Harrison and others. 31 December 1954, 8 p. (Brig-
        ham Young University, Technical Report No. 2). ASTIA AD-51 284

IV E N G I N E E R I N G   S C I E N C E S

H. Solid Mechanics

1232 (continued)

3. Convergence of the Infinite Set of Equations Involved in Plate Problems, by H. J. Fletcher, 32 p., figures. (Brigham Young University, Technical Report No. 3: 15 June 1954 - 31 January 1955). ASTIA AD-61 628 (mc)

4. Isosceles Right Triangle Plates Supported on Two Legs, by Kenneth M. Larson and others. 20 February 1956, 22 p. (Brigham Young University, Technical Report No. 4). ASTIA AD-90 102 (mc)

5. Bending of Isosceles Right Triangular Plates, by Kenneth M. Larsen. 15 August 1956, 30 p. (Brigham Young University, Technical Report No. 5).

6. Natural Frequencies of Plates with Opposite Edges Supported, by H. J. Fletcher and others. 12 September 1956, 14 p., tables. (Brigham Young University, Technical Report No. 6). ASTIA AD-107 224 (mc)

7. Bending of Thin Rectangular Plates, by H. J. Fletcher and C. J. Thorne, in Proceedings of the Second U. S. National Congress of Applied Mathematics, (June 1954), p. 389-406.

8. The Natural Frequencies of Certain Vibrating Rectangular Plates, by Norman R. Woodfield. April 1957, 34 p., tables. (Brigham Young University, M.S. thesis).

9. Bending of Plates Using Trigonometric Series, by H. J. Fletcher. Various paging. (Brigham Young University, Final Report: 15 June 1954 - 15 June 1957).

IV E N G I N E E R I N G   S C I E N C E S

H. Solid Mechanics

1288 THEORETICAL AND EXPERIMENTAL STUDIES OF MECHANICAL PROPERTIES OF METALS SUBJECTED TO TRIAXIAL STRESSES

Contractor: Pennsylvania State University
             University Park, Pennsylvania

Chief Investigators: L. W. Hu
                      Joseph Marin

Contract No. DA-36-061-ORD-446   Renewed: DA-36-061-ORD-505
Duration: 16 Sept 54 - 15 Sept 55   16 Sept 1955 - 15 Sept 1957
Amount: $ 16,066.69 $ 30,577.40
Type of Contract: Fixed Price   Cost

Primary Scientific Liaison: Frankford Arsenal
Scientific Cognizance: Ordnance Materials Research Office

Scope: Studies will be concerned with the effect of hydrostatic pressure on (1) the mechanical properties of metals under hydrostatic pressure up to 400,000 psi, (2) the creep behavior of metals subjected to axial load with superimposed hydrostatic pressure up to 200,000 psi, and (3) the buckling strength of cylindrical tubes under various hydrostatic pressures.

Progress (to 15 September 1957): Work on this project consisted of three main parts: development of triaxial stress testing machinery and triaxial stress experiments, determination of the mechanical properties of metals subjected to triaxial stresses, and analysis of combined stress problems. Four new testing methods to study the mechanical properties of metals under high pressure were developed. Studies were made of the applications of electrical resistance strain gages under high pressure. The fracture strength of metals under triaxial stress state of three unequal principal stresses was studied at high pressure level. The plastic stress-strain relations in tension for metals under high pressure were directly determined without interruption in loading. The applications of the concept of associated flow rules to the plastic flow of anisotropic bodies were studied and the results of this study are included in report #2. Methods for determining the yield stress components in combined stress experiments were developed. The final report has been received and the contract had been terminated.

Technical Reports:

1. Research and Development on Theoretical and Experimental Studies of Mechanical Properties of Metals Subjected to Triaxial Stresses, by L. W. Hu and Joseph Marin. 15 September 1955, 71 p., figures. (The Pennsylvania State University, Department of Engineering Mechanics and Engineering Research, Final Report under DA-446). ASTIA AD-75 117 (mc)

IV ENGINEERING SCIENCES

H. Solid Mechanics

1288 (continued)

2. Modified Tresca's Yield Condition and Associated Flow Rules for Anisotropic Materials and Applications, by L. W. Hu. October 1956, 27 p., figures, tables. (Pennsylvania State University, Department of Engineering Mechanics and Engineering Research, Technical Report No. 1). ASTIA AD-111 298 (mc)

3. Elastoplastic Analysis of Rotating Annulus by A Perturbation Method, by M. J. Owen. October 1956, 21 p., tables. (Pennsylvania State University, Department of Engineering Mechanics and Engineering Research, Technical Report No. 2). ASTIA AD-111 299 (mc)

4. Analysis of Die Profiles in Wire Drawing, by L. W. Hu. (Manuscript submitted to the Journal of The Franklin Institute).

5. Determination of Yield Stress Components in Combined Stress Experiments, by L. W. Hu. November 1956, 14 p., figures. (The Pennsylvania State University, Departments of Engineering Mechanics and Engineering Research, Technical Report No. 3). ASTIA AD-116 262

6. Plastic Behavior of Aluminum Alloy 17S-T4 Subjected to Triaxial Stresses, by L. W. Hu and M. J. Owen. December 1956, 25 p., figures, tables. (The Pennsylvania State University, Departments of Engineering Mechanics and Engineering Research, Technical Report No. 4). ASTIA AD-116 261

7. Experimental and Theoretical Studies on the Mechanical Properties of Metals Under Triaxial Stresses, by L. W. Hu and J. Marin. 98 p., figures, tables. (Pennsylvania State University, Final Report: 15 September 1955 - 15 September 1957).

IV ENGINEERING SCIENCES

H. Solid Mechanics

1301 AN ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF THE TORSIONAL BUCKLING OF THIN CYLINDRICAL SHELLS

    Contractor: University of Florida
                Gainesville, Florida

    Chief Investigator: William A. Nash

Contract No. DA-01-009-ORD-404	Renewed: DA-01-009-ORD-462
Duration: 1 Jan 55 - 31 Dec 55	1 Jan 56 - 30 June 57
Amount: $ 8,400.21	$ 9,510.00
Type of Contract: Fixed Price	Cost

    Primary Scientific Liaison: Watertown Arsenal
    Scientific Cognizance: Ballistic Research Laboratories

Scope: An experimental and analytical investigation of the torsional buckling strength of cylinders with known initial deviations from perfect circularity.

Progress (to 30 June 1957): Tests have been completed on twenty-six thin cylindrical shells subject to torsion. In all cases the geometries of the specimens were such that failure occured by elastic buckling at stresses well below the elastic limit of the material. Data collected include not only the buckling load but also measurements of the initial imperfections present in each specimen prior to application of load as well as electric strain gage measurements of strains in the pre-buckled state. Two analytical treatments found in the literature explain the observed reduction in buckling load of a thin cylindrical shell subject to torsion from the load value indicated by linear small-deflection theory using a nonlinear large-deflection analysis. A series of tests has corroborated to a large extent the validity of each of these theories. The peak load-carrying capacity of imperfect shells as indicated by these two theories was found to range from approximately 60 to 80% of the classical small-deflection value. Elastic buckling of these shells was usually found to occur in just this range. It was found that, in general, for a shell with known initial imperfections, the two theories bracket the experimentally determined elastic buckling load. The final report has been received and the contract has been terminated.

Technical Reports:

1. Buckling of Initially Imperfect Cylindrical Shells Subject to Torsion, by W. A. Nash. Not dated, 20 p., figures. (University of Florida; also published in the Journal of Applied Mechanics, vol. 24, no. 1 (1957), p. 125-130.

IV ENGINEERING SCIENCES

H. Solid Mechanics

1301 (continued)

2. Buckling of Initially Imperfect Clamped-End Cylindrical Shells
    Subject to Torsion, by W. A. Nash. April 1956, 21 p., figures.
    (University of Florida). ASTIA AD-95 671 (mc)

3. An Experimental Investigation of the Torsional Buckling of
    Initially Imperfect Cylindrical Shells, by W. A. Nash and C. N.
    Tang.

4. An Experimental Analysis of the Buckling of Thin Initially Imper-
    fect Cylindrical Shells Subject to Torsion, by William A. Nash.
    August 1957, 26 p., figures, tables. (University of Florida,
    Final Report).

IV ENGINEERING SCIENCES

H. Solid Mechanics

1307 EXPERIMENTAL INVESTIGATION OF STRESS WAVES IN ELASTIC SOLIDS

Contractor: The Pennsylvania State University
             University Park, Pennsylvania

Chief Investigator: J. N. Brennan

Contract No. DA-36-061-ORD-448
Duration: 17 September 1954 - 15 September 1956
Amount: $ 12,427.41
Type of Contract: Cost

Primary Scientific Liaison: Watertown Arsenal

Scope: An experimental and theoretical investigation will be con-
ducted on (a) the propagation of elastic stress waves in cylindrical
bars when the wave length is of the same order of magnitude as the
radius of the bar, and (b) the propagation of ultrasonic pulses in
elastic media subjected to large hydrostatic stresses.

Progress (to 15 September 1956): An apparatus has been developed
which can be used to measure displacements of the order of microinches
at rates from a few cycles per second to more than 100 kc/sec. Its
chief advantage is that in no way does it touch or influence the ob-
ject whose vibrations are being studied and it can be easily used for
measuring relative amplitudes over a surface. In connection with the
study of the effect of large hydrostatic pressure on the propagation
velocity of ultrasonic pulses in metals, a test chamber capable of
withstanding a working pressure of 100,000 psi has been developed,
together with means for producing the required pressure, and an elec-
tronic pulse system and transducer for producing the required pulses.
Driving rings used to couple the transducer to the disk have been con-
structed strong enough to withstand the inertial forces involved. At-
tempts to excite resonance in a specimen having a radius wavelength
ratio of 0.6 failed; however, in a specimen having a ratio of 0.4, many
different resonances could be excited in the frequency range from 15
to 40 kc. Several of these frequencies were close to the calculated
theoretical value of 17.5 kc. Attempts to determine which of the fre-
quencies, if any, correspond to the fundamental axial mode have been
unsuccessful. There were indications that the frequency is 22 kc in-
stead of the theoretical value of 17.5 kc. The final report has been
received and the contract has been terminated.

Technical Reports:

1. A Dynamic Capacitance Type Micrometer, by Edwin F. Dobies. 30
    October 1955, 17 p., figures. (The Pennsylvania State University,
    Engineering Research Department). (A part of #3).

IV ENGINEERING SCIENCES

H. Solid Mechanics

1307 (continued)

2. Effect of Large Hydrostatic Pressure on the Propagation Velocity
    of Ultrasonic Pulses in Metals, by L. Y. Tu. October 1955, 23 p.,
    figures. (The Pennsylvania State University, Engineering Research
    Department). (A part of #3).

3. Experimental Investigation of Stress Waves in Elastic Solids, by
    J. N. Brennan. 15 February 1956, 41 p., figures. (The Pennsyl-
    vania State University, Engineering Research Department, Technical
    Report No. 1 containing #1 and #2). ASTIA AD-87 503 (mc)

4. Experimental Investigation of Stress Waves in Elastic Solids, by
    J. N. Brennan. 15 February 1957, 78 p., figures, tables. (The
    Pennsylvania State University, Engineering Research Department,
    Technical Report No. 2, Final Report).

IV ENGINEERING SCIENCES

H. Solid Mechanics

1502 STATICS AND DYNAMICS OF CURVED AND TWISTED BARS

Contractor: Rensselaer Polytechnic Institute
             Troy, New York

Chief Investigator: Enrico G. Volterra

Contract No. DA-30-115-ORD-709
Duration: 1 December 1955 - 30 November 1957
Amount: $ 23,420.00
Type of Contract: Cost

Primary Scientific Liaison: Office of Ordnance Research

Scope: To apply the so-called method of internal constraints to static
and dynamic problems of curved and twisted bars. Static problems will
comprise curved bars bent by external forces which may or may not lie
in the plane of initial curvature. Dynamic studies will be concerned
with the vibrations of straight and curved bars, taking account of
shear and of rotatory inertia.

Progress (to 30 November 1957): Differential equations of motion de-
rived in a previous paper by applying the method of internal constraints
to a curved elastic bar of finite length have been solved. The solu-
tions have been expressed in terms of the eigenvalues and eigenfunc-
tions of the corresponding equations of motion for the case of a
straight bar. The problem of dispersion of longitudinal waves in
elastic rods of infinite lengths and of rectangular cross-section has
been studied by applying the one-dimensional theory of wave propagation
based on the method of internal constraints. The results have been
compared with those given by the Elementary, Love, and Bishop approxi-
mate theories, and in the case of two-dimensional elasticity, with the
exact theories given by Rayleigh and Lamb. Equations of motion for
cylindrical shells and elastic plates have been derived, taking into
account the effects of shear and rotatory inertia by assuming that
during motion a condition of constraint is present. Equations of
motion for curved and twisted elastic bars of uniform cross-section
have been derived, taking into account the influence of shear and of
rotatory inertia. A study has also been made of free and forced vibra-
tions of straight bars of uniform cross-section, taking into account
the effects of shear and of rotatory inertia. A second approximation
of the method of internal constraints has been developed taking into
account second-order terms in the equations of constraint and by
satisfying the requirement that normal stresses vanish on the surface
of the bar or the plate under consideration. In addition, problems of
wave dispersion in infinite bars and of free vibrations of finite bars
have been investigated. A one-dimensional theory of longitudinal wave
propagation in cylindrical elastic rods has been postulated, and takes
into account second-order terms in the equation of constraints and
brings to an engineering level the otherwise complicated numerical work
involved in the exact theory. The final report has been received and
the contract has been terminated.

IV ENGINEERING SCIENCES

H. Solid Mechanics

1502 (continued)

Technical Reports:

1. Eigenvibrations of Curved Elastic Bars According to the Method of Internal Constraints, by E. Volterra. December 1955, 45 p.; also (Rensselaer Polytechnic Institute, Progress Report No. 1; also published in Ingenieur-Archiv, vol. 24, no. 5 (1956), p. 317-329). ASTIA AD-85 397

2. On the Dispersion of Longitudinal Waves in Elastic Rods of Rectangular Cross-Section According to the One-Dimensional Theory of Wave Propagation, Based on the Method of Internal Constraints, by E. Volterra. January 1956, 43 p., figures. (Rensselaer Polytechnic Institute, Progress Report No. 2). ASTIA AD-84 940

3. The Equations of Motion for Elastic Plates and Cylindrical Shells Deduced by the Use of Method of Internal Constraints, by E. G. Volterra. February 1956, 27 p. (Rensselaer Polytechnic Institute, Technical Report No. 3). ASTIA AD-91 193 (mc)

4. The Equations of Motion for Curved and Twisted Elastic Bars Deduced by the Use of the Method of Internal Constraints, by E. Volterra. 7 March 1956, 32 p. (Rensselaer Polytechnic Institute, Technical Report No. 4; also published in Ingenieur-Archiv, vol. 24, no. 6 (1956), p. 392-400). ASTIA AD-22 885

5. Free and Forced Vibrations of Straight Elastic Bars According to the Method of Internal Constraints, by E. G. Volterra and E. C. Zachmanoglou. Not dated, 29 p. (Rensselaer Polytechnic Institute, Research Division, Technical Report No. 5). ASTIA AD-117 487

6. A Second Approximation of the Method of Internal Constraints as Applied to Dynamic Problems, by E. C. Zachmanoglou and Enrico Volterra. 20 May 1957, 38 p., figures. (Rensselaer Polytechnic Institute, Technical Report No. 6).

7. An Engineering Theory of Longitudinal Wave Propagation in Cylindrical Elastic Rods, by E. C. Zachmanoglou and E. Volterra. 6 September 1957, 24 p., figures. (Rensselaer Polytechnic Institute, Technical Report No. 7).

8. Statics and Dynamics of Curved and Twisted Bars, by E. C. Zachmanoglou and E. Volterra. September 1957, 8 p. (Rensselaer Polytechnic Institute, Final Report).

IV ENGINEERING SCIENCES

L. Aerodynamics

1082 EXPERIMENTAL AND ANALYTICAL STUDY OF THE MAGNUS EFFECT

Contractor: Case Institute of Technology
University Circle
Cleveland 6, Ohio

Chief Investigators: R. E. Bolz
G. Kuerti
W. M. Swanson

Contract No. DA-33-019-ORD-1434
Duration: 12 October 1953 - 31 December 1956
Amount: $ 14,600.00
Type of Contract: Fixed Price

Primary Scientific Liaison: Office of Ordnance Research
Scientific Cognizance: Ballistic Research Laboratories; Redstone Arsenal

Scope: An experimental and analytical study of the Magnus effect will be undertaken. The experimental work involves measuring lift, drag, and moment in a rotating cylinder in a wind tunnel, mapping the flow field surrounding the cylinder, and determining the circulation as a function of radius. The effect of Reynolds number, angle of yaw, and cylinder roughness will be studied. The analytical study will have as its objective the establishment of a theory for the Magnus effect in at least the two-dimensional, non-turbulent case.

Progress (to 31 December 1956): A complete set of data on lift coefficient vs. velocity ratio has been taken on cylinders rotating at speeds up to 6000 rpm. Indicated lift coefficients covering a range of -0.8 to 17.5 have been obtained over a velocity ratio range of 0 to 16.5 and at Reynolds numbers from 3.4×10^4 to 4.2×10^5. A complete set of drag coefficients as a function of velocity ratio and Reynolds number has also been taken. A modification of the original apparatus to permit utilizing an x-ray recorder made it possible to repeat the runs in a period of time substantially shorter than the original runs during which meter readings were made. Data taken by the two methods were in good agreement. No maximum lift coefficient was obtained during the investigation even though the velocity ratio was extended to a value of 17 at which point the lift coefficient had a value of 14.7 and was still increasing at a constant rate. Velocity and pressure data were taken for boundary layer and essentially irrotational-flow regions around the cylinder for velocity ratios of 1 and 2. Static pressure distributions around the cylinder were obtained for two values of velocity ratio. These were compared with the pressure distributions calculated from potential flow theory, the circulation being determined from the experimental lift coefficient. Pitotstatic surveys were made at 30° intervals around the cylinder surface to a distance of one-third of the radius out from the cylinder

IV ENGINEERING SCIENCES

L. Aerodynamics

1082 (continued)

and yielded total and static pressure profiles in both the boundary layer and potential flow regions. Velocity profiles were determined from these data and were compared with profiles calculated from potential-flow theory. As yet no stisfactory method has been devised for the solution of any analytical formulation of the problem. The final report has been received and the contract has been terminated.

Technical Reports:

1. An Experimental Investigation of the Two-Dimensional Magnus Effect, by W. M. Swanson. 31 December 1956, 205 p., figures. (Case Institute of Technology, Final Report). ASTIA AD-122 946; ASTIA AD-122 945

V METALLURGICAL SCIENCES

A. Solid State Metallurgy

351 STUDY OF VARIOUS ASPECTS OF THE DIFFUSION PROCESS IN ALLOYS APPLYING THE RELAXATION METHOD

Contractor: Yale University
                New Haven, Connecticut

Chief Investigator: Arthur S. Nowick

Contract No. DA-19-059-ORD-848	Renewed: DA-19-059-ORD-1480
Duration: 9 May 52 - 10 July 53	10 July 1953 - 30 June 1955
Amount: $ 10,315.54	$ 22,973.00
Type of Contract: Fixed Price	Cost

Primary Scientific Liaison: Frankford Arsenal

Scope: The nature of the relaxation process based on anelastic relaxation produced by local rearrangement of solute atoms under an applied shear stress will be studied, together with the dependence of the heat and entropy of activation for diffusion on concentration for various alloy systems. An investigation will be made of the properties of vacancies in metals and will involve measuring the heat of formation of a vacancy, the mean lifetime of a vacancy, and the effects of dislocations on the mean lifetime. The possibility that vacancies may be created during plastic deformation will be considered, and study will be made of the relation between the rate of formation of superstructure (long range ordering) and the rate of atomic diffusion.

Progress (to 30 June 1955): A study has been made of the kinetics and thermodynamics of stress-induced ordering in substitutional solid solutions. Included in this study was an investigation of the effects of quenched-in vacancies in producing an increase in the rate of relaxation in Ag-Zn alloys. The most striking results were the verification of the vacancy mechanism, the independent measurement of the activation energy for the jump of a vacancy, and the discovery that vacancies anneal out of these alloys in two distinct stages. Attempts were also made to increase the relaxation rate through neutron irradiation. The negative results obtained offer strong evidence that the principal annealing process in irradiated metals and alloys is not the migration of vacancies. In addition, a study was made of the kinetics of the grain boundary relaxation in the quenched state. Work was also directed toward a study of the thermodynamics of stress-induced ordering in Ag-Zn alloys by measuring the variation of relaxation strength with temperature. These data provided the basis for obtaining the temperature of self-induced ordering in these alloys, i.e., the temperature at which ordering would proceed spontaneously, without the help of applied stress, if sufficient mobility existed. A study was made of the effects of dislocations on the kinetics of stress-induced ordering. In this connection, a survey was made of all known dislocation effects on internal friction and dynamic modulus of cold-worked metals, in which it was found that the effects could naturally be

351 (continued)

subdivided into three types involving three distinct mechanisms. One
type which appeared to be of greatest importance in freshly deformed
metals was the Koster effect, and a further study was made of the re-
lation of the recovery of this effect to other low-temperature re-
covery phenomena. Additional experiments were conducted to obtain a
better understanding of the Koster effect, and the results revealed
the importance of deformation temperature on the magnitude of the
dislocation contribution to the internal friction and dynamic elastic
moduli. The final report has been received and the contract has been
terminated.

Technical Reports:

1. Anelastic Measurement of Atomic Mobility Under Non-Equilibrium
    Conditions, by A. S. Nowick and R. J. Sladek, in Acta Metallurgica,
    vol. 1 (March 1953), p. 131-140. (Technical Report No. 1).

2. The Decay of Lattice Defects Frozen into an Alloy by Quenching,
    by A. E. Roswell and A. S. Nowick, in Journal of Metals (September
    1953), p. 1259-1266. (Technical Report No. 2).

3. Internal Friction and Dynamic Modulus of Cold-Worked Metals, by
    A. S. Nowick, in the Journal of Applied Physics, vol. 25, no. 9
    (September 1954), p. 1129-1134. (Technical Report No. 3). ASTIA
    AD-47 623

4. On the Interpretation of Low-Temperature Recovery Phenomena in
    Cold-Worked Metals, by A. S. Nowick, in Acta Metallurgica, vol.
    3, no. 4 (July 1955), p. 312-321. (Technical Report No. 4).

5. Study of Various Aspects of the Diffusion Process in Alloys Apply-
    ing The Relaxation Method, by Arthur S. Nowick. 7 p. (Yale Univer-
    sity, Final Report: 9 May 1952 - 30 June 1955).

1453 ANELASTICITY OF SUBSTITUTIONAL SOLID SOLUTIONS

Contractor: Yale University
             New Haven, Connecticut

Chief Investigator: Arthur S. Nowick

Contract No. DA-19-059-ORD-2186
Duration: 1 July 1955 - 30 September 1957
Amount: $ 13,700.00
Type of Contract: Cost

Primary Scientific Liaison: Frankford Arsenal
Scientific Cognizance: Ordnance Materials Research Office

Scope: (1) Complete a study of relaxation strength of the stress-in-
duced ordering phenomenon as a function of crystal orientation in sin-
gle crystals of AgZn alloys; (2) initiate a study of relaxation
strength as a function of orientation in body-centered cubic solid
solutions; (3) begin a study of criteria for occurrence of large in-
ternal friction peaks; and (4) determine how the state of long range
order affects the anelastic behavior of an alloy.

Progress (to 30 September 1957): Investigations have been made which
involve the Zener relaxation phenomenon in solid solutions. Inves-
tigations of the variation of the relaxation time after quenching with
total time at appropriate annealing temperatures showed that the
manner in which vacancies precipitate out of a solid solution is
strongly affected by the presence of dislocations. The variation of
relaxation strength with temperature for three AgZn solid solutions
showed the existence of a critical temperature for spontaneous
ordering in these alloys near 150°K. A study of the variation of
relaxation strength with crystal orientation both in AgZn and MgLi
solid solutions showed results which were in qualitative and quan-
titative disagreement with the predictions of present theories. The
results gave a strong indication that next-nearest-neighbor effects
may contribute the major part of the relaxation phenomena. The final
report has been received and the contract has been terminated.

V   M E T A L L U R G I C A L   S C I E N C E S

A. Solid State Metallurgy

1453 (continued)

Technical Reports:

1. Atomic Mobility in a Cu-Al Alloy after Quenching and Neutron Ir-
   radiation, by Chi Yao Li and A. S. Nowick, in The Physical Review,
   vol. 103, no. 2 (July 1956), p. 294-303. (Technical Report No. 1).

2. Recovery of Internal Friction and Elastic Constants, by A. S.
   Nowick, in Proceedings of the American Society for Metals, (1957),
   p. 146-175. (Technical Report No. 2).

3. Anelasticity of Substitutional Solid Solutions, by Arthur S.
   Nowick, Arthur E. Roswell and others. 19 p., figures. (Yale
   University, Final Report: 1 July 1955 - 30 August 1957).

V   M E T A L L U R G I C A L   S C I E N C E S

D. Chemical Metallurgy

1285 A STUDY OF THE THERMODYNAMIC PROPERTIES OF SILVER-MAGNESIUM ALLOYS

    Contractor: New York University
                 45 Fourth Avenue
                 New York 3, New York

    Chief Investigator: Polykarp Herasymenko

    Contract No. DA-30-069-ORD-1405
    Duration: 1 February 1955 - 31 January 1957
    Amount: $ 19,499.00
    Type of Contract: Cost

    Primary Scientific Liaison: Frankford Arsenal

Scope: To study the thermodynamic properties of silver-magnesium al-
loys in the range from 0 to 65 at. % magnesium by measuring the parti-
al vapor pressure of magnesium. X-ray diffraction measurements will
also be made on these alloys. The data will be used to study the cor-
relation of the thermodynamic properties with the degree of ordering
in the alloys.

Progress (to 31 January 1957): The vapor pressure of Mg over α and β
alloys of Ag and Mg was investigated in the range from about 13 to 50
atomic percent Mg. The alloys were formed by heating pure Ag wire
specimens in Mg vapor of constant partial pressure. Solid Mg located
at the colder end of the iron reaction tube served as the source of
Mg vapor. Abrupt changes in the curves of partial thermodynamic func-
tions were observed at 16.6 and 25 atomic percent Mg in the α field,
and at about 40 and 50 atomic percent Mg in the β field. The observed
changes were found to be due to changes in ordering. The final report
has been received and the contract has been terminated.

Technical Reports:

1. Thermodynamic Properties of Silver-Magnesium Alloys, by P. Herasy-
   menko. April 1956, 8 p., figures. (New York University, Tech-
   nical Report No. 1). ASTIA AD-91 486

2. Vapor Pressure of Magnesium Over Alpha and Beta Silver-Magnesium
   Alloys, by P. Herasymenko. April 1957, 10 p., figures, tables.
   (New York University, Final Report).

V   METALLURGICAL   SCIENCES

D. Chemical Metallurgy

1500 THE FREE ENERGY CHANGE OF EUTECTOID AND NON-EUTECTOID TRANSFORMATIONS

Contractor: Carnegie Institute of Technology
             Schenley Park
             Pittsburgh 13, Pennsylvania

Chief Investigator: G. M. Pound

Contract No. DA-36-061-ORD-482   Renewed: DA-36-061-ORD-543
Duration: 1 June 55 - 31 May 56   1 June 1956 - 31 August 1956
Amount: $ 8,944.00 $ 2,250.00
Type of Contract: Fixed Price   Fixed Price

Primary Scientific Liaison: Watertown Arsenal
Scientific Cognizance: Ordnance Materials Research Office;
                        Frankford Arsenal

Scope: The investigation will include but will not be limited to
studies of the free energy change of eutectoid transformations; spe-
cifically it will concern calorimetric studies on steels containing
nickel, chromium, or boron, and similar studies on non-ferrous eutec-
toid systems such as Cu-Be and Al-Zn.

Progress (to 31 August 1956): A constant heat flow calorimeter has
been developed to operate within the temperature range from 400 to
800°C giving thermal data with deviations in reproducibility of < 1%.
Thermal measurements have been made on carbon and low-alloy eutectoid
steels containing Mn, Mo, Ni, Co, Cu-Al, and Cu-Be eutectoids. The
specific heat of pearlite in carbon eutectoid steel was found to be
influenced above 600°C by the addition of Mo or Co as an alloying ele-
ment, and the specific heat of Cu was increased by the addition of Be
or Al. The enthalpy of the pearlite to austenite reaction changed
with the addition Co, Mn, or Mo to plain-carbon eutectoid steel. A
decrease in the enthalpy of the pearlite to austenite transformation
with increasing ferrite-cementite interfacial area was observed, and
indicated that approximately 12% of the free energy released in the
austenite to pearlite reaction is consumed by the formation of the
ferrite-cementite interface. The enthalpy of both the Cu-Al and Cu-
Be eutectoid reaction was considerably less than that found in the
Fe-C system. A decrease in the enthalpy with increasing interfacial
area was detected for austenitization of the pearlite in the Cu-Al
system, but this effect was not completely established as a result of
the interfacial energy released. From the thermal data, the free en-
ergy change for the various eutectoid reactions can be calculated.
The final report has been received and the contract has been termi-
nated.

V   METALLURGICAL   SCIENCES

D. Chemical Metallurgy

1500 (continued)

Technical Reports:

1. Determination of the Free Energy Change of Eutectoid Reactions
    and the Interfacial Energy in Pearlitic Eutectoids, by John J.
    Kramer and Guy M. Pound. 30 September 1956, 167 p., figures,
    tables. (Carnegie Institute of Technology, Metals Research Labo-
    ratory, Final Report). ASTIA AD-121 881

V   METALLURGICAL   SCIENCES

F. Symposia and Conferences

1556 SAGAMORE RESEARCH CONFERENCE ON ORDNANCE MATERIALS

       Contractor: Syracuse University Research Foundation
                     Syracuse, New York

       Chief Investigator: George Sachs

       Contract No. DA-30-115-ORD-667
       Duration: 1 August 1955 - 30 September 1957
       Amount: $ 14,160.53
       Type of Contract: Cost

       Primary Scientific Liaison: Ordnance Materials Research Office

Scope: Necessary equipment and facilities will be provided for a
Research Conference on Strength Limitations of Metals, and assistance
will be furnished for planning, arranging, and administering it. The
Conference will be held at Syracuse University Sagamore Conference
Center, Sagamore Lake, N. Y., and sponsored by the University and by
Ordnance Materials Research Office. Speakers will be secured, the
conference program will be prepared, published, and distributed, and a
resume of the conference program will be prepared and published. A
second conference will be held at Duke University, Durham, North
Carolina, cosponsored by The Ordnance Materials Research Office and
The Office of Ordnance Research, U. S. Army. Speakers recommended by
a committee on nominations will be secured, facilities will be pro-
vided, and a conference report will be prepared and distributed to
acquaint Ordnance Corps personnel with current advances in the field
of serviceability testing of Ordnance materials.

Progress (to March 1956): The conference on strength limitations of
metals was held at the Sagamore Conference Center, 24 - 26 August
1955. Lectures were presented by nineteen speakers. The conference
was attended by approximately eighty persons connected with some
phase of metallurgical research or application. The lectures pre-
sented the principal relations which control, guide, and encourage
the researcher in his quest for maximum strength for a particular
alloy and for a particular application. Proceedings of this confer-
ence are set forth in report #1 listed below. The second conference
was held at Duke University, Durham, North Carolina, 5 - 7 December
1956. The emphasis was placed on the advancements in testing tech-
niques, and particularly on the development and design of more
realistic tests. It was shown how either successful performance or
failure of structural parts can now be predicted in certain instances,
from the results of special laboratory tests. Proceedings of this
conference on materials evaluation in relation to component behavior
are set forth in report #2 listed below. This contract has been
terminated.

V   METALLURGICAL   SCIENCES

F. Symposia and Conferences

1556 (continued)

Technical Reports:

1. Proceedings of the 1955 Sagamore Research Conference, "Strength
Limitations of Metals." March 1956, 402 p., figures, tables;
2 vols. (Syracuse University Research Institute). ASTIA AD-99
249, ASTIA AD-99 183

2. Proceedings of the Third Sagamore Ordnance Materials Research
Conference, "Materials Evaluation in Relation to Component Be-
havior." 5, 6 and 7 December 1956, 609 p., figures, tables.
(Syracuse University Research Institute).

LISTING OF TERMINATED RESEARCH PROPOSALS

LISTING OF TERMINATED RESEARCH PROPOSALS (Continued)

Proposal No.	Page	Proposal No.	Page
385	VII-165	526	VII-524
388	VII-248	533	VII-119
390	VII-349	534	VII-569
392	VII-656	536	VII-63
395	VII-210	538	VII-422
396	VII-545	539	VII-27
399	VII-249	543	VII-192
400	VII-577	544	VII-663
402	VII-518	547	VII-216
403	VII-705	548	VII-253
408	VII-653	561	VII-22
410	VII-397	562	VII-49
417	VII-279	565	VII-39
423	VII-34	568	VII-571
425	VII-187	570	VII-525
426	VII-12	571	VII-284
427	VII-281	572	VII-4
429	VII-520	573	VII-94
435	VII-189	574	VII-665
444	VII-352	586	VII-195
445	VII-24	587	VII-16
446	VII-282	590	VII-286
447	VII-150	592	VII-151
450	VII-491	602	VII-197
452	VII-437	613	VII-674
455	VII-166	615	VII-199
456	VII-489	619	VII-358
457	VII-212	622	VII-475
460	VII-445	626	VII-325
463	VII-46	627	VII-96
465	VII-250	629	VII-573
474	VII-419	631	VII-439
479	VII-92	640	VII-326
482	VII-13	642	VII-52
483	VII-316	644	VII-558
485	VII-672	655	VII-399
488	VII-48	658	VII-254
491	VII-547	664	VII-669
492	VII-36	665	VII-745
497	VII-354	667	VII-658
499	VII-567	669	VII-255
501	VII-214	670	VII-687
507	VII-483	672	VII-447
508	VII-252	674	VII-646
509	VII-190	675	VII-54
510	VII-37	679	VII-477
514	VII-420	684	VII-683
516	VII-356	688	VII-554
520	VII-14	689	VII-65
521	VII-191	690	VII-361
525	VII-685	695	VII-688

LISTING OF TERMINATED RESEARCH PROPOSALS (Continued)

Proposal No.	Page	Proposal No.	Page
698	VII-121	852	VII-289
703	VII-98	854	VII-427
708	VII-389	855	VII-331
712	VII-137	860	VII-366
715	VII-363	867	VII-368
716	VII-365	868	VII-6
718	VII-660	869	VII-153
720	VII-400	874	VII-531
723	VII-306	875	VII-291
729	VII-287	877	VII-495
730	VII-329	884	VII-133
735	VII-698	885	VII-406
736	VII-493	887	VII-666
737	VII-535	888	VII-710
738	VII-494	892	VII-429
739	VII-123	910	VII-370
740	VII-124	916	VII-176
741	VII-126	920	VII-655
742	VII-152	922	VII-372
744	VII-754	924	VII-485
747	VII-402	925	VII-374
749	VII-404	931	VII-68
751	VII-201	940	VII-749
757	VII-100	943	VII-409
759	VII-479	944	VII-376
760	VII-737	948	VII-178
761	VII-101	950	VII-333
762	VII-318	956	VII-378
763	VII-168	967	VII-690
765	VII-308	976	VII-480
767	VII-41	996	VII-70
771	VII-103	999	VII-529
775	VII-171	1000	VII-497
776	VII-459	1003	VII-18
779	VII-575	1013	VII-649
781	VII-128	1014	VII-717
782	VII-579	1016	VII-644
788	VII-527	1019	VII-461
794	VII-131	1040	VII-335
798	VII-55	1045	VII-712
808	VII-67	1050	VII-20
817	VII-678	1053	VII-392
828	VII-288	1058	VII-261
833	VII-76	1072	VII-643
836	VII-172	1081	VII-319
838	VII-647	1082	VII-771
841	VII-680	1086	VII-756
842	VII-257	1087	VII-692
844	VII-174	1089	VII-724
846	VII-259	1101	VII-451
851	VII-425	1106	VII-380

LISTING OF TERMINATED RESEARCH PROPOSALS (Continued)

LISTING OF TERMINATED RESEARCH CONTRACTS

LISTING OF TERMINATED RESEARCH CONTRACTS (Continued)

Contract No.	Proposal Number	Page	Contract No.	Proposal Number	Page
DA-11-022-ORD-875	516	VII-356	DA-19-020-ORD-1029	355	VII-472
-877	345	VII-552	-1093	328	VII-9
-878	402	VII-518	-1287	548	VII-253
-881	460	VII-445	-1323	283	VII-235
-939	485	VII-672	-1433	808	VII-67
-993	629	VII-573	-1614	347	VII-244
-994	664	VII-669	-1767	375	VII-743
-995	313	VII-514	-1816	479	VII-92
-997	571	VII-284	-1887	510	VII-37
-998	602	VII-197	-1891	539	VII-27
-999	544	VII-663	-1903	444	VII-352
-1038	587	VII-16	-2023	565	VII-39
-1048	759	VII-479	-2244	779	VII-575
-1121	507	VII-483	-2245	690	VII-361
-1156	570	VII-525	-2293	547	VII-216
-1167	590	VII-286	-2312	626	VII-325
-1207	592	VII-151	-2451	665	VII-745
-1213	828	VII-288	-2568	771	VII-103
-1214	874	VII-531	-2569	674	VII-646
-1223	838	VII-647	-2597	875	VII-291
-1246	910	VII-370	-2607	751	VII-201
-1247	860	VII-366	-2831	1019	VII-461
-1248	767	VII-41	-3100	885	VII-406
-1249	794	VII-131	-3172	1086	VII-756
-1264	817	VII-678	-3177	1087	VII-692
-1268	723	VII-306	-3244	887	VII-666
-1276	1276	VII-182	-3312	1142	VII-537
-1281	842	VII-257	-3431	1322	VII-105
-1309	1000	VII-497	-3538	1371A	VII-455
-1318	944	VII-376	-3699	1553	VII-735
-1345	1003	VII-18	-3754	1623	VII-109
-1490	115	VII-220	-3777	1371B	VII-387
-1494	888	VII-710	-4373	1823	VII-723
-1502	956	VII-378			
-1507	976	VII-480	DA-19-059-ORD-848	351	VII-773
-1508	940	VII-749	-849	326	VII-240
-1511	1045	VII-712	-971	574	VII-665
-1513	1058	VII-261	-1317	735	VII-698
-1571	1194	VII-707	-1480	351	VII-773
-1579	1218	VII-296	-1494	326	VII-240
-1581	1151	VII-533	-1500	574	VII-665
-1729	1364	VII-741	-1611	925	VII-374
-1979	1476	VII-411	-1691	1155	VII-499
-1989	1549	VII-734	-1955	1236	VII-337
-1998	1599	VII-729	-2049	1222	VII-382
			-2186	1453	VII-775
DA-19-020-ORD-592	10	VII-155	-2196	735	VII-698
-896	5	VII-217	-2300	1222	VII-382

LISTING OF TERMINATED RESEARCH CONTRACTS (Continued)

Contract No.	Proposal Number	Page	Contract No.	Proposal Number	Page
DA-20-018-ORD-11814	87	VII-159	DA-23-072-ORD-811	1213	VII-530
-11913	146	VII-468	-876	1336	VII-739
-11914	143	VII-145	-928	846	VII-259
-12079	269	VII-146	-964	1111	VII-682
-12099	234	VII-752	-965	695	VII-688
-12242	317	VII-470			
-12258	329	VII-73	DA-30-069-ORD-459	178B	VII-539
-12277	410	VII-397	-479	248	VII-346
-12300	304	VII-457	-609	232	VII-501
-12332	640	VII-326	-683	231	VII-512
-12389	270	VII-1	-750	447	VII-150
-12720	427	VII-281	-765	533	VII-119
-12738	747	VII-402	-782	388	VII-248
-12763	87	VII-159	-783	615	VII-199
-12811	631	VII-439	-791	688	VII-554
-12853	573	VII-94	-956	716	VII-365
-12916	867	VII-368	-980	509	VII-190
-13272	1101	VII-451	-1004	568	VII-571
-13281	1040	VII-335	-1056	765	VII-308
-13282	892	VII-429	-1061	744	VII-754
-13354	1013	VII-649	-1069	855	VII-331
-13474	1258	VII-702	-1090	679	VII-477
			-1113	869	VII-153
DA-23-072-ORD-196	23	VII-157	-1135	232	VII-501
-214	82	VII-203	-1137	836	VII-172
-216	29	VII-141	-1138	231	VII-512
-217	72	VII-185	-1158	533	VII-119
-222	84	VII-312	-1257	1089	VII-724
-231	117	VII-115	-1263	999	VII-529
-297	275	VII-233	-1289	1179	VII-676
-392	390	VII-349	-1316	1252	VII-700
-413	435	VII-189	-1324	1320	VII-463
-447	508	VII-252	-1326	1250	VII-43
-471	627	VII-96	-1405	1285	VII-777
-472	844	VII-174	-1622	1529	VII-731
-491	613	VII-674	-1725	1581	VII-751
-493	695	VII-688			
-583	1336	VII-739	DA-30-115-ORD-224	131	VII-313
-585	627	VII-96	-225	174	VII-81
-596	1568	VII-487	-226	100	VII-163
-648	851	VII-425	-241	378	VII-303
-676	868	VII-6	-249	306	VII-208
-677	846	VII-259	-291	175	VII-45
-761	1111	VII-682	-309	501	VII-214
-764	1050	VII-20	-317	361	VII-74
-768	924	VII-485	-326	486	VII-522
-773	1081	VII-319	-331	174	VII-81
-783	1009	VII-292	-378	655	VII-399

LISTING OF TERMINATED RESEARCH CONTRACTS (Continued)

Contract No.	Proposal Number	Page	Contract No.	Proposal Number	Page
DA-30-115-ORD-420	667	VII-658	DA-36-034-ORD-295		
-424	526	VII-524	T.O. 4	67	VII-311
-439	922	VII-372	T.O. 5	69	VII-272
-459	788	VII-527	T.O. 6	68	VII-270
-513	967	VII-690	T.O. 7	69	VII-272
-549	1315	VII-560	T.O. 8	67	VII-311
-651	1405	VII-86	T.O. 9	68	VII-270
-667	1556	VII-780	-421	148	VII-341
-704	967	VII-690	-491	180	VII-541
-709	1502	VII-769	-502	202	VII-549
			-506	151	VII-83
DA-33-008-ORD-123	4	VII-111	-573	205	VII-314
-187	225	VII-164	-587	300	VII-237
-223	97	VII-161	-614	287	VII-543
-262	258	VII-347	-670	303	VII-116
-263	256	VII-550	-694	179	VII-565
-264	204	VII-204	-727	308	VII-86
-377	365	VII-517	-843	348	VII-89
-379	341	VII-242	-853	340	VII-148
-394	562	VII-49	-865	289	VII-3
-408	296	VII-59	-935	457	VII-212
-453	561	VII-22	-938	408	VII-653
-454	538	VII-422	-940	488	VII-48
-467	154	VII-415	-969	187	VII-509
-485	97	VII-161	-975	720	VII-400
-556	536	VII-63	-977	689	VII-65
-575	497	VII-354	-978	492	VII-36
-607	670	VII-687	-1044	749	VII-404
-888	760	VII-737	-1084	672	VII-447
-1153	1454	VII-265	-1127	300	VII-237
			-1135	205	VII-314
DA-33-019-ORD-653	222	VII-231	-1140	312	VII-238
-876	514	VII-420	-1153	644	VII-558
-878	366	VII-118	-1169	703	VII-98
-1022	730	VII-329	-1176	669	VII-255
-1077	499	VII-567	-1182	698	VII-121
-1093	482	VII-13	-1194	308	VII-86
-1104	619	VII-358	-1206	348	VII-89
-1166	622	VII-475	-1217	287	VII-543
-1172	675	VII-54	-1240	303	VII-116
-1193	854	VII-427	-1261	762	VII-318
-1207	884	VII-133	-1266	833	VII-76
-1434	1082	VII-771	-1270	943	VII-409
-1996	1409	VII-435	-1274	749	VII-404
			-1292	950	VII-333
DA-36-034-ORD-295			-1311	488	VII-48
T.O. 1	67	VII-311	-1351	408	VII-653
T.O. 2	69	VII-272	-1456	187	VII-509
T.O. 3	68	VII-270	-1475	151	VII-83

LISTING OF TERMINATED RESEARCH CONTRACTS (Continued)

Contract No.	Proposal Number	Page	Contract No.	Proposal Number	Page
DA-36-034-ORD-1477	672	VII-447	DA-36-061-ORD-518	1558	VII-297
-1487	718	VII-660	-543	1500	VII-778
-1489	916	VII-176	-544	1464	VII-704
-1492	1106	VII-380			
-1519	644	VII-558			
-1531	1201	VII-651			
-1619	698	VII-121			
-1622	1239	VII-714			
-1645	1333	VII-444			
-1676	1238	VII-433			
-1774	1302	VII-384			
-2019	1394	VII-697			
-2035	1509	VII-107			
-2199	1562	VII-668			
DA-36-061-ORD-67	78	VII-503			
-106	79	VII-506			
-109	71	VII-465			
-149	293	VII-57			
-175	400	VII-577			
-176	376	VII-61			
-184	367	VII-275			
-205	534	VII-569			
-237	79	VII-506			
-275	543	VII-192			
-295	525	VII-685			
-312	71	VII-465			
-322	293	VII-57			
-326	586	VII-195			
-340	376	VII-61			
-345	761	VII-101			
-348	367	VII-275			
-350	534	VII-569			
-368	78	VII-503			
-379	79	VII-506			
-383	543	VII-192			
-392	463	VII-46			
-411	400	VII-577			
-444	1156	VII-746			
-446	1288	VII-763			
-448	1307	VII-767			
-472	525	VII-685			
-478	761	VII-101			
-482	1500	VII-778			
-489	1464	VII-704			
-495	1156	VII-746			
-505	1288	VII-763			
-511	463	VII-46			

LIST OF PRIMARY SCIENTIFIC LIAISON AND SCIENTIFIC COGNIZANCE (C) PARTICIPANTS

Office, Chief of Ordnance

Proposal No. 1254(C)   Page VII-453

Aberdeen Proving Ground
Human Engineering Laboratory

Proposal No. 1151(C)   Page VII-533

Detroit Arsenal

Proposal No.	1336(C)	Page VII-739
	1445(C)	VII-726
	1549	VII-734

Ordnance Weapons Command

Proposal No. 1529   Page VII-731

Office of Scientific Research (ARDC)

Proposal No. 1515   Page VII-733

Office of Naval Research

Proposal No. 1119   Page VII-431

Signal Corps Engineering Laboratory

Proposal No. 1013(C)   Page VII-649

Ordnance Materials Research Office

Proposal No.	667(C)	Page VII-658
	1288(C)	VII-763
	1453(C)	VII-775
	1500(C)	VII-778
	1556	VII-780
	1568(C)	VII-487
	1623	VII-109

Rock Island Arsenal

Proposal No.	306	Page VII-208
	447	VII-150
	485	VII-672
	869	VII-153
	884	VII-133
	924	VII-485
	1156(C)	VII-746
	1164(C)	VII-704
	1568	VII-487

White Sands Proving Ground

Proposal No.	690(C)	Page VII-361
	776	VII-459
	1445(C)	VII-726
	1529(C)	VII-731
	1599	VII-729

Redstone Arsenal

Proposal No.	586	Page VII-195
	664(C)	VII-669
	718(C)	VII-660
	760(C)	VII-737
	887(C)	VII-666
	916(C)	VII-176
	940(C)	VII-749
	976	VII-480
	1009(C)	VII-292
	1045(C)	VII-712
	1058(C)	VII-261
	1081(C)	VII-319
	1082(C)	VII-771
	1087(C)	VII-692
	1179(C)	VII-676
	1258(C)	VII-702
	1276	VII-182
	1302(C)	VII-384
	1454	VII-265
	1553(C)	VII-735
	1581	VII-751

Picatinny Arsenal

Proposal No.	12	Page VII-299
	64	VII-267
	87	VII-159

LIST OF PRIMARY SCIENTIFIC LIAISON AND SCIENTIFIC COGNIZANCE (C) PARTICIPANTS
(Continued)

Picatinny Arsenal (cont'd)

Proposal No.	222	Page VII-231
	303	VII-116
	378	VII-303
	455	VII-166
	543(C)	VII-192
	590	VII-286
	613	VII-674
	763	VII-168
	771	VII-103
	781	VII-128
	841(C)	VII-680
	844	VII-174
	846(C)	VII-259
	916(C)	VII-176
	948	VII-178
	1009	VII-292
	1016(C)	VII-644
	1173(C)	VII-694
	1238	VII-433
	1245	VII-179
	1258(C)	VII-702
	1362(C)	VII-385
	1369	VII-310
	1466(C)	VII-72

Watertown Arsenal

Proposal No.	25	Page VII-561
	26	VII-413
	165	VII-85
	191	VII-557
	202	VII-549
	231	VII-512
	232	VII-501
	234	VII-752
	256	VII-550
	340	VII-148
	365	VII-517
	474	VII-419
	479	VII-92
	486	VII-522
	514	VII-420
	526	VII-524
	565	VII-39
	570	VII-525
	627(C)	VII-96
	644(C)	VII-558

Watertown Arsenal (cont'd)

Proposal No.	689	Page VII-65
	920(C)	VII-655
	996(C)	VII-70
	1086	VII-756
	1230	VII-759
	1232	VII-761
	1301	VII-765
	1307	VII-767
	1322	VII-105
	1409	VII-435
	1500	VII-778
	1586(C)	VII-487

Ballistic Research Laboratories

Proposal No.	71	Page VII-465
	158	VII-79
	174(C)	VII-81
	248	VII-346
	355	VII-472
	390	VII-349
	452(C)	VII-437
	456	VII-489
	460	VII-455
	463(C)	VII-46
	497	VII-354
	520	VII-14
	627(C)	VII-96
	631	VII-439
	667(C)	VII-658
	672	VII-447
	690(C)	VII-361
	716	VII-365
	759	VII-479
	760	VII-737
	771(C)	VII-103
	788	VII-527
	846(C)	VII-259
	851	VII-425
	854	VII-427
	887(C)	VII-666
	892	VII-429
	920(C)	VII-655
	956	VII-378
	976(C)	VII-480
	996(C)	VII-70
	1009(C)	VII-292

LIST OF PRIMARY SCIENTIFIC LIAISON AND SCIENTIFIC COGNIZANCE (C) PARTICIPANTS
(Continued)

INDEX OF CONTRACTORS

Note: The first number in each line is the Proposal Number, the second is
       the page number.

INDEX OF CONTRACTORS (Continued)

INDEX OF CONTRACTORS (Continued)

INDEX OF CONTRACTORS (Continued)

Note: The first number in each line is the Proposal Number, the second is
the page number.

INDEX OF CONTRACTORS (Continued)

Note: The first number in each line is the Proposal Number, the second is
the page number.

INDEX OF CONTRACTORS (Continued)

<u>Note</u>: The first number in each line is the Proposal Number, the second is
the page number.

INDEX OF CONTRACTORS (Continued)

<u>Note</u>: The first number in each line is the Proposal Number, the second is
the page number.

INDEX OF CONTRACTORS (Continued)

<u>Note</u>: The first number in each line is the Proposal Number, the second is the page number.

Yerkes Observatory
140, VII-31
1003, VII-18

INDEX OF CHIEF INVESTIGATORS

(Note: The first number is the Proposal No., the second is the page no.)

Adamson, A. W.
403, VII-705

Ahlfors, Lars B.
444, VII-352

Albert, A. A.
1194, VII-707

Anderson, Carl M.
775, VII-171

Anderson, R. B.
385, VII-165

Argersinger, W. J., Jr.
84, VII-312

Arnold, J. R.
767, VII-41

Ashkin, Julius
293, VII-57

Audrieth, L. F.
763, VII-168
1245, VII-149

Bachman, Charles H.
174, VII-81

Baenziger, N. C.
1058, VII-261

Baldwin, William M.
499, VII-567

Ball, Leslie W.
1550, VII-728

Barnes, R. G.
1509, VII-107

Bartlett, J. H.
485, VII-672

Beck, Clifford
689, VII-65

Bender, Myron
590, VII-286

Benedict, W. S.
642, VII-52

Bigelow, L. A.
68, VII-270

Bijlaard, P. P.
486, VII-522

Blatt, A. H.
1179, VII-676

Bloch, Ingram
296, VII-59

Blomquist, R. F.
465, VII-250

Bogdanoff, J. L.
365, VII-517

Boley, Forrest
808, VII-67

Bolz, R. E.
1082, VII-771

Boyer, J. H.
87, VII-159

Boyer, Joseph H.
948, VII-178

Boyle, A. J.
427, VII-281

Brandt, W. W.
670, VII-687

Breckenridge, Robert G.
738, VII-494

Brennan, J. N.
79, VII-506
1307, VII-767

Brenner, J.
216, VII-323

Brenner, J. L.
1357, VII-338

Brewster, Ray Q.
82, VII-203

Brinkley, Stuart R., Jr.
757, VII-100

Broida, H. P.
712, VII-137

Brown, B. F.
202, VII-549

Brown, Norman
180, VII-541

Brown, O. L. I.
131, VII-313

Brucker, W. H.
191, VII-557

Buck, R. C.
516, VII-356

Bureau, Florent
944, VII-376

Burke, W. J.
12, VII-299

Butler, George B.
380, VII-277

Cameron, R. H.
246, VII-343

INDEX OF CHIEF INVESTIGATORS (Continued)

(Note: The first number is the Proposal No., the second is the page no.)

INDEX OF CHIEF INVESTIGATORS (Continued)

(Note: The first number is the Proposal No., the second is the page no.)

INDEX OF CHIEF INVESTIGATORS (Continued)

(Note: The first number is the Proposal No., the second is the page no.)

Grosse, A. V. 916, VII-176	Harshbarger, Boyd 672, VII-447	Hoff, N. J. 999, VII-529
Grove, E. L. 658, VII-254	Hauser, C. R. 69, VII-272	Holt, M. L. 89, VII-143
Grunwald, E. 155, VII-226	Hawley, Newton S. 266, VII-395	Hornig, Donald F. 1087, VII-692
Gumbel, E. J. 744, VII-754	Healey, F. H. 457, VII-212	Howard, F. L. 712, VII-137
Gunder, Dwight F. 526, VII-524	Herasymenko, Polycarp 568, VII-571 1285, VII-777	Howe, Robert M. 631, VII-439
Gunton, Robert C. 463, VII-46	Hereford, F. L. 348, VII-89	Hu, Kuo Hao 384, VII-246
Gustin, W. S. 258, VII-347	Hermann, Rudolf 874, VII-531	Hu, L. W. 1288, VII-763
Hackerman, Norman 29, VII-141	Hexter, R. M. 967, VII-690	Hudson, George E. 679, VII-477
Hahn, Thomas M., Jr. 536, VII-63	Hiedemann, E. A. 270, VII-1	Huff, Gerald 168, VII-321
Haight, Gilbert P., Jr. 1081, VII-319	Hiltner, W. A. 140, VII-31	Hurty, W. C. 429, VII-520
Hales, Wayne B. 877, VII-495	Hine, Jack 446, VII-282	Hutchison, A. Witt 586, VII-195
Hall, James L. 543, VII-192	Hinman, George W. 376, VII-61	Jacchia, Luigi 328, VII-9
Hall, Lewis D. 396, VII-545	Hirschfelder, J. O. 664, VII-669	Jacobsmeyer, V.P., S.J. 627, VII-96
Hanson, Howard G. 838, VII-647	Hlavaty, V. 154, VII-415	Jacobson, Nathan 1236, VII-337
Harrison, George R. 510, VII-37	Hoard, J. L. 378, VII-303	Jaumot, Frank E. 703, VII-98
Harrison, William B. 1164, VII-750	Hoelscher, H. E. 698, VII-121	Johnson, R. E. 1277, VII-696

INDEX OF CHIEF INVESTIGATORS (Continued)

(Note: The first number is the Proposal No., the second is the page no.)

Johnson, V. R. 924, VII-485	Kleinberg, Jacob 435, VII-189	Linford, Henry 447, VII-150
Johnson, Virgil R. 1568, VII-487	Knight, S. B. 312, VII-238	Lingafelter, E. C. 684, VII-683
Jonassen, H. B. 18, VII-219	Kolthoff, I. M. 602, VII-197	Lippincott, Ellis R. 846, VII-259
Kaplansky, Irving 1194, VII-707	Kraus, Gerard 4, VII-111	Long, F. A. 378, VII-303
Kaslow, C. E. 225, VII-164	Krinsky, Albert 736, VII-493	Lonseth, A. T. 452, VII-437
Kassner, J. L. 658, VII-254	Kuczynski, G. C. 491, VII-547	Lord, R. C. 5, VII-217
Katz, Ernst 329, VII-73	Kuerti, G. 1082, VII-771	Lucas, H. J. 729, VII-287
Keirs, Russell J. 841, VII-680	Lane, Frank 1115, VII-441	Luther, H. A. 851, VII-425
Kerker, Milton 501, VII-214	Lee, Samuel H., Jr. 613, VII-674	MacKenzie, Scott 875, VII-291
Kezios, Stothe P. 940, VII-749	Leffler, J. E. 155, VII-226	Macon, Nathaniel 1278, VII-442
Kharasch, Norman 417, VII-279	Leighton, Walter 390, VII-349	Madow, W. G. 460, VII-445
King, A. J. 100, VII-163	Letsinger, Robert L. 828, VII-288	Majors, Harry, Jr. 1230, VII-759
King, Cecil V. 869, VII-153	Levedahl, W. J. 712, VII-137	Maloney, J. O. 117, VII-115
King, R. M. 366, VII-118	Levinstein, Henry 667, VII-658	Maltzman, Irving 450, VII-491
Kisslinger, Fred 629, VII-573	Lewis, Bernard 1515, VII-733	Mann, D. E. 781, VII-128
Klee, V. L. 1014, VII-717	Lieber, Paul 788, VII-527	Manning, L. A. 520, VII-14

INDEX OF CHIEF INVESTIGATORS (Continued)

(Note: The first number is the Proposal No., the second is the page no.)

Marin, Joseph
    78, VII-503
    1288, VII-763

Martus, J. A.
    347, VII-244

Mason, Charles
    423, VII-34

Masur, E. F.
    570, VII-525

Mattice, H. C.
    788, VII-527

McCullough, J. D.
    399, VII-249

McCuskey, S. W.
    482, VII-13

McLeod, N. K.
    1320, VII-463

McNaughton, Robert
    1445, VII-726

Mehl, R. F.
    400, VII-577

Milgram, A. N.
    248, VII-346

Millard, Ben
    547, VII-216

Millman, Jacob
    1581, VII-751

Mingins, Charles R.
    771, VII-103

Moise, E. E.
    410, VII-397

Montgomery, Deane
    1239, VII-714

Moore, Dwight G.
    739, VII-123

Moore, G. A.
    782, VII-579

Morawetz, Herbert
    765, VII-308

Morris, Kelso B.
    340, VII-148

Mostow, George D.
    749, VII-404

Muldawer, Leonard
    287, VII-543

Myers, Phillip S.
    1000, VII-497

Myers, P. S.
    1549, VII-734

Naghdi, Paul M.
    234, VII-752

Nash, Ralph R.
    1315, VII-560

Nash, William A.
    1301, VII-765

Nassau, J. J.
    482, VII-13

Neyman, J.
    1254, VII-453

Nielsen, A. H.
    562, VII-49

Nijenhuis, A.
    943, VII-409

Nikodym, O. M.
    619, VII-358

Norris, C. B.
    465, VII-250

Nowick, Arthur S.
    351, VII-773
    1453, VII-775

Noyce, D. S.
    852, VII-289

Noyes, Richard M.
    615, VII-199

Nyman, Carl J.
    177, VII-229

O'Brien, Brian
    361, VII-74

Ogg, Richard A., Jr.
    1173, VII-694

Olkin, Ingram
    1599, VII-729

Ollom, John F.
    463, VII-46

Orchin, M.
    385, VII-165

Overberger, C. G.
    533, VII-119

Owen, R. B.
    548, VII-253

Parham, William E.
    64, VII-267

Paul, Gordon
    888, VII-710

Peacock, Charles L.
920, VII-655

INDEX OF CHIEF INVESTIGATORS (Continued)

(Note: The first number is the Proposal No., the second is the page no.)

Peck, R. E.
    794, VII-131

Penico, Anthony J.
    626, VII-325

Pepinsky, Ray
    761, VII-101

Phillips, Ralph S.
    715, VII-363
    1362, VII-385

Pierce, William A.
    655, VII-399

Pigford, R. L.
    179, VII-565

Pollard, Harry
    922, VII-372

Pound, G. Marshall
    534, VII-569
    1500, VII-778

Quastler, Henry
    1151, VII-533

Rado, Tibor
    514, VII-420

Ramirez, Fausto
    1252, VII-700

Read, T. A.
    178B, VII-539

Reyerson, L. H.
    723, VII-306

Reynolds, C. A.
    72, VII-185

Richardson, Frances M.
    1562, VII-668

Rickart, Charles
    1222, VII-382

Rigg, M. W.
    205, VII-314

Rightmire, B. G.
    375, VII-743
    665, VII-745
    1142, VII-537

Roberts, Walter Orr
    1050, VII-20

Robertson, Harry S.
    798, VII-55

Rosen, Joseph S.
    508, VII-252

Ross, S.
    306, VII-208

Rubin, Bernard
    742, VII-152

Rubin, Sylvan
    1466, VII-72

Runner, Mervin E.
    592, VII-151

Sachs, George
    1556, VII-780

Saibel, Edward
    1156, VII-746

Samelson, Hans
    720, VII-400

Sard, Arthur
    716, VII-365

Sawyer, Raymond B.
    151, VII-83

Schechter, Samuel
    148, VII-341

Scherer, P. C.
    303, VII-116

Schrieber, Kurt C.
    1464, VII-704

Schubert, W. M.
    483, VII-316

Sears, P. G.
    1454, VII-265

Selberg, Atle
    1239, VII-714

Shaffer, B. W.
    232, VII-501

Shelton, J. Reid
    884, VII-133

Shelton, George R.
    741, VII-126

Sherburne, R. K.
    776, VII-459

Sherwood, Thomas K.
    887, VII-666

Shull, C. G.
    1623, VII-109

Simons, J. H.
    158, VII-79

Sisler, H. H.
    222, VII-231

Smith, Frank C.
    572, VII-4

Smith, Fred
    544, VII-663

INDEX OF CHIEF INVESTIGATORS (Continued)

(Note: The first number is the Proposal No., the second is the page no.)

INDEX OF CHIEF INVESTIGATORS (Continued)

(Note: The first number is the Proposal No., the second is the page no.)

SUBJECT INDEX

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

Abelian Groups 855, VII-331
Abelian Integrals 444, VII-352
Abelian Subalgebras 950, VII-333
Abelian Varieties 1239, VII-714
Absorption Spectra 658, VII-254
Accelerators
    SEE Particle Accelerators
Accelerometers
    Applications 737, VII-535
Accommodation Coefficients 794, VII-131
Acetic Acid 586, VII-195
Acetic Anhydride 155, VII-226; 586, VII-195
Acetone
    Diffusion 378, VII-303
Acetonitrile 592, VII-151; 695, VII-688
Acetophenone 841, VII-680; 852, VII-289
Acetyl Fluoride 367, VII-275
Acetylene
    Combustion 776, VII-459
    Spectra 562, VII-49
Acetylene Flame 175, VII-45; 642, VII-52
Acetylenes 115, VII-220
Acoustic Birefringence 270, VII-1
Acylation 367, VII-275; 735, VII-698
Adhesion 465, VII-250
Adhesives 465, VII-250
Adiabatic Reactions 664, VII-669
Adipic Acid 204, VII-204
Adjustable-Speed Drive 1155, VII-499
Admissibility 460, VII-445
Aerosols 501, VII-214
Air
    Heat Conductivity 794, VII-131
Airfoils
    Mathematical Analysis 925, VII-374
Alcohols 1087, VII-692
    Synthesis 69, VII-272
Aldol Condensation 852, VII-289
Aldoximes 69, VII-272
Algebra
    Theory 640, VII-236; 708, VII-389; 1040, VII-335; 1239, VII-714
    See also Banach Algebras
            Cartan Subalgebras
            Commutative Algebra
            Group Algebra
            Jordan Algebras
            Involutorial Algebras
            Linear Algebra
            Matrix Algebra
            Operator Algebra
            Vector Algebras

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

Algebraic Functions 885, VII-406
Algebraic Geometry 885, VII-406
Algebraic Isomorphisms 950, VII-333
Algebras
    Structure 626, VII-325; 1040, VII-335
Alicyclic Compounds 735, VII-698
Alicyclic Azides 87, VII-159; 948, VII-178
Aliphatic Alcohols 1087, VII-692
Alkali Halides 341, VII-242; 1087, VII-692
    Luminescence 384, VII-246
Alkali Superoxides 435, VII-189
Alkaline Earth Metals
    Peroxides 97, VII-161; 100, VII-163
Alkaline Earth Metals
    Superoxides 97, VII-161
Alkanesulfonates 684, VII-683
Alkyl Azides 948, VII-178
Alkyl Halides 1087, VII-692
    Reactions 828, VII-288
Alkyl Nitrites 1173, VII-694
Alkyl Sulfates 684, VII-683
Alkylation 69, VII-272; 590, VII-286
Alkynes 417, VII-279
Allene 5, VII-217
    Spectra 562, VII-49
Alloys
    Diffusion 703, VII-98
    Elasticity 178B, VII-539
    Heat Treatment 629, VII-573
    Internal Friction 178B, VII-539
    Ordering 351, VII-773; 491, VII-547; 568, VII-571; 1285, VII-777
    Oxidation 499, VII-567
    Phase Changes 703, VII-98
    Scaling 499, VII-567
    Transformations 287, VII-543
    Thermoelectricity 779, VII-575
Allylamine 765, VII-308
Allylic Esters 483, VII-316
Aluminum 178B, VII-539
    Heat of Absorption 204, VII-204
    Internal Friction 79, VII-506
    Polygonization 688, VII-554
    Structure 644, VII-558
    Subgrain Structure 688, VII-554
    Ultraviolet Absorption 392, VII-656
Aluminum Alloys 345, VII-552; 1453, VII-775; 1500, VII-778
    Anisotropy 313, VII-514
    Diffusion 703, VII-98

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

Aluminum Alloys (continued)
    Internal Friction 79, VII-506
    Properties 738, VII-494; 1288, VII-763
    Stress Analysis 78, VII-503; 231, VII-512; 234, VII-752;
        1288, VII-763
Aluminum Catalysts 1107, VII-294
Aluminum Compounds
    Structure 1509, VII-107
Aluminum Films 833, VII-76
Aluminum Halides 425, VII-187
Aluminum Isotopes
    Decay 808, VII-67
Aluminum Oxide 833, VII-76
Aluminum Powder
    Combustion 916, VII-176
Amides
    Dielectric Constants 341, VII-242
    Dipole Moments 341, VII-242
    Hydrolysis 67, VII-311
    Structure 684, VII-683
Amines 509, VII-190; 762, VII-318
    Complex Compounds 177, VII-229
    Fluorination 68, VII-270
    Properties 380, VII-277
    Reactions 69, VII-272; 380, VII-277
    Synthesis 729, VII-287
Amino Acids 525, VII-685; 1454, VII-265
Aminotoluenes 948, VII-178
Ammonia 574, VII-665; 1173, VII-694; 1245, VII-179
    Oxidation 763, VII-168
    Reactions 751, VII-201
Ammonium Bromide
    Solubility 695, VII-688
Ammonium Halides 341, VII-242
Ammonium Salts 155, VII-226; 1173, VII-694
Analysis of Variance 672, VII-447
    See also Multivariate Analysis
Analytic Functions 497, VII-354; 516, VII-356; 888, VII-710
Analytic Structures 1503, VII-721
Anelasticity 1453, VII-775
Anemometers 759, VII-479; 760, VII-737; 877, VII-495
Anilinium 155, VII-226
Anisaldehyde 852, VII-289
Anisotropy 313, VII-514
Anodes 485, VII-672
Anodic Films 485, VII-672
Anolytes 485, VII-672
Antennas 1013, VII-649

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

Antimony
    Quadrupole Moment Spectra 308, VII-86
Antimony Alloys
    Properties 738, VII-494
    Thermoelectricity 779, VII-575
Antimony Isotopes
    Decay 808, VII-67; 920, VII-655
Antioxidants 884, VII-133
Antiozonants 884, VII-133
Appell Polynomials 516, VII-356
Applied Mathematics Seminar 1823, VII-723
Applied Mechanics Congress 1310, VII-534
Approximation 716, VII-365; 922, VII-372
Argon
    Heat Conductivity 794, VII-131
    Properties 539, VII-27
    Spectra 488, VII-48
Aromatic Compounds
    Spectra 658, VII-254
Aroyl Chlorides 69, VII-272
Arsenic
    Analytical Methods 72, VII-185
    Quadrupole Moment Spectra 308, VII-86
α-Arylalkyl Chlorides 69, VII-272
Asteroids 561, VII-22
Astronomy
    Instrumentation 1072, VII-643
Atmosphere
    Density 328, VII-9
    Ionization 520, VII-14
    Properties 587, VII-16
    Temperature 328, VII-9
Attapulgite 306, VII-208
Austenite 202, VII-549; 534, VII-569: 629, VII-573; 1500, VII-778
Automation 1529, VII-731
Automorphisms 1040, VII-335
Azides
    Structure 761, VII-101
Azides (Organic) 87, VII-159; 613, VII-674; 948, VII-178
Azidocarbonyl Compounds 87, VII-159; 948, VII-178
Azines 533, VII-119
Azo Compounds 533, VII-119
Azulenes
    Synthesis 417, VII-279

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
       Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
       Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
      Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
      Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
       Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
       Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
       Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
       Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

Note: The first number following each subject heading is the Proposal
      Number, the second is the page number.

Note: The first number following each subject heading is the Proposal
      Number, the second is the page number.

SUBJECT INDEX.(Continued)

Note: The first number following each subject heading is the Proposal
      Number, the second is the page number.

Ligands 347, VII-244
Light
      Atmospheric Attentuation 844, VII-174
Light Scattering Functions 501, VII-214
Lime 740, VII-124
      Applications 111, VII-113
Limit Problems 1238, VII-433
Lin Operation 1014, VII-717
Linear Algebra 497, VII-354; 1194, VII-707
Linear Algebraic Equations 1089, VII-724
Linear Differential Equations 246, VII-343; 390, VII-349
Linear Equations 956, VII-378; 1357, VII-338
Linear Functionals 1014, VII-717
Linear Integral Equations 452, VII-437
Linear Molecules
      Spectra 115, VII-220
Linear Operators 1476, VII-411
Linear Spaces 1476, VII-411
Linear Systems 885, VII-406
Liquids
      Dielectric Properties 1087, VII-692
      Diffusion 403, VII-705
      Equations of State 664, VII-669; 874, VII-531
      Properties 270, VII-1; 289, VII-3; 525, VII-685; 664, VII-669;
                  674, VII-646; 686, VII-6
      Structure 868, VII-6
      Transport Properties 403, VII-705; 874, VII-531
Lithium 751, VII-201
Lithium Chloride 341, VII-242; 525, VII-685
Lithium Compounds
      Solubility 300, VII-237; 1394, VII-697
Lithium Compounds (Organic) 828, VII-288
Lithium Hydride 916, VII-176
Lithium Hydroxide 425, VII-187; 967, VII-690
Lithium Stearate Greases 1237, VII-263
Logarithmic Potential Functions 867, VII-368
Logic
      SEE Mathematical Logic
Low Temperature Research
      SEE Cryogenics
Lubricants 1464, VII-704
      Adsorption 457, VII-212
      Properties 924, VII-485
      Synthesis 82, VII-203
      Thickeners 306, VII-208
Lubrication 1156, VII-746; 1568, VII-487
      See also Gear Lubrication

VII - 838

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
      Number, the second is the page number.

Lucite
      Properties 79, VII-506
Luminescence 384, VII-246
Lustrex
      Properties 79, VII-506
Lutecium Isotopes 767, VII-41
      Decay 931, VII-68

Machining 232, VII-501
Magnesia 740, VII-124
Magnesium
      Creep 1315, VII-560
Magnesium Alloys 287, VII-543
      Creep 1315, VII-560
      Properties 1285, VII-777
      Stress Analysis 78, VII-503
Magnesium Complexes 347, VII-244
Magnesium Hydroxide 967, VII-690
Magnesium Powder
      Combustion 916, VII-176
Magnetohydrodynamics 1823, VII-723
Magnus Effect 1082, VII-771
Maleic Anhydride
      Hydrogenation 1558, VII-297
Manganese
      Complex Ions 18, VII-219
      Determination 615, VII-199
      Meson Capture 445, VII-24
Manganese Alloys 499, VII-567; 534, VII-569
Manganese Carbonyls 1277, VII-696
Manganese Complexes 347, VII-244
Manifolds (Mathematics) 258, VII-347; 266, VII-395; 410, VII-397;
                  720, VII-400; 943, VII-409; 1106, VII-380;
                  1503, VII-721
Manich Reaction 380, VII-277
Manufacturing Systems
      Mathematical Analysis 1529, VII-731
Mappings 1014, VII-717
      See also Conformal Mapping
Markov Chains 1254, VII-453

VII - 839

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
       Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
       Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
      Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
      Number, the second is the page number.

Note: The first number following each subject heading is the Proposal
      Number, the second is the page number.

Note: The first number following each subject heading is the Proposal
      Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
       Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
       Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

Propionic Acids
    Chelation 347, VII-244
Propionitrile
    Fluorination 68, VII-270
Propylene 5, VII-217
    Combustion 776, VII-459
Propylsodium
    Reactions 828, VII-288
Protective Coatings
    SEE Coatings, Protective
Protons
    Scattering 1466, VII-72
Psychomotor Tests 450, VII-491
Pulse Counting 492, VII-36
Pyridine 310, VII-301
    Complex Compounds 177, VII-229
    Derivatives 312, VII-238
    Spectra 312, VII-238
Pyrimidine 571, VII-284
Pyrometers 1549, VII-734
γ-Pyrone 5, VII-217
Pyrotechnics 844, VII-174

Quadratic Functionals 390, VII-349
Quadrupole Moment Spectra 308, VII-86
Quantum Electrodynamics 293, VII-57
Quantum Theory 1371A, VII-455
Quinoline 312, VII-238
Quinuclidine 10, VII-155

RDX
    Detonation 423, VII-34
Racemization 875, VII-291
Radiation
    Detection 316, VII-23; 377, VII-33; 392, VII-656; 445, VII-24;
                757, VII-41
Radioactive Dating Techniques 757, VII-41
Radioactive Nuclei
    Decay 408, VII-653; 808, VII-67; 931, VII-68
Radioactive Tracers 869, VII-153; 1562, VII-668
Radiocarbon 767, VII-41
Radiography 565, VII-39
Radioisotopes 767, VII-41
Raman Spectra 5, VII-217; 115, VII-220; 669, VII-255
Random Current 1254, VII-453
Raney Catalysts 1107, VII-294

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

Raney Nickel 204, VII-204; 1258, VII-702
Rare Gases
    Analysis 488, VII-48
    Purification 488, VII-48
Raschig Synthesis 1245, VII-179
Rearrangement Reactions 69, VII-272; 483, VII-316
Rectangular Distribution 460, VII-445
Rectifier Nets 1445, VII-726
Red Giant Stars 482, VII-13
Redox Reactions
    SEE Oxidation-Reduction Reactions
Reduction of Order Theorem 690, VII-361
Reflective Coatings 833, VII-76
Reformatsky Reaction 69, VII-272
Refractometers 1322, VII-105
Refractory Materials 111, VII-113
Reisz Theory 860, VII-366
Relativity 154, VII-415; 1119, VII-431
Relaxation 351, VII-773
Reliability 1550, VII-728
Resins
    SEE Chelate Resins
        Ion Exchange Resins
Resistors
    Temperature Factors 736, VII-493
Riccati Equations 956, VII-378
Riemann Spaces 154, VII-415; 258, VII-347; 943, VII-409; 1239, VII-714
Riemann Surfaces 444, VII-352
Riemann-Roch Theorem 444, VII-352
Rijke Tube 355, VII-472
Ring Expansion Joints 854, VII-427; 1409, VII-435
Rings (Mathematics) 626, VII-325; 730, VII-329; 1194, VII-707;
                      1222, VII-382
    See also Jordan Rings
             Lie Rings
             Pontryagin Rings
Rock Salt 178B, VII-539
Rockets
    Vibration 737, VII-535
Rods
    Stresses 526, VII-524
Rotating Disc Experiment 313, VII-514
Rubber
    Aging 884, VII-133
    Oxidation 884, VII-133
    Properties 884, VII-133

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

Note: The first number following each subject heading is the Proposal
      Number, the second is the page number.

Note: The first number following each subject heading is the Proposal
      Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal Number, the second is the page number.

SUBJECT INDEX (Continued)

Note: The first number following each subject heading is the Proposal
Number, the second is the page number.

DISTRIBUTION LIST

Distribution of Volume II, part 2 of the Annual
Consolidated Report on Research and Development Proj-
ects, Department of the Army Project 599-01-004,
Ordnance Basic Research, is being effected in accord-
ance with the Distribution List contained in Volume
1.