NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Bibliography 39-7

Publications
of the
Jet Propulsion Laboratory
July 1965 through June 1966

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

December 15, 1966

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JET PROPULSION LABORATORY

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December 15, 1966

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Foreword

JPL Bibliography 39-7 is a compilation of official reports of the Jet Propulsion Laboratory released July 1, 1965 through June 30, 1966. Current security classifications of all documents are indicated; however, their titles and abstracts given herein are unclassified. JPL reporting in the open literature is also included.

Jet Propulsion Laboratory reports may be requested by either entry or report number. When ordering classified documents, the government contract under which they will be used should be indicated, and requests forwarded to JPL via the cognizant contracting officer for certification of security clearance and "need-to-know." Copies of unclassified reports are available upon direct request to the Laboratory.

Contents

Technical Reports and Memorandums

Technical Reports are designed to report on a single significant development, on the completion of a recognizable phase, or on the completion of an entire project, or may record data or a development growing out of an assigned project but not directly related to it.

Technical Memorandums report the results of a special study of a problem, provide preliminary information on a project, or present any other material which is intended for a limited audience.

Adams, J. B.

A01 THE UTILITY OF UNMANNED PROBES IN LUNAR SCIENTIFIC EXPLORATION
Speed, R. C., Nash, D. B., Adams, J. B.
Technical Memorandum No. 33-241, July 15, 1965
(Unclassified)

For abstract, see Entry S25.

Adams, J. L.

A02 THE JPL HIGH-IMPACT PROGRAM—1965
Adams, J. L.
Technical Report No. 32-844, February 1, 1966
(Unclassified)

This Report summarizes the progress of the JPL High-Impact Survival Program since September, 1964. During this period, impact work has increased in intensity at JPL because of such efforts as the *Voyager* landing capsule and the *Surveyor* critical data recorder. Specific efforts underway include the investigation of mechanism elements and electronic packaging techniques under impact and the development of a ruggedized gas chromatograph, an impact-resistant 3-w solid-state S-band transmitter, impact-resistant flat-plate batteries, and ruggedized antennas. The JPL development goal has remained the survival of a 10,000-g impact. Preimpact velocities up to 500 ft/sec are under consideration in order to cover possible Mars hard-landing situations. Test facilities have been developed in order to provide the necessary velocities. This Report presents the status of these various efforts along with experimental results where pertinent. It should be noted that this Report is concerned only with impacts in which the impact velocity is well below wave propagation velocities.

Allen, J. D.

A03 MARINER IV PHOTOGRAPHY OF MARS: INITIAL RESULTS
Allen, J. D., et al.
Technical Report No. 32-890 (Unclassified)
(Reprinted from *Science*, *Vol. 149, No. 3684,* August 6, 1965, pp. 627–630)

The 22 photographs of Mars taken by *Mariner IV* have been successfully received on Earth. The Martian surface photographed is rather densely populated with impact craters whose sizes range up to at least 120 kilometers in diameter. It is inferred that the visible Martian surface is extremely old and that neither a dense atmosphere nor oceans have been present on the planet since the crater surface was formed.

Anderson, F. A.

A04 PROPERTIES AND PERFORMANCE OF THE JPL-533 PROPELLANT
Anderson, F. A.
Technical Memorandum No. 33-135, December 1, 1965
(Confidential)

This document summarizes the method of manufacturing and processing the JPL-533 propellant. It also discusses the physical, ballistic, and thermodynamic properties of this propellant.

A05 PROPERTIES AND PERFORMANCE OF THE JPL-534 PROPELLANT
Anderson, F. A.
Technical Memorandum No. 33-136, December 1, 1965
(Confidential)

This document summarizes the method of manufacturing and processing the JPL-534 propellant. It also includes a discussion of the physical, ballistic, and thermodynamic properties of this propellant.

Anderson, H. R.

A06 MARINER IV MEASUREMENTS NEAR MARS: INITIAL RESULTS
Anderson, H. R., et al.
Technical Report No. 32-833, November 30, 1965
(Unclassified)

This Report is a general discussion of *Mariner IV* and the measurements performed by the spacecraft during its flight in the vicinity of the planet Mars.

The discussion concerns itself with six aspects of the flight: (1) spacecraft description and encounter sequence; (2) the absence of Martian radiation belts and the implication thereof; (3) the search for trapped electrons and a magnetic moment at Mars; (4) zodiacal dust; (5) magnetic field measurements; (6) occultation experiment: results of the first direct measurement of Mars' atmosphere and ionosphere.

Anderson, J. D.

**A07 CHARACTERISTICS AND FORMAT OF THE
TRACKING DATA TO BE OBTAINED BY THE
NASA DEEP SPACE INSTRUMENTATION
FACILITY FOR LUNAR ORBITER**
Lorell, J., Anderson, J. D., Sjogren, W. L.
Technical Memorandum No. 33-230, June 15, 1965
(Unclassified)

For abstract, see Entry L19.

Anderson, T. O.

**A08 DEMONSTRATION OF A QUANTILE SYSTEM FOR
COMPRESSION OF DATA FROM DEEP SPACE
PROBES**
Anderson, T. O., Eisenberger, I., Lushbaugh, W. A.,
Posner, E. C.
Technical Report No. 32-772, December 1, 1965
(Unclassified)

The theory and design of an advanced engineering prototype of a quantile system of data compression for space telemetry are described. The basic idea is to transmit a few *quantiles* (or percentage points, as they are sometimes called) of a histogram of experimental values formed aboard a spacecraft. Only these quantiles are transmitted to Earth, and yet a large part of the information that was contained in the original histogram can be reconstructed on Earth. Compression ratios on the order of 100 to 1 are obtainable at 100% efficiency with a simple device that performs no on-board arithmetic operations.

After summarizing the theoretical background governing the use of quantiles, what the design considerations of such a system should be are considered. Data compression ratios are computed for a typical application of the quantile system. The detailed description of the advanced engineering quantile system that has been built at Jet Propulsion Laboratory is discussed; in addition, a block diagram is given and analyzed. An important feature of the quantile system is its self-adaptive features; these are studied. Examples are given whereby quantile systems for compressing telemetry data can find application in civilian technology. Finally, experimental results using the constructed system are given.

Arms, R. J.

**A09 LOCALIZED-INDUCTION CONCEPT ON A
CURVED VORTEX AND MOTION OF AN
ELLIPTIC VORTEX RING**
Arms, R. J., Hama, F. R.

Technical Report No. 32-731 (Unclassified)
(Reprinted from *The Physics of Fluids*, Vol. 8, No. 4, April 1965, pp. 553–559)

The localized-induction concept for the induction effect of a smooth curved vortex on itself is derived. This is an approximation applicable to the limiting case of a vortex filament of infinitesimal core size and of negligible long-distance effect, and has been successfully utilized in the investigations of the motion and deformation of a curved vortex filament given various initial configurations. Two theorems obtained under this concept are that the arc length of a vortex filament and the projected area of a closed vortex filament are both invariant with respect to time. These theoretical predictions are examined by a numerical analysis of the motion of an initially plane elliptic vortex ring of various eccentricities.

Ashkenas, H.

**A10 EXPERIMENTAL METHODS IN RAREFIED GAS
DYNAMICS: THE STRUCTURE AND UTILIZATION
OF SUPERSONIC FREE JETS IN LOW DENSITY
WIND TUNNELS**
Ashkenas, H., Sherman, F. S.
Technical Report No. 32-869 (Unclassified)
(Reprinted from *Rarefied Gas Dynamics*, Vol. 2, 1966, pp. 84–105)

The aim of this paper is to give a concise and easily employed guide to the results of the theory of inviscid and slightly viscous flow in the central core of a supersonic free jet; to give a résumé and confirmation of experimental results concerning the location of shock waves at high Reynolds number; to apply this information to the prediction of jet sizes and the Mach and Reynolds number ranges corresponding to various pumping systems; and to give a preliminary experimental description of the manner in which the jet flow itself undergoes transition from an inviscid-continuum flow to a free-molecular flow as the orifice Reynolds number decreases.

Aviziensis, A.

**A11 A STUDY OF THE EFFECTIVENESS OF FAULT-
DETECTING CODES FOR BINARY ARITHMETIC**
Aviziensis, A.
Technical Report No. 32-711, May 15, 1965
(Unclassified)

The effectiveness of a class of low-cost fault-detecting codes for binary arithmetic is investigated. Causes of arithmetical errors are studied, and error magnitudes are related to logic faults and to the arithmetic algorithms of the processor. The effectiveness of the fault-detecting codes is considered for three types of logic faults. Cases of one-use and of repeated use of the faulty logic element during an algorithm are investigated separately. Fault location and the application of several check factors are developed as extensions of the fault-detecting algorithm.

Back, L. H.

B01 PREDICTION OF HEAT TRANSFER FROM LAMINAR BOUNDARY LAYERS WITH EMPHASIS ON LARGE FREE-STREAM VELOCITY GRADIENTS AND HIGHLY COOLED WALLS
Back, L. H., White, A. B.
Technical Report No. 32-728, April 1, 1965
(Unclassified)

Laminar boundary layer heat transfer and shear stress predictions from existing similarity solutions are extended to perfect gas flows, with a large free-stream velocity gradient parameter β and variable density–viscosity product $\rho\mu$ across the boundary layer resulting from a highly cooled wall. The dimensionless enthalpy gradient at the wall g'_w, to which the heat flux is related, is found not to vary appreciably with β. Thus, the application of similarity solutions on a local basis, to predict heat transfer from accelerated flows to an arbitrary surface, may be a reasonable approximation involving a minimum amount of calculation time. Unlike g'_w, the dimensionless velocity gradient at the wall f'_w, to which the shear stress is related, is strongly dependent on β.

B02 LAMINAR BOUNDARY-LAYER HEAT TRANSFER FROM A PARTIALLY-IONIZED MONATOMIC GAS BY THE SIMILARITY APPROACH
Back, L. H.
Technical Report No. 32-867, December 15, 1965
(Unclassified)

Laminar boundary-layer heat transfer from a singly-ionized monatomic gas to a highly cooled wall, with no applied external electric or magnetic fields, is analyzed by the similarity solution approach. The gas is assumed to be electrically neutral with ambipolar diffusion by ion-electron pairs. In addition, equal electron and atom-ion temperatures are assumed, and sheath effects are not considered. From existing perfect gas similarity solutions, the number of parameters that need to be investigated is reduced to those directly related to ionization effects. Solutions for the limiting cases of a large diffusion rate compared to the net production rate of ions, and for local equilibrium, are obtained for constant Prandtl number and a range of Lewis numbers. An approximation prediction method is then suggested to account for variable free-stream velocity and ionization effects in a flow over a highly cooled wall.

Barath, F. T.

B03 THE HIGH-ALTITUDE ROCKET RADAR PROJECT
Brown, W. E., Jr., Barath, F. T., Jordan, R. L.,
Laderman, A., Martin, D. P., Friedman, H. L., Gutierrez, R.
Technical Memorandum No. 33-196, June 15, 1965
(Unclassified)

For abstract, see Entry B30.

Barber, T. A.

B04 SYSTEMS COMPARISON OF DIRECT AND RELAY LINK DATA RETURN MODES FOR ADVANCED PLANETARY MISSIONS
Barber, T. A., Billy, J. M., Bourke, R. D.
Technical Memorandum No. 33-228, February 15, 1966
(Unclassified)

This Report analyzes advanced planetary missions using a *Saturn IB* and simultaneous orbiting and landing spacecraft. An analysis of the relative data return capability of two alternate modes is given. One mode, the relay link, uses transmission of the lander produced data to a planetary relay communications satellite, then transmission to the Earth; the other, the direct link, uses transmission directly from the lander to the Earth. Numerical results are given for sample advanced planetary missions to Mars.

Barth, C. A.

B05 ULTRAVIOLET SPECTROSCOPY OF PLANETS
Barth, C. A.
Technical Report No. 32-822, December 1, 1965
(Unclassified)

The ultraviolet spectrum of a planet is produced by the following physical processes: (1) dayglow, the scattering of solar photons by atoms and molecules in the upper atmosphere of the planet; (2) daylight, the combination of Rayleigh scattering of solar radiation and absorption by atmospheric constituents that produces the planetary albedo in the ultraviolet; and (3) electron excitation, the excitation of atoms and molecules in the upper atmosphere by auroral electrons and by photoelectrons.

A quantitative description of each of these processes is given. The atoms and molecules that are prominent in planetary ultraviolet spectra are listed. Calculations are given of planetary molecular emission spectra that are the result of optically thin and optically thick fluorescent scattering and of excitation by auroral bombardment and by photoelectrons. Rocket measurements of the dayglow spectrum of the Earth are given for the spectral region between 2000 and 4000 Å. The main spectral features are the nitric oxide gamma bands, the ionized molecular nitrogen first negative bands, and the nitrogen second positive bands. A rocket measurement of the Earth's ultraviolet albedo between 1900 and 3200 Å is also given. This spectrum shows the absorption produced by ozone in the Earth's atmosphere.

Bastow, J. G.

B06 PROCEEDINGS OF THE MAGNETICS WORKSHOP MARCH 30–APRIL 1, 1965
Bastow, J. G.
Technical Memorandum No. 33-216, September 15, 1965
(Unclassified)

This Magnetics Workshop was concerned with the magnetic control of spacecraft. It was sponsored by the National Aero-

nautics and Space Administration and was presented at the Jet Propulsion Laboratory in Pasadena, California, from March 30 to April 1, 1965.

NASA Headquarters decided to convene this Magnetics Workshop because the need was seen to bring together the various independent groups distributed throughout the country who are concerned with the magnetic properties of spacecraft. Encouragement was offered them to discuss their particular experiences, to exchange ideas, and to provide the opportunity for other groups who are entering this field to be brought up-to-date on the state of the art. In planning this agenda, by means of a working group consisting of representatives from NASA Headquarters, JPL, and NASA's Ames and Goddard Centers, it became perfectly obvious that the topic could not be thoroughly covered in one 3-day workshop. The meetings in turn would stimulate new approaches to old problems. Therefore, it was decided not to attempt to cover the entire field at this time, but to contemplate additional workshops to be held in the future at NASA centers.

B07 MARINER-MARS SPACECRAFT MAGNETIC CONTAMINATION STATUS REPORT
Bastow, J. G.
Technical Memorandum No. 33-261, December 15, 1965
(Unclassified)

Magnetic mapping results of more than 1900 items of the *Mariner-Mars* spacecraft are tabulated in this Report.

Bauman, A. J.

B08 SOME DESIGN CONSIDERATIONS, LARGE EXPULSION BLADDERS FOR NITROGEN TETROXIDE AND HYDRAZINE
Bauman, A. J.
Technical Report No. 32-862, January 15, 1966
(Unclassified)

The problems of chemical compatibility, permeation and folding of bladders are discussed in the context of the requirements of the advanced liquid propulsion systems (ALPS). An extensive review of the literature on subjects pertinent to these problems is summarized. Several experiments are described in which bladder materials were permeated by the fuel and oxidizer, and the meaning of the results discussed. Folded paper models illustrating some attempts to find a scheme for collapsing bladders in a controlled manner are shown; none were found suitable for the ALPS application. Three appendixes review the status of knowledge concerning oxidization resistance and permeation of polymers and the nature of teflon. A lengthy bibliography and list of references are included.

Beattie, W. H.

B09 EXPERIMENTAL PROCEDURES FOR MOLECULAR WEIGHT DETERMINATION BY LIGHT SCATTERING
Beattie, W. H., Laudenslager, R. K., Moacanin, J.

Technical Memorandum No. 33-242, January 1, 1966   ·
(Unclassified)

The experimental procedures for determining molecular weights of polymers from the angular dependence of light scattering are described in detail. A Brice-Phoenix light scattering photometer, which was modified to optimize its performance, was used to study the molecular weight of a sample of polystyrene distributed by the National Bureau of Standards. Results of the study are given.

Beaudet, R. A.

B10 MICROWAVE SPECTRUM, STRUCTURE, AND DIPOLE MOMENT OF 2, 4-DICARBAHEPTABORANE (7)
Beaudet, R. A., Poynter, R. L.
Technical Report No. 32-823 (Unclassified)
(Reprinted from *The Journal of Chemical Physics, Vol. 43, No. 7*, October 1965, pp. 2166–2170)

The microwave spectra of all monosubstituted carbon and boron isotopic forms, and one disubstituted boron isotopic form of 2, 4-dicarbaheptaborane (7) have been analyzed. The skeletal boron and carbon atomic coordinates determined from the rotational constants show that the molecule is a pentagonal bipyramid. The two carbon atoms lie in the pentagonal base plane and are separated by one boron atom. The two apex boron atoms appear to lie on, or very near the C axis which is perpendicular to the pentagonal base. A molecule-dipole moment of 1.32 $\pm$ 0.03 D is oriented along the planar symmetry axis.

Benedict, A. G.

B11 TABLES OF TWO-SIDED TOLERANCE FACTORS FOR NORMAL DISTRIBUTIONS
Chamberlain, R. G., Benedict, A. G.
Technical Memorandum No. 33-217, June 15, 1965
(Unclassified)

For abstract, see Entry C07.

Benson, S. W.

B12 THEORY OF THE LOW-TEMPERATURE CHROMATOGRAPHIC SEPARATION OF THE HYDROGEN ISOTOPES
King, J., Jr., Benson, S. W.
Technical Report No. 32-870 (Unclassified)
(Reprinted from *The Journal of Chemical Physics, Vol. 44, No. 3*, February 1966, pp. 1007–1014)

For abstract, see Entry K12.

B13 ELECTROSTATIC INTERACTIONS IN GAS-SOLID CHROMATOGRAPHY
King, J., Jr., Benson, S. W.
Technical Report No. 32-905 (Unclassified)

(Reprinted from *Analytical Chemistry*, Vol. 38, No. 2, February 1966, pp. 261–265)

For abstract, see Entry K13.

Bentley, K. E.

B14 DETECTION OF LIFE-RELATED COMPOUNDS ON PLANETARY SURFACES BY GAS CHROMATOGRAPHY-MASS SPECTROMETRY TECHNIQUES
Bentley, K. E., Giffin, C. E., Whitten, D. G., Wilhite, W. F.
Technical Report No. 32-713 (Unclassified)
(Reprinted from the *AAS Science and Technology Series*, Vol. 2, 1964, pp. 93–117)

An important scientific objective of the unmanned exploration of the planets is the quest for life on other planets. Included in the biological experiments being developed is the analysis of planetary soil for life-related compounds. This paper describes the program in progress at the Jet Propulsion Laboratory to develop a system using a gas chromatograph and mass spectrometer in series to perform this analysis. The article explores the relative merits of this approach; also background information in areas of pyrolysis, gas chromatography miniaturization, sample enrichment devices, and mass spectrometry miniaturization is given.

B15 PYROLYSIS STUDIES. CONTROLLED THERMAL DEGRADATION OF MESOPORPHYRIN
Whitten, D. G., Bentley, K. E., Kuwada, D.
Technical Report No. 32-812 (Unclassified)
(Reprinted from the *Journal of Organic Chemistry*, Vol. 31, 1966, pp. 322–324)

For abstract, see Entry W22.

Bergens, D.

B16 PHOTON-ACTUATED MULTIPLEX SWITCH DEVELOPMENT
Bergens, D.
Technical Report No. 32-794, December 15, 1965 (Unclassified)

A photon-actuated electronic switch has been developed for multiplexing low-level analog signals. The development was done by the Components Division of the International Business Machines Corporation under contract to the Jet Propulsion Laboratory. The device represents a significant advance in this type of solid-state switching in terms of miniaturization, speed, simplicity, and potential reliability.

The switch consists of a gallium arsenide diode, as an infrared light source, and a double-emitter silicon transistor that detects the infrared photons and acts as the switch. Efficient coupling between the diode and the transistor has been achieved. Device development, theoretical considerations, problem areas, and test results are covered.

The Report is a condensation of the final IBM report, supplemented by test results and more user-oriented.

Berson, J. A.

B17 NITROGEN ANALOGS OF SESQUIFULVALENE. II. THEORETICAL CORRELATION OF GROUND-STATE PROPERTIES
Berson, J. A., Evleth, E. M., Jr., Manatt, S. L.
Technical Report No. 32-776 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 13, July 5, 1965, pp. 2901–2907)

The dipole moments of a series of nitrogen anhydro bases and pyridones can be calculated by a modified Hückel technique. The agreement with experimental values is quite good. Despite pronounced bond alteration, the conjugated systems of the anhydro bases have substantial charge separation, a result that is not predicted by considerations of nmr chemical shifts. The relative acidities of the conjugate acids of these substances are not properly predicted by Hückel theory. The large spread in acidities in the series cyclopentadiene, indene, and fluorene is drastically compressed by attachment of a pyridinium nucleus. Much of the effect of annelation of the five-membered ring on the acidities of the anhydro bases of the 2-series seems to be attributable to intramolecular overcrowding in the annelated derivatives, which produces noncoplanarity of the conjugated system.

B18 NITROGEN ANALOGS OF SESQUIFULVALENE. III. THEORETICAL CORRELATION OF EXCITED-STATE PROPERTIES
Evleth, E. M., Jr., Berson, J. A., Manatt, S. L.
Technical Report No. 32-776 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 13, July 5, 1965, pp. 2908–2913)

For abstract, see Entry E11.

Biber, K. W.

B19 DESCRIPTION AND ANALYSIS OF 890-MHz NOISE-MEASURING EQUIPMENT
Biber, K. W., Whittlesey, A. C.
Technical Report No. 32-898, March 31, 1966 (Unclassified)

This Report describes a narrow-band, low-noise system used with the *Ranger* spacecraft system for measuring noise at a frequency of 890.046 MHz $\pm$ 50 kHz. It includes a description of the equipment and its operation, a mathematical evaluation of system performance capabilities and of particular circuit constraints upon system operation, and a procedure for system calibration and operation.

Billy, J. M.

B20 SYSTEMS COMPARISON OF DIRECT AND RELAY LINK DATA RETURN MODES FOR ADVANCED PLANETARY MISSIONS
Barber, T. A., Billy, J. M., Bourke, R. D.
Technical Memorandum No. 33-228, February 15, 1966 (Unclassified)

For abstract, see Entry B04.

Bird, T. H.

B21 LARGE-SCALE LUNAR PHOTOGRAMMETRY
Bird, T. H.
Technical Report No. 32-918 (Unclassified)
(Reprinted from *Photogrammetric Engineering,*
March 1966, pp. 227-233)

With the advent of the *Ranger VII* pictures of the lunar surface, a new area with its challenges and problems is being opened to the photogrammetry profession. Large-scale photography and the resulting mapping tasks are bringing forth some new problems to the attention of photogrammetrists. Investigation of the lunar surface from the lunar surface is a realistic possibility. Utilization of modified terrestrial type camera systems is being considered. Accurate results for interpretation and mapping are being demanded. The problems and solutions being considered are complex and new when compared with conventional photogrammetry. Primary problems lie in areas of: (1) utilization of television presentations; (2) multi-purpose imaging systems; (3) techniques and procedures of calibration; (4) data reduction and mapping techniques for large-scale analysis. Definitive data are needed in maximizing terrestrial types of camera systems in order to obtain the best photogrammetric utilization of coming space exploration projects.

Blank, G. B.

B22 SAMPLING AND HANDLING OF DESERT SOILS
Cameron, R. E., Blank, G. B., Gensel, D. R.
Technical Report No. 32-908, April 15, 1966
(Unclassified)

For abstract, see Entry C02.

Bollman, W. E.

**B23 DESIGN PARAMETERS FOR BALLISTIC
INTERPLANETARY TRAJECTORIES.
PART II. ONE-WAY TRANSFERS TO
MERCURY AND JUPITER**
Clarke, V. C., Jr., Bollman, W. E., Feitis, P. H., Roth, R. Y.
Technical Report No. 32-77, January 15, 1966
(Unclassified)

For abstract, see Entry C10.

Bourke, D. G.

**B24 THE ANALYSIS OF TIME MULTIPLEXING
SYSTEMS FOR PARTIAL SUCCESS**
Bourke, D. G.
Technical Report No. 32-698, January 15, 1965
(Unclassified)

This Report is an attempt to improve analysis methods for time multiplexing systems under partial-success criteria. Results of the analysis are in the form of probability distribution for the number of surviving measurements in a multiplexer configuration. This form of result allows such criteria to be applied as the expected number of measurements, the expected value of the weighted measurements, or the probability that the number of surviving weighted measurements will be greater than some preassigned value.

The analysis for multiplexer configuration is based upon first modeling the basic multiplexer deck. A representative solid-state deck used by the Jet Propulsion Laboratory is used as an example. After the probability distribution of surviving measurements is obtained, its general form is used to extend the analysis to general and more complex multiplexer configurations of more than one deck. Some numerical results are presented and areas for further investigations are discussed.

Bourke, R. D.

**B25 GEOMETRIC ASPECTS OF GROUND
STATION-SATELLITE COMMUNICATIONS**
Bourke, R. D.
Technical Report No. 32-820, October 15, 1965
(Unclassified)

This Report presents a discussion of the geometric aspects of communications between a ground station and a satellite in an elliptic orbit whose line of apsides is fixed. The range to the satellite along a given vector from the ground station is shown to take on, at maximum, two values; a means for calculating these values is presented. In addition, an averaging method is used to develop an expression for the long-term fraction of time a satellite and ground station are covisible. Applications of these results to various communications satellites and ground stations are shown.

**B26 SYSTEMS COMPARISON OF DIRECT AND RELAY
LINK DATA RETURN MODES FOR ADVANCED
PLANETARY MISSIONS**
Barber, T. A., Billy, J. M., Bourke, R. D.
Technical Memorandum No. 33-228, February 15, 1966
(Unclassified)

For abstract, see Entry B04.

Brereton, R. G.

**B27 VENUS: PRELIMINARY SCIENCE OBJECTIVES
AND EXPERIMENTS FOR USE IN
ADVANCED MISSION STUDIES**
Brereton, R. G., et al.
Technical Memorandum No. 33-282, May 1, 1966
(Unclassified)

This Report reviews current knowledge about the planet Venus and describes several scientific objectives and supporting experiments for a 1500-lb *Mariner*-type spacecraft to be flown to the planet in the early 1970's. A combination of flyby and atmospheric-entry-capsule mission appears to best satisfy the scientific requirements for the mission.

Brois, S. J.

B28 THE RELATIVE SIGNS OF THE NUCLEAR
MAGNETIC RESONANCE PROTON–PROTON
COUPLING CONSTANTS IN STYRENE
SULFIDE AND STYRENIMINE
Manatt, S. L., Elleman, D. D., Brois, S. J.
Technical Report No. 32-746 (Unclassified)
(Reprinted from the *Journal of the American Chemical
Society, Vol. 87, No. 10,* May 20, 1965, pp. 2220–2225)

For abstract, see Entry M5.

Brooke, C. W., Jr.

B29 DEVELOPMENT OF AN ELECTROCHEMICAL
ENERGY SOURCE FOR THE *MARINER II*
SPACECRAFT
Brooke, C. W., Jr.
Technical Report No. 32-854, March 15, 1966
(Unclassified)

This Report describes in detail the development of an elec-
trochemical energy source for the *Mariner II* spacecraft. The
data presented trace the development of this battery, begin-
ning with the definition of the electrical and mechanical
requirements for the battery and concluding with the telem-
etered data obtained from the battery during 109 days of
spaceflight to Venus. The design changes resulting from the
type approval test program on the development model battery
and the additional changes dictated by the *Mariner II* space-
craft system requirements were combined in the final silver-
zinc battery design.

Brown, W. E., Jr.

B30 THE HIGH-ALTITUDE ROCKET RADAR PROJECT
Brown, W. E., Jr., Barath, F. T., Jordan, R. L.,
Laderman, A., Martin, D. P., Friedman, H. L., Gutierrez, R.
Technical Memorandum No. 33-196, June 15, 1965
(Unclassified)

This Memorandum describes the status of the High-Altitude
Rocket Radar Project at the Jet Propulsion Laboratory. The
purpose of the project is defined; the basic theoretical consid-
erations are presented; and the operational systems and sub-
systems currently being developed, together with some of the
technical problems encountered, are described.

Caltech–JPL

C01 PROCEEDINGS OF THE CALTECH–JPL
LUNAR AND PLANETARY CONFERENCE
SEPTEMBER 13–18, 1965
Caltech–JPL
Technical Memorandum No. 33-266, June 15, 1966
(Unclassified)

The conference which is described in these proceedings was
jointly sponsored by the California Institute of Technology
and the Jet Propulsion Laboratory as a symbol of the close
scholarly relationships between the two organizations, which
have been administratively linked for many years. With the
help of the National Aeronautics and Space Administration,
the conference was held at the California Institute of Tech-
nology, Pasadena, California, September 13–18, 1965, and
brought together more than one hundred and thirty scientists
to discuss recent and current studies of the Moon, Jupiter,
Venus, and Mars. Conference participants came from many
centers of scientific activity in the United States, England,
France, Israel, and the USSR.

Cameron, R. E.

C02 SAMPLING AND HANDLING OF DESERT SOILS
Cameron, R. E., Blank, G. B., Gensel, D. R.
Technical Report No. 32-908, April 15, 1966
(Unclassified)

Variability and characteristics of terrestrial soils and varia-
bility in methods and techniques used in sampling and han-
dling are important factors responsible for discrepancies in
results of investigations on soils. Procedures for soil sampling,
as well as selection of the soil to be sampled, are usually
determined by the purpose for which the soil will be used.
Information is presented for the sequential selection, charac-
terization, and sampling of a desert soil site. Procedures are
recommended and illustrations given for photography of major
features, sterilization of sampling equipment and sample con-
tainers, the collection of desert soils, and their handling, pro-
cessing, storage, shipment, and dispersal. Aseptic technique is
emphasized for the collection and handling of soil samples for
microbiological studies.

Campbell, D. H.

C03 IMMUNOADSORBENTS: PREPARATION AND
USE OF CELLULOSE DERIVATIVES
Campbell, D. H., Weliky, N.
Technical Report No. 32-900, May 1, 1966
(Unclassified)

Chemicals, biochemicals, and biological materials that com-
bine or complex specifically with insoluble substances can be
isolated from mixtures by combination with these insoluble
substances followed by dissociation under conditions that do
not significantly alter the properties of interest of the desired
materials. Antibodies (i.e., proteins of immunity that are syn-
thesized by animals and humans and react specifically with
foreign macromolecules) can be isolated from the blood by
directly linking these foreign macromolecules (antigens), or
small portions of them (haptens), by chemical bonds to insol-
uble cellulose derivatives and using these insoluble substances
(immunoadsorbents) to complex with, and remove antibodies
from, the other components of blood serum or plasma. Methods
are described in detail for performing these operations, and
precautions are discussed for avoiding difficulties in applying
these methods to different adsorbents and different antigen–
antibody systems. Many antibodies can be isolated in greater
than 90% yield and purity.

A brief review is given of the history of the insoluble ad-
sorbent technique and its effectiveness and applicability for

the isolation of antibody, antigens, and the study of antigen–antibody interactions.

Carley, W. J.

C04 MARS ENTRY AND LANDING CAPSULE
Carley, W. J.
Technical Memorandum No. 33-236, February 15, 1966
(Unclassified)

The problems involved in delivering an *Apollo*-type entry capsule to Mars, entering and descending through its atmosphere, and placing a scientific payload on its surface are examined in some detail. The results indicating the feasibility and complexity of various approaches to this mission are given.

Carpenter, R.

C05 A REVIEW OF RADAR ASTRONOMY—PARTS I, II
Muhleman, D. O., Goldstein, R., Carpenter, R.
Technical Report No. 32-824 (Unclassified)
(Reprinted from *IEEE Spectrum, Vol. 2, No. 10,*
October 1965, pp. 44–55 and *Vol. 2, No. 11,*
November 1965, pp. 78–89)

For abstract, see Entry M13.

Chahine, M. T.

**C06 EXACT NUMERICAL SOLUTION OF THE
COMPLETE BGK EQUATION FOR STRONG
SHOCK WAVES**
Chahine, M. T., Narasimha, R.
Technical Report No. 32-671 (Unclassified)
(Reprinted from *Rarefied Gas Dynamics, Vol. 1, Sec. 2,*
1965, pp. 140–160)

The numerical convergence of the iterative solution to the complex BGK equation is investigated. The previous numerical techniques are vastly improved, resulting in a considerable saving in computing time and smaller errors. Consequently the number of iterations is raised above 10. New shock profiles are computed for a range of Mach numbers and a special study of the development of the complete distribution function within the shock wave is carried out.

Chamberlain, R. G.

**C07 TABLES OF TWO-SIDED TOLERANCE FACTORS
FOR NORMAL DISTRIBUTIONS**
Chamberlain, R. G., Benedict, A. G.
Technical Memorandum No. 33-217, June 15, 1965
(Unclassified)

Comprehensive tables of two-sided tolerance factors for the normal distribution are presented. The tables presented are comprehensive and have been prepared by means of an IBM 7090 computer program.

Chaney, W. D.

**C08 FINAL *MARINER II* TRACKING SYSTEM
DATA ANALYSIS REPORT**
Chaney, W. D.

Technical Report No. 32-727, September 1, 1965
(Unclassified)

The analysis of the Deep Space Instrumentation Facility spacecraft tracking performance during *Mariner II* spaceflight is summarized. Ground system configurations, and a summary of tracking histories and tracking performances during scheduled premidcourse, midcourse and postmidcourse view periods are included. The tracking data used to determine the spacecraft orbit are also summarized.

Chapman, C. P.

**C09 DERIVATION OF THE MATHEMATICAL
TRANSFER FUNCTION OF AN
ELECTRODYNAMIC VIBRATION EXCITER**
Chapman, C. P.
Technical Report No. 32-934, May 1, 1966
(Unclassified)

This Report presents a detailed solution of the mathematical equation that describes a typical electrodynamic vibration system. The mathematical analysis is compared with the empirical transfer function of a particular vibration exciter to demonstrate the validity of the equation and the value of mathematics and computers for analysis of vibration techniques.

Clarke, V. C., Jr.

**C10 DESIGN PARAMETERS FOR BALLISTIC
INTERPLANETARY TRAJECTORIES.
PART II. ONE-WAY TRANSFERS TO
MERCURY AND JUPITER**
Clarke, V. C., Jr., Bollman, W. E., Feitis, P. H., Roth, R. Y.
Technical Report No. 32-77, January 15, 1966
(Unclassified)

The general characteristics of ballistic interplanetary trajectories are discussed, and detailed equations are developed for the analytical model. Extensive data are presented in graphical form for trajectories to Mercury (launch dates: 1967–1968) and Jupiter (launch dates: 1968–1973). These graphs include: (1) curves of *vis viva* geocentric energy vs launch date for minimum-energy trajectories and (2) curves of 19–21 different trajectory parameters vs launch date for various *vis viva* geocentric energies. The trajectories were computed on the IBM 7090 digital computer by numerical evaluation of the analytical model, after which specific parameters of interest were automatically plotted, carefully checked, and analyzed. Procedures are outlined for use of these data by the trajectory engineer in the design and analysis of interplanetary trajectories.

C11 EARTH–MOON TRAJECTORIES, 1960–70
Richard, R. J., Clarke, V. C., Jr., Roth, R. Y.,
Kirhofer, W. E.
Technical Report No. 32-503 (Rev. 1), September 15, 1965
(Unclassified)

For abstract, see Entry R12.

Clauss, R. C.

**C12 A 2388-Mc TWO-CAVITY MASER FOR
PLANETARY RADAR**
Clauss, R. C.
Technical Report No. 32-583 (Unclassified)
(Reprinted from *Microwave Journal, Vol. 8,* May 1965,
pp. 74–77)

Description of a two-cavity maser fabricated by simple and
rugged construction techniques which has proved to be a use-
ful device for radar and radio astronomy. High gain and good
gain stability are achieved in a liquid-helium bath at 4.2°K.
Operation at a fixed frequency with a small bandwidth require-
ment enables the cavity maser to compare favorably with more
sophisticated amplifiers. The maser was used to receive radar
echoes and measure blackbody radiation from Venus. After
modifications the 35°K receiving system was used to receive
radar echoes from Venus, Mars, and Mercury. The system has
also been used in radiometric experiments to determine an-
tenna parameters and radio source intensity and ellipticity.
The continuous daily use of the device over a period of five
months indicates the success of the cryogenic system, on which
reliable field operation of a maser system depends.

Clayton, R. M.

**C13 AN EXPERIMENTAL CORRELATION OF THE
NONREACTIVE PROPERTIES OF INJECTION
SCHEMES AND COMBUSTION EFFECTS
IN A LIQUID-PROPELLANT ROCKET ENGINE.
PART VI. THE RELATION BETWEEN THE
STARTING TRANSIENT AND INJECTION
HYDRAULICS**
Clayton, R. M., Rupe, J. H.
Technical Report No. 32-255, October 29, 1965
(Unclassified)

Starting-flow-transient criteria for gas-pressurized liquid-
bipropellant rocket engines are presented. These criteria are
based on a consideration of the hydraulic characteristics of
the propellant-feed system, with particular emphasis on the
propellant valve, the injector, and the injector-manifold vol-
ume. The desirability of a short starting transient without
chamber-pressure overshoot is presumed.

A nonreactive testing technique is presented for the evalua-
tion of the starting-flow transient prior to the commitment of
an engine to its initial firing.

Results of the application of both the flow criteria and the
nonreactive testing technique in an injection research program
utilizing a 20,000-lb-thrust rocket motor are also presented.

**C14 EXPERIMENTAL MEASUREMENTS ON A
ROTATING DETONATION-LIKE WAVE
OBSERVED DURING LIQUID ROCKET
RESONANT COMBUSTION**
Clayton, R. M., Rogero, R. S.
Technical Report No. 32-788, August 15, 1965
(Unclassified)

A single, high-amplitude pressure wave rotating with super-
sonic velocity about the combustion chamber axis has been
observed during the resonant combustion mode of several
liquid rocket research engines. The occurrence of this very
steep-fronted disturbance has led to the investigation of the
applicability of a rotating detonation-like wave concept to
explain the phenomenon. Results of a portion of the experi-
mental phase of the investigation are presented. The engine
was operated with nitric acid and aniline/furfuryl alcohol
propellants at a nominal thrust of 20,000 lb and 300 psia cham-
ber pressure.

The observed pressure ratio across the wave front varied
along the chamber wall from in excess of 20:1 near the injector
to 4:1 near the nozzle entrance. The pressure ratio at the face
varied from approximately 20:1 in outer half radius to less
than 4:1 near the center. The nonsymmetrical wave exhibited
a rise time of less than 3 μsec at certain boundary locations.

A discussion on the performance of the high-response in-
strumentation system is also presented.

Cohn, G. I.

**C15 ELECTROSTATIC CHARGING AND DISCHARGING
MODELS AND ANALYSIS FOR *RANGER*
SPACECRAFT DURING LAUNCH**
Cohn, G. I.
Technical Report No. 32-771, August 1, 1965
(Unclassified)

Spacecraft can become charged by processes such as rocket
motors exhausting electrically charged combustion products,
triboelectrification, interception of drift currents, and photo
and secondary emission. The charging is limited by various
discharge mechanisms such as conduction via the ambient
space charge, corona, and arcing. Discharges and charging
may be sufficiently rapid to induce pulses of significant size in
various electrical circuits within the spacecraft despite substan-
tial amounts of shielding. These pulses may actuate a device
at an inappropriate time and may even result in its destruction.
A preliminary investigation of this causal chain is pursued with
the aid of circuit theory and field theory.

Collins, D. J.

**C16 MEASUREMENT OF THE THERMAL
CONDUCTIVITY OF NOBLE GASES IN
THE TEMPERATURE RANGE
1500 TO 5000 deg KELVIN**
Collins, D. J., Menard, W. A.
Technical Report No. 32-903 (Unclassified)
(Reprinted from *Journal of Heat Transfer, Transactions
of the ASME,* February 1966, pp. 52–56)

The thermal conductivities of argon, neon, and krypton in
the temperature range 1500 to 5000 deg Kelvin have been
deduced from the measurement of heat transfer rates from the

heated gases to the end wall in the reflected shock wave. Pressures ranged from approximately ½ atm to 3 atm. The relationship between thermal conductivity and temperature was assumed to be of the form $k = aT^b$. The constant "b" was determined by a best fit to the data and the constant "a" by the known values of "k" below 1500 K. The effect of density variation in the thermal boundary layer was found to be significant in reducing the data; some previous investigations have neglected this effect.

Cooper, J. L.

C17 ADVANTAGES OF MULTIPOINT CONTROL FOR VIBRATION TESTING OF COMPLETE *RANGER* SPACECRAFT
Cooper, J. L.
Technical Report No. 32-847, January 1, 1965
(Unclassified)

Vibration tests performed at JPL on early *Ranger* spacecraft were made using single-point control of the input vibratory accelerations. The results of these tests clearly showed the inadequacies inherent in this method of control for large structures. Because the fixture required to attach the *Ranger* spacecraft to the shaker could not be made rigid throughout the frequency range of the test, uncontrolled inputs resulted at all the spacecraft mounting points except the point being controlled. A method for controlling each mounting point was required if realistic vibration tests were to be made. A six-channel control system was developed and put into use on *Ranger* Block III spacecraft (*Rangers VII–IX*). The control system operated in two modes: (1) automatic selection and control on the highest acceleration sensed by any one of the six control accelerometers; (2) control on the square root of the sum of the squares of the acceleration sensed by the six control accelerometers. The results obtained from single-point control demonstrate that the spacecraft input is greatly affected by control point selection. That is, an overtest or undertest will occur depending on which point is selected for control. With multipoint control, the input at each mounting point is not controlled perfectly. However, the test requirements are satisfied, and that is not possible with single-point control. Multi-point control also yields a predetermined upper bound that any one mounting point cannot exceed, thus, in effect, holding all the mounting points within a narrower band than could be realized with single-point control.

Coyle, G.

C18 *MARINER IV* SCIENCE PLATFORM STRUCTURE AND ACTUATOR DESIGN, DEVELOPMENT AND FLIGHT PERFORMANCE
Coyle, G.
Technical Report No. 32-832, November 15, 1965
(Unclassified)

This Report describes the *Mariner IV* scan platform and actuator and the developmental problems encountered. Equip-

ment test results and flight experience are summarized to support the discussion of design adequacy. The scan structure and actuator design are considered to be a reasonable solution within the framework of schedule, structural efficiency, interface definition, and—most important—desired functional objectives. The design techniques and problem areas described are considered to be useful data for application to future spacecraft programs.

Cuddihy, E. F.

C19 OUTGASSING RATES IN POLYMERIC FOAMS
Cuddihy, E. F., Moacanin, J.
Technical Report No. 32-840, December 15, 1965
(Unclassified)

Diffusion rates for carbon dioxide were determined on closed-cell polyurethane foams of varying densities by monitoring, for two to three weeks, the loss of weight from specimens suspended in a vacuum of 10^{-7} mm Hg. The experimental data were used to calculate diffusion coefficients for these materials, which were found to be of the order of 10^{-6} to 10^{-5} cm^2/sec between 22 and 81°C.

The solution of the diffusion equation for an idealized model for a foam yielded the following expression for the diffusion coefficient:

$$D = P_c \left(\frac{RT}{M} \right) \left(\frac{\rho_0}{\rho} \right) \left[\frac{1}{(1 - \rho/\rho_0)^{1/3}} + 1 + (1 - \rho/\rho_0)^{1/3} \right]$$

which relates the diffusion coefficient D to the foam density ρ and to the permeation constant P_c, and the density ρ_0 of the bulk polymer; R is the gas constant, T the temperature, and M the molecular weight of the gas.

Using this equation and experimentally obtained values of D, a P_c, of 5.1×10^{-9} (cc STP) mm/sec/cm^2/cm Hg was calculated for the polyurethane material comprising the foam, which agrees within a factor of 2 for reported P_c constants for polyurethane.

Dallas, S. S.

D01 HIGH-ENERGY TRAJECTORIES FROM EARTH TO MARS AND RETURN
Dallas, S. S.
Technical Report No. 32-803, December 15, 1965
(Unclassified)

The speed increment requirements are investigated for a spacecraft traveling (1) from a circular parking orbit about the Earth, (2) to the vicinity of the planet Mars, (3) into a circular parking orbit about Mars, (4) out of the circular parking orbit about Mars (after a stay time of 7 days), (5) to the vicinity of the Earth, and (6) back into the circular parking orbit about the Earth.

A three-dimensional analytic conic approximation to the accurate integrated trajectory is used in the analysis. This ap-

proximation is similar to the one used initially in the computation of one-way interplanetary trajectories.

The characteristics of the high-energy trajectories from Earth to Mars and return for the entire decade beginning January 1970 and ending January 1980 are investigated for four round-trip flight times. The four round-trip flight times (including a 7-day stay time at Mars) are 67, 127, 247, and 487 days. The one-way flight times of the departure and return trajectories are the same. The trajectories were computed by an IBM 7090 digital computer once for each day (zero hours GMT) in the decade. The energy information that is presented for the complete decade of launch dates can be used in parametric studies of advanced manned spaceflight missions to Mars. In addition, theoretical phenomena inherent in round-trip trajectories are discussed and explained; such phenomena include the occurrence of the out-of-the-ecliptic one-way trajectory or the nearly rectilinear one-way trajectory.

Davis, J. P.

D02   REVIEW OF INDUSTRY-PROPOSED IN-PILE THERMIONIC SPACE REACTORS. VOLUME I. GENERAL
Davis, J. P., Gronroos, H., Phillips, W.
Technical Memorandum No. 33-262, October 15, 1965
(Unclassified)

This Memorandum, which is part of a three-volume survey of industry-proposed in-pile thermionic reactor concepts and potential nuclear fuels for space application, summarizes the present status of development and the problem areas associated with design. For a given fuel and at low power levels —less than 200 kwe—the externally fueled concept, by virtue of its high attainable fuel-volume fraction, results in smaller cores than the flashlight or single-diode internally fueled concepts. At higher power levels the differences are less pronounced. None of the potential nuclear fuels for thermionic reactors have yet demonstrated the burnup capability required for high-power, long-life systems.

DeMore, W. B.

**D03   PRIMARY PROCESSES IN OZONE PHOTOLYSIS**
DeMore, W. B., Raper, O. F.
Technical Report No. 32-906 (Unclassified)
(Reprinted from *The Journal of Chemical Physics, Vol. 44, No. 5*, March 1966, pp. 1780–1783)

The photolysis of O_3 dissolved in liquid Ar at $87°K$ has been studied at 2537 Å and at wavelengths near 3130 Å. Quantum yields of O_3 photodecomposition were determined for O_3 concentrations ranging from 5×10^{-1} to 0.3 mole/liter at 2537 Å and 0.03 to 0.67 mole/liter at 3130 Å. Disappearance of O_3 is attributed to the reactions

$$\phi/_{abs}$$
$$O_3 \rightarrow O_2 + O(^1D),$$
$$O(^1D) + O_3 \rightarrow 2O_2,$$
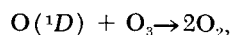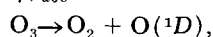
where ϕ is the quantum yield of $O(^1D)$ formation at a given wavelength. The limiting photodecomposition quantum yield at high O_3 concentration is about 2 at 2537 Å and about ½ at 3130 Å.

Quantum yields were also determined at several wavelengths in the interval 2970 to 3340 Å for the photo-exchange reaction

$$O_3 + {}^{36}O_2 \rightarrow {}^{52}O_3 + O_2.$$
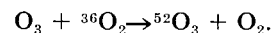
The foregoing studies, together with previous work, show that the $O(^1D)$ quantum yield in O_3 photolysis is unity below 3000 Å but falls to a value of 0.4 ± 0.15 in the 3130-Å region. The exchange experiments show that the total quantum yield of atomic oxygen, including $O(^1D)$ and $O(^3P)$, retains a constant value of unity throughout the wavelength range studied, with onset of $O(^3P)$ formation occurring at 3000 Å.

From these results the rate of $O(^1D)$ production in the lower atmosphere is calculated to be 1.2 ± 0.5 pphm/h (pphm is parts per hundred million), based on an assumed O_3 concentration of 10 pphm and a solar zenith angle of 45°.

Devine, C. J.

D04   THE EPHEMERIDES OF THE EARTH–MOON BARYCENTER, VENUS, MARS, AND MERCURY CONSIDERING THE EARTH AND MOON AS SEPARATE BODIES
Devine, C. J., Dunham, D. W.
Technical Memorandum No. 33-232, March 1, 1966
(Unclassified)

The differential equations for the motion of the Earth–Moon barycenter considering the Earth and Moon as separate bodies are discussed. The ephemerides of the Earth–Moon barycenter, Venus, Mars, and Mercury constructed with these differential equations are compared with the ephemerides of the same planets constructed with differential equations in which the Earth and Moon are considered as a point mass located at the barycenter of the Earth–Moon system. Position residuals and angle residuals between the two systems are plotted.

Dipprey, D. F.

D05   ON THE EVOLUTION OF ADVANCED PROPULSION SYSTEMS FOR SPACECRAFT
Dipprey, D. F., Rupe, J. H., Porter, R. N., Evans, D. D.
Technical Report No. 32-735, July 15, 1965
(Unclassified)

In a current research and advanced development program, the use of Earth-storable propellants in unmanned-spacecraft propulsion systems is under investigation. The term *Earth-storable* is applied to hypergolic propellants which exist in liquid form at $70 \pm 30°F$. Achievement of simplicity in propulsion-system design and operation is facilitated by the use of these propellants for flights to the near planets and the Moon. Propulsion-system requirements for such missions are

briefly outlined, and the major hazards of space flight are discussed in relation to their effect on propulsion systems.

The basic concepts of a proposed spacecraft propulsion system are presented, and component design is shown to be integrated with these concepts so that solutions to individual component problems are compatible. In the pursuit of system and component reliability, strong emphasis on simplicity and predictability is placed in opposition to the use of redundancy. The scope of this advanced development program has been delineated by three basic design choices related to the use of (1) gas-pressurized tankage for propellant pumping, (2) flexible, impermeable barriers at the liquid–vapor interface in propellant tanks, and (3) thrust chambers of refractory and ablative materials which do not require regenerative cooling. For consistent achievement of stable, efficient combustion processes, the development of procedures for a priori injector design is shown to be mandatory.

Progress is summarized in the development of an engine, a gas generator, expulsion devices, regulators, and valves, all designed to meet the requirements of spacecraft propulsion systems burning Earth-storable propellants. A methodology for a priori injector design is presented, together with its application to a simple 10-element injector of the unlike-impinging-jet configuration. Nonreactive-spray properties are used to obtain quantitative descriptions of mass and mixture-ratio distributions, and methods of obtaining the mass-distribution model for an element are outlined.

Drake, F. D.

D06 RADIOMETRIC MAPPING OF THE MOON AT
3 MILLIMETERS WAVELENGTH
Gary, B., Stacey, J., Drake, F. D.
Technical Report No. 32-838 (Unclassified)
(Reprinted from *The Astrophysical Journal, Supplement Series, Vol. 12, No. 108,* November 1965, pp. 239–262)

For abstract, see Entry G02.

Drummond, A. J.

D07 EVALUATION OF THE SIMULATED SOLAR
SPECTRUM IN THE JPL 25-FT SPACE SIMULATOR
Drummond, A. J., Hickey, J. R., Schaefle, W. E.
Technical Report No. 32-749, August 31, 1965
(Unclassified)

Detailed results of the Eppley Laboratory, Inc., spectral investigation of the solar simulation in the JPL 25-ft space simulator during October and November, 1964, are presented. The light source consisted of 133 2.5-kw mercury-xenon compact arc lamps. Two filter radiometers, a prism monochromator, and a grating monochromator were employed. Detailed results from both techniques are presented together with the correlation philosophy and results thereof. A comparison is made with the sunlight spectrum in space, and absorptances of some surface coatings under the two light sources are tabulated.

Drummond, D.

D08 JPL SPACECRAFT STERILIZATION TECHNOLOGY
PROGRAM: A STATUS REPORT
Drummond, D., Magistrale, V.
Technical Report No. 32-853, December 31, 1965
(Unclassified)

This document presents the technical status of Jet Propulsion Laboratory's spacecraft sterilization program, including hardware development, physical plant design and development, and sterilization technology research and development. Status reports of current tasks have been prepared by the cognizant engineers and scientists, and relevant material previously published by JPL has been abstracted.

Dunham, D. W.

D09 THE EPHEMERIDES OF THE EARTH–MOON
BARYCENTER, VENUS, MARS, AND MERCURY
CONSIDERING THE EARTH AND MOON
AS SEPARATE BODIES
Devine, C. J., Dunham, D. W.
Technical Memorandum No. 33-232, March 1, 1966
(Unclassified)

For abstract, see Entry D04.

Dunne, J. A.

D10 THE APPLICATION OF ROSS FILTERS TO
THE NON-DISPERSIVE X-RAY ANALYSIS
OF ALUMINUM AND SILICON
Dunne, J. A.
Technical Report No. 32-917 (Unclassified)
(Reprinted from the *Norelco Reporter, Vol. 13, No. 1,* January–March 1966, pp. 21–24)

This paper describes the use of balanced filter pairs for the non-dispersive analysis of Al and Si in Al-Si mixtures. Less than 0.1 weight percent (wt. %) Al can be detected in a matrix of 50 wt. % Si and 50 wt. % methylcellulose. In the less favorable case of Si in an Al-rich matrix, the limit of detectability is approximately ½ wt. % Si in a 50 wt. % Al_2O_3 and 50 wt. % methylcellulose matrix. The filter pair for Al analysis consists of a 3 mg/cm^2 Al transmitting and a 5 mg/cm^2 Mg absorbing filter. For Si analysis, a 10 mg/cm^2 polystyrene-Si film and 7 mg/cm^2 Al foil are used for the transmitting and absorbing filters, respectively.

Easterling, M.

E01 THE EFFECT OF THE INTERPLANETARY MEDIUM
ON S-BAND TELECOMMUNICATIONS
Easterling, M., Goldstein, R.
Technical Report No. 32-825, September 1, 1965
(Unclassified)

Consideration of the accumulated effects on microwave signals traveling through many millions of miles of space becomes important. Mechanisms have been theorized for the generation of multipath, rotation of polarization, deflection, attenuation,

'and other telecommunication problems in space. There is no a priori way of assessing the magnitude of the effects of the interplanetary medium on telecommunications. Since the advent of radar astronomy, a method of measuring these influences under actual conditions has been found. The medium has been tested by sending waves through it, then analyzing the echoes reflected from the planets. The techniques used and the results obtained at S-band over a considerable area of the plane of the ecliptic are described in this paper.

Edwards, D. K.

E02 FAR-INFRARED REFLECTANCE OF SPACECRAFT COATINGS
Edwards, D. K., Hall, W. M.
Technical Report No. 32-873, January 31, 1966
(Unclassified)

Reflectances and transmittances as functions of wavelengths are reported for 17 specimens of painted aluminum and paint films. Such measurements were made with a directional integrating-sphere reflectometer in the 0.33- to 2.5-μ region, a directional heated-cavity reflectometer in the 1.5- to 23-μ region, and a far-infrared reciprocal paraboloid reflectometer in the 20- to 61-μ region. The spectral range thus includes 98% of the room-temperature emission spectrum as well as 98% of the extraterrestrial solar spectrum. Coatings of clear resins on aluminum were discovered to have high reflectances in the far-infrared when the film thicknesses were approximately 25 μ or thinner. Reflectance data for the clear-resin-coated aluminum were found to be predictable with some accuracy from the measurements of binormal transmittance of resin films together with use of the Fresnel relations. Pigmented paint resins were found to have low reflectances in the far-infrared region investigated even when the film thicknesses on aluminum substrates were as small as 25 μ.

Eisenberg, A.

E03 EQUILIBRIA BETWEEN METALLIC SODIUM AND AROMATIC HYDROCARBONS
Rembaum, A., Eisenberg, A., Haack, R.
Technical Report No. 32-765 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 10, May 20, 1965, pp. 2291–2292)

For abstract, see Entry R08.

Eisenberger, I.

E04 TESTS OF HYPOTHESES AND ESTIMATION OF THE CORRELATION COEFFICIENT USING QUANTILES, II
Eisenberger, I.
Technical Report No. 32-755, September 15, 1965
(Unclassified)

Further results are presented in the investigation into the use of quantiles in data compression of space telemetry. Tests of hypotheses are given using one, two, and four optimum sample quantiles. In Test $\overline{A}$, one decides whether the mean of a normal population has a value of μ_1 or a value of μ_2 when the variance is unknown. Test $\overline{D}$ decides whether the unknown means of two normal populations are identical when the common variance is unknown. Test $\overline{E}$ decides whether the unknown variances of two normal populations are identical when the common mean and variance are unknown. Test $\overline{F}$ decides whether or not two normal populations are independent when their common mean and variance are unknown. In addition, estimators of the correlation coefficient are constructed. Suboptimum test statistics and estimators using the same four quantiles are also given. In all cases, the sample sizes are assumed to be large.

E05 DEMONSTRATION OF A QUANTILE SYSTEM FOR COMPRESSION OF DATA FROM DEEP SPACE PROBES
Anderson, T. O., Eisenberger, I., Lushbaugh, W. A., Posner, E. C.
Technical Report No. 32-772, December 1, 1965
(Unclassified)

For abstract, see Entry A08.

Elleman, D. D.

E06 THE RELATIVE SIGNS OF THE NUCLEAR MAGNETIC RESONANCE PROTON–PROTON COUPLING CONSTANTS IN STYRENE SULFIDE AND STYRENIMINE
Manatt, S. L., Elleman, D. D., Brois, S. J.
Technical Report No. 32-746 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, Vol. 87, No. 10, May 20, 1965, pp. 2220–2225)

For abstract, see Entry M05.

Estabrook, F. B.

E07 RIGID MOTIONS IN EINSTEIN SPACES
Wahlquist, H. D., Estabrook, F. B.
Technical Report No. 32-868, March 15, 1966
(Unclassified)

For abstract, see Entry W02.

Evans, D. D.

E08 ON THE EVOLUTION OF ADVANCED PROPULSION SYSTEMS FOR SPACECRAFT
Dipprey, D. F., Rupe, J. H., Porter, R. N., Evans, D. D.
Technical Report No. 32-735, July 15, 1965
(Unclassified)

For abstract, see Entry D05.

E09 DEVELOPMENT OF THE *RANGER* BLOCK III SPACECRAFT PROPULSION SYSTEM
Evans, D. D., Groudle, T. A., Mattson, R. F.
Technical Report No. 32-829, March 15, 1966
(Unclassified)

This Report describes the design, development, and flight operation of the midcourse propulsion system utilized on the

Ranger Block III spacecraft. This monopropellant-hydrazine-fueled system delivers 50 lb of thrust and is capable of imparting a variable impulse to the spacecraft in order to accomplish required trajectory corrections resulting from launch-vehicle disperson errors. These corrections are required so that the time-of-arrival and impact point can be optimized in order to obtain high-resolution television pictures of the lunar surface. The propellant feed system utilizes a convenient high-pressure gas-storage system, a unique pressure regulator, and a propellant tank containing a bladder for positive expulsion. Engine ignition is accomplished through the injection of a small quantity of a hypergolic oxidizer, nitrogen tetroxide. All valving functions are accomplished by explosively actuated valves. A detailed description of component and system testing is included, along with the in-flight performance of the system during the *Ranger VI, VII, VIII,* and *IX* missions.

Evleth, E. M., Jr.

E10 NITROGEN ANALOGS OF SESQUIFULVALENE. II. THEORETICAL CORRELATION OF GROUND-STATE PROPERTIES
Berson, J. A., Evleth, E. M., Jr., Manatt, S. L.
Technical Report No. 32-776 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society, Vol. 87, No. 13,* July 5, 1965, pp. 2901–2907)

For abstract, see Entry B17.

E11 NITROGEN ANALOGS OF SESQUIFULVALENE. III. THEORETICAL CORRELATION OF EXCITED-STATE PROPERTIES
Evleth, E. M., Jr., Berson, J. A., Manatt, S. L.
Technical Report No. 32-776 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society, Vol. 87, No. 13,* July 5, 1965, pp. 2908–2913)

The experimental energies and intensities of the electronic absorption bands of a series of nitrogen analogs of sesquifulvalene are compared with the results of three kinds of theoretical treatment. Although the Hückel theory and its variant, the ω-method, are satisfactory in correlating much of the data, they fail to account for the major observed difference in behavior between the members of the 2- and 4-series, namely, the occurrence of two strong long wave length bands in the 2-series but of only one in the 4-series. Treatment of the data by first-order perturbation theory, using the series of anions phenylcyclopentadienide, phenylindenide, and phenylfluorenide, gives better results.

The transition energies are correlated with the values calculated from perturbation theory with a correlation coefficient of 0.953; the value of the resonance integral β, obtained from the slope of the correlations, is -47.6 kcal/mole.

Ewing, G. E.

E12 INDUCED INFRARED ABSORPTION OF SOLUTIONS OF H_2 AND D_2 IN LIQUID NEON
Ewing, G. E., Trajmar, S.
Technical Report No. 32-764 (Unclassified)
(Reprinted from *The Journal of Chemical Physics, Vol. 42, No. 11,* June 1, 1965, pp. 4038–4046)

The induced infrared absorption spectra of solutions of H_2 and D_2 in liquid neon ($27.2\,°K$) have been studied. Absorption features were found which differed by less than 7 cm^{-1} from frequencies of vibration-rotation transitions expected for the freely rotating H_2 or D_2 molecule. Rotatory energy levels of H_2 and D_2 in neon solution are, therefore, essentially the same as for gas-phase molecules. Evidence for quantized translational energy levels for the solute was found. Broad absorption features which shift in frequency with isotope change in solute are assigned to vibration-translation combination bands in which the H_2 (or D_2) molecule, in addition to increasing its vibrational level, increases its translational level in its solvent cage. The spectroscopic determination of quantized-translational energy levels permits the estimation of a solute-solvent interaction potential. A harmonic-oscillator potential to describe the intermolecular interaction is consistent with the observation that the translational energy levels for D_2 in neon are $\sqrt{2}$ smaller than those of H_2 in neon. This quadratic potential is also in order-of-magnitude agreement with the potential calculated from the Lennard-Jones and Devonshire cell model of the liquid state. The problems of quantitative determination of translational energy levels from spectroscopic data are discussed. This study has provided a spectroscopic estimate of the liquid-state interaction potential for the H_2 and D_2 neon system and an approximate evaluation of all the types of energy of the solute: vibration, rotation, and translation.

E13 THE NEAR-ULTRAVIOLET BANDS OF MgO: ANALYSIS OF THE $D\Delta' - A^1\Pi$ AND $C^1\Sigma^- - A^1\Pi$ SYSTEMS
Trajmar, S., Ewing, G. E.
Technical Report No. 32-770 (Unclassified)
(Reprinted from *The Astrophysical Journal, Vol. 142, No. 1,* July 1, 1965, pp. 77–83)

For abstract, see Entry T10.

Fedors, R. F.

F01 THE TENSILE FAILURE ENVELOPE OF AMORPHOUS ELASTOMERS: EFFECTS OF STATISTICAL VARIABILITY AND CROSSLINK DENSITY
Landel, R. F., Fedors, R. F.
Technical Report No. 32-633 (Unclassified)
(Reprinted from the *Proceedings of the Fourth International Congress On Rheology,* Brown University, Providence, R.I., August 26–30, 1963. Interscience Publishing Co., New York, 1965, pp. 543–566)

For abstract, see Entry L02.

F02 STATISTICAL VARIABILITY OF ULTIMATE PROPERTIES OF SBR GUM VULCANIZATES
Fedors, R. F., Landel, R. F.
Technical Report No. 32-783 (Unclassified)

The statistical variability of ultimate properties for 8 samples of SBR–sulfur gum vulcanizates differing in crosslink density by a factor of about 25 was studied. It is shown that these variability data, determined at one rate and one temperature, can be correlated when plotted as a reduced failure envelope. The envelope obtained in this manner agrees reasonably well with the reduced envelope previously reported which was constructed from break data obtained by testing (1) single specimens of constant crosslink density at varying rate and temperature, and (2) single specimens at constant rate and temperature but varying crosslink density. It is also shown that the statistical variability data for all samples, including a benzene-soluble one, can be represented by a double exponential cumulative distribution function. It is also shown, in agreement with previous work, that the most probable values of σ_b when plotted as a function of ν_e exhibit a maximum in σ_b at a low value of ν_e.

Feitis, P. H.

F03 DESIGN PARAMETERS FOR BALLISTIC INTERPLANETARY TRAJECTORIES. PART II. ONE-WAY TRANSFERS TO MERCURY AND JUPITER
Clarke, V. C., Jr., Bollman, W. E., Feitis, P. H., Roth, R. Y.
Technical Report No. 32-77, January 15, 1966
(Unclassified)

For abstract, see Entry C10.

F04 TRANSLATIONAL AND ROTATIONAL MOTION OF A BODY ENTERING THE MARS ATMOSPHERE
Feitis, P. H.
Technical Report No. 32-845 (Unclassified)
(Reprinted from *Raumfahrtforschung*, *Vol. 9, No. 3*, July–September 1965, pp. 124–131)
Report presented at joint annual meeting of the WGLR-DGRR (Scientific Society for Air and Space Travel, E. V., German Society for Rocketry and Space Travel, E. V.), September 16, 1965, Berlin.

The density distribution within the Martian atmosphere is derived as a function of altitude and the atmospheric parameters, assuming the perfect gas law holds. The equations of motion of simple bodies are established and solved. The solution consists of equations for the velocity, the acceleration, and time as explicit functions of altitude. The case of oblique entry into the atmosphere is also treated. It is also shown how the altitudes at which acceleration and heating are maximum can be calculated.

A sphere entering the atmosphere is studied. It is assumed that the center of gravity of the sphere does not coincide with its center. The diameter containing the sphere's center of gravity will be called its "axis." The rotational motion of the sphere is considered, assuming that the axis of the sphere is initially inclined with respect to the trajectory. The axis carries out an oscillation in a plane, the amplitude of which decreases and then increases after maximum acceleration is reached. If in addition the sphere is spinning initially, it will carry out a complicated precessional motion around the velocity vector.

The results obtained above are compared with the exact solutions. For the exact solution, a numerical integration of the equations of motion is carried out taking into account all forces neglected above. It is seen that the new theory of motion is a considerable improvement over the old theories.

Filice, A.

F05 EVIDENCE FOR A DARKENED LUNAR SURFACE LAYER IN THE LIGHT OF *RANGER VII* PHOTOGRAPHS
Filice, A.
Technical Memorandum No. 33-267, October 1965
(Unclassified)

Examination of *Ranger VII* photographs indicates that the lunar maria may possess a dark, fine-grained surface layer averaging several meters in thickness. The primary observational evidence for this layer is the lower albedo of craters less than 40 m in diameter relative to craters more than 40 m in diameter in the last *Ranger VII* high-resolution photographs. The evidence implies that a crater of more than 40 m in diameter penetrates or disrupts an upper dark layer and exposes bright under-lying material. The high albedo of new rays is caused primarily by concentrations of secondary craters that penetrate darkened material.

Fischbach, D. B.

F06 KINETICS OF GRAPHITIZATION. I. THE HIGH-TEMPERATURE STRUCTURAL TRANSFORMATION IN PYROLYTIC CARBONS
Fischbach, D. B.
Technical Report No. 32-532, February 1, 1966
(Unclassified)

The kinetics of this graphitization transformation has been investigated for several pyrolytic carbons in the temperature range 2400–3000°C. The transformation was found to be thermally activated, with an effective activation energy of about 260 kcal/mole. The fundamental graphitization process appeared to be the same for all of the carbons studied. Substrate nucleated carbons deposited under the usual conditions graphitized in a succession of stages of first-order form. Variations in both the rate and the mode of transformation can be understood in terms of the dependence of the graphitization process on apparent crystallite layer diameter. A simple method of the graphitization process consistent with these observations is discussed. The significance of these observations for engineering applications is considered briefly.

F07 TENSILE AND STRUCTURAL PROPERTIES OF GLASSY CARBON
Kotlensky, W. V., Fischbach, D. B.
Technical Report No. 32-842, November 15, 1965
(Unclassified)

For abstract, see Entry K22.

Floyd, E. L.

F08 MOTOR-DRIVEN MECHANISMS FOR SPACE FLIGHT APPLICATIONS
Floyd, E. L.
Technical Report No. 32-866, February 15, 1966
(Unclassified)

A scanning mechanism was employed on the *Mariner II* spacecraft to orient the radiometer experiment. A similar device was used to orient the television camera on *Mariner IV.* These mechanisms were designed to withstand the launch-vehicle boost environment, long storage (109 days for *Mariner II* and 228 days for *Mariner IV*) in the space environment, and operation at planet encounter.

Fox, N.

F09 THE USE OF CONVENTIONAL WIND TUNNELS TO SIMULATE PLANETARY ATMOSPHERIC AERODYNAMICS
Koester, H., Fox, N.
Technical Report No. 32-762, November 15, 1965
(Unclassified)

For abstract, see Entry K19.

F10 AN EXPERIMENTAL STUDY OF THE FLOW FIELD PRODUCED BY THREE HYPERSONIC JETS IMPINGING ON A SURFACE IN A VACUUM ENVIRONMENT
Marte, J. E., Fox, N.
Technical Memorandum No. 33-231, July 30, 1965
(Unclassified)

For abstract, see Entry M13.

Frank, D. R.

F11 FACTORS AFFECTING THE REPRODUCIBILITY OF SMALL SOLID-PROPELLANT BATCH-CHECK ROCKET MOTORS FOR QUALITY-CONTROL PURPOSES
Frank, D. R.
Technical Memorandum No. 33-260, October 15, 1965
(Unclassified)

The effort expended and the initial results in evaluating a small solid-propellant batch-check motor are described. The intended use of the motor is to predict the performance of a full-size flight motor based on the measurement of a parameter W, relating the nozzle throat, the propellant weight and the motor chamber pressure integral. In all cases care was taken to control the measurement of these parameters. The motor uses a replaceable graphite-throat insert that undergoes a detailed inspection before testing. The insert is used only once, and the performance calculation is based solely on the prefire measurement. To determine the motor-chamber pressure integral, three independent pressure-measurements are made. The pressure transducers are calibrated on a high-accuracy Ruska deadweight calibrator prior to use. Expected reproducibility between the pressure integral data of any channel for a given test is ±0.05%.

Initial motor evaluation indicates that when an aluminized propellant is used the nozzle throat coating, during the early portion of the test, causes a significant change on the reproducibility of the motor. Data evaluation using aluminized propellant indicates an accuracy of ±0.02% for motors within a propellant batch. An accuracy of ±0.10% has been obtained from a non-aluminized propellant batch. At the present time the batch-check motor has not been used for its intended purpose because a correlation between the batch check and a full-size motor has not been made.

Friedman, H. L.

F12 THE HIGH-ALTITUDE ROCKET RADAR PROJECT
Brown, W. E., Jr., Barath, F. T., Jordan, R. L., Laderman, A., Martin, D. P., Friedman, H. L., Gutierrez, R.
Technical Memorandum No. 33-196, June 15, 1965
(Unclassified)

For abstract, see Entry B30.

Gardner, J. A.

G01 ELECTRON DENSITY AND TEMPERATURE MEASUREMENTS IN THE EXHAUST OF A MPD SOURCE
Kelly, A. J., Nerheim, N. M., Gardner, J. A.
Technical Report No. 32-796, September 15, 1965
(Unclassified)

For abstract, see Entry K06.

Gary, B.

G02 RADIOMETRIC MAPPING OF THE MOON AT 3 MILLIMETERS WAVELENGTH
Gary, B., Stacey, J., Drake, F. D.
Technical Report No. 32-838 (Unclassified)
(Reprinted from *The Astrophysical Journal, Supplement Series, Vol. 12, No. 108,* November 1965, pp. 239–262)

This is the first of two articles describing an observational investigation of the Moon's brightness temperature at a wavelength of 3.3 mm (frequency of 90.4 Gc/s). The study was made with the 15-foot-diameter radio telescope at the Aerospace Corporation, El Segundo, California. The antenna beam width of 2.8 enabled construction of high angular resolution maps giving contours of brightness temperature over the lunar

disk for fourteen phases of the Moon. This paper describes the techniques of observation and data reduction. A description is also given of an empirical relationship between lunar phase, location on Moon, and brightness temperature. It was found that the brightness temperature of the maria exceeds that of the neighboring highlands by 2.6 ±0.2° (p.e.) K.

Gavin, T. R.

G03 EXPERIMENTAL ASSEMBLY AND STERILIZATION LABORATORY (EASL) OPERATIONS: PHASE I
Kapell, G. F., McDade, J. J., Gavin, T. R.
Technical Report No. 32-941, April 15, 1966
(Unclassified)

For abstract, see Entry K02.

Gayman, M.

G04 DEVELOPMENT OF A POINT DAMPER FOR THE *RANGER* SOLAR PANELS
Gayman, M.
Technical Report No. 32-793, September 1, 1965
(Unclassified)

The increase in solar panel size on *Rangers VI* through *IX* over those used on prior *Ranger* flights resulted in intolerably higher structural gains during simulated-launch vibration testing. Rather than adding more solar panel attachments as a remedy, dampers were designed to absorb some of the input energy from the spacecraft. Of the three types of dampers considered, the one selected, on the basis of probable availability within schedule, demonstrated satisfactory reduction of the dynamic gains. The damper design, geometry, and discussion of the assembly and test equipment are included in this Report. Data reduction is given in detail, and damper development results are discussed.

Gayman, W. H.

G05 A NOTE ON BOUNDARY-CONDITION SIMULATION IN THE DYNAMIC TESTING OF SPACECRAFT STRUCTURE
Gayman, W. H.
Technical Report No. 32-938, April 15, 1966
(Unclassified)

A common practice of subjecting an entire spacecraft to a sine-sweep environmental vibration test is examined in the light of the actual boundary conditions prevailing at the interface of the spacecraft and its launch vehicle. By recourse to some simple experiments, it is shown that the conventional sine-sweep test is not only inappropriate as a structural test, but also may provide either an overly severe or an unconservative test of certain subassemblies or assemblies. Recommendations are made for fuller utilization of dynamic-response analyses that treat the flexible spacecraft as an integral part of the flexible space vehicle system. It is concluded that such analyses can aid the acquisition and interpretation of struc-

tural flight test data and, also, establish the nature of the required structural qualification testing.

Geller, M.

G06 MANY-ELECTRON-THEORY *AB INITIO* CALCULATION FOR THE Be ATOM
Geller, M., Taylor, H. S., Levine, H. B.
Technical Report No. 32-799 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, *Vol. 43, No. 5*, September 1965, pp. 1727–1736)

The details and results of an *ab initio* calculation of the energy of the Be atom using the Sinanoğlu many-electron theory are presented. Comparisons are made with earlier calculations on the Be atom by this technique and by other techniques. Finally, the pitfalls and shortcomings of the many-electron theory on extension to larger systems are discussed.

Gensel, D. R.

G07 SAMPLING AND HANDLING OF DESERT SOILS
Cameron, R. E., Blank, G. B., Gensel, D. R.
Technical Report No. 32-908, April 15, 1966
(Unclassified)

For abstract, see Entry C02.

Giffin, C. E.

G08 DETECTION OF LIFE-RELATED COMPOUNDS ON PLANETARY SURFACES BY GAS CHROMATOGRAPHY–MASS SPECTROMETRY TECHNIQUES
Bentley, K. E., Giffin, C. E., Whitten, D. G., Wilhite, W. F.
Technical Report No. 32-713 (Unclassified)
(Reprinted from the *AAS Science and Technology Series*, *Vol. 2*, 1964, pp. 93–117)

For abstract, see Entry B14.

Gin, W.

G09 HEAT STERILIZATION OF PYROTECHNICS AND ON-BOARD PROPULSION SYSTEMS
Gin, W.
Technical Memorandum No. 33-263, January 10, 1966
(Unclassified)

Chemical-propellant rockets, both liquid and solid, for primary propulsion and possibly for auxiliary power supply, and electroexplosive subsystems are being investigated at JPL in order to arrive at engineering design criteria and constraints applicable to these equipments when incorporated into heat-sterilized spacecraft. General problems, presently applied developmental solutions, and future work are described.

Progress is reported on the development of a general-purpose, hot-bridge-wire squib initiator.

The technology required for a sealed, liquid-propellant supply system which withstands sterilization temperatures is

being developed. The principal conclusions of an analysis of the general relationships among the thermodynamic and spatial variables of a closed system are presented. Exploratory tests have been performed on the power switching and pyrotechnic control circuitry used in the *Mariner-Mars* and *Ranger* Block III spacecraft. Test results show no evidence of serious degradation of the electrical components and functions.

Progress has been made in the determination of the ability of current solid propellants to withstand the sterilization temperature cycling. Possible methods of achieving substantial decontamination prior to terminal heat sterilization are described. Design considerations for configurations that may yield minimum-stress propellant grains are discussed and exploratory test results are shown.

The conclusion is reached that the requirement for dry-heat sterilization at temperatures up to 145°C for three 36-hr cycles imposes no fundamental obstacles for pyrotechnic, liquid-propellant, or solid-propellant subsystems.

Goldstein, R.

G10   A REVIEW OF RADAR ASTRONOMY—PARTS I, II
Muhleman, D. O., Goldstein, R., Carpenter, R.
Technical Report No. 32-824 (Unclassified)
(Reprinted from *IEEE Spectrum, Vol. 2, No. 10,*
October 1965, pp. 44–55 and *Vol. 2, No. 11,*
November 1965, pp. 78–89)

For abstract, see Entry M31.

G11   THE EFFECT OF THE INTERPLANETARY MEDIUM ON S-BAND TELECOMMUNICATIONS
Easterling, M., Goldstein, R.
Technical Report No. 32-825, September 1, 1965
(Unclassified)

For abstract, see Entry E01.

Goranson, G. G.

G12   COMMENTS ON THE OPERATION OF THE JPL 25-ft SPACE SIMULATOR
Goranson, G. G.
Technical Report No. 32-885, January 25, 1965
(Unclassified)

The Jet Propulsion Laboratory's 25-ft space simulator has been used continuously during 1963 and 1964 for tests of *Ranger, Mariner* and *Surveyor* spacecraft. Comments are made concerning the importance of combined solar and space simulation to the JPL flight projects. Problems, which are peculiar to the operation of a large space simulator, are discussed relative to operating experience at JPL.

Gray, L. D.

G13   SPECTRAL EMISSIVITY CALCULATIONS FOR THE PARALLEL BANDS OF CARBON DIOXIDE AT 4.3 MICRONS
Gray, L. D.

The quasi-statistical band model is used to compute spectral emissivities for homogeneous paths of CO_2. Emissivities are presented for temperatures from 150 to 600°K, covering the temperature range encountered in planetary atmospheres where carbon dioxide adsorption is expected to be significant. These emissivities can be used to calculate atmospheric transmission.

The present results are compared with both experimental measurements and other theoretical calculations. Spectrally, the agreement with observed values of absorption is seen to be somewhat better than in previous calculations.

G14   SPECIAL ABSORPTION OF THE 4.6-μ BANDS OF N_2O
Gray, L. D.
Technical Report No. 32-792 (Unclassified)
(Reprinted from *Applied Optics, Vol. 4, No. 11,*
November 1965, pp. 1494–1499)

The spectral absorption due to parallel bands of nitrous oxide is computed in the region of the ν_3 fundamental for temperatures of 200 and 300°K. The harmonic-oscillator approximation was used to compute the relative intensities of vibrational transitions for which no published data are available. The total integrated intensity of all of the transitions considered in the calculation was normalized to a value of $1850 \text{ cm}^{-2} \text{ atm}^{-1}$ at 300°K. Values of the spectral absorption computed using the quasi-statistical band model and a half-width of 0.05 cm^{-1} at 300°K are compared with published experimental data for various amounts of absorbing gas and total pressures; the results are seen to be in good agreement. A comparison of the spectral absorption obtained using the quasi-statistical band model and the strong-line and weak-line approximations is also given.

G15   RELATIVE INTENSITY CALCULATIONS FOR CARBON DIOXIDE
Gray, L. D., Selvidge, J. E.
Technical Report No. 32-817, (Unclassified)
(Reprinted from the *Journal of Quantitative Spectroscopy and Radiative Transfer, Vol. 5, No. 2,* March–April 1965,
pp. 291–301)

Internal and vibrational partition functions of $^{12}C^{16}O_2$ are tabulated for the temperature range 150–1200°K at 10°K intervals. Rotational line intensities, relative to the total intensity of the band at 300°K, are presented for transitions arising from the state 00^00 and from the state 01^10.

Gronroos, H.

G16   REVIEW OF INDUSTRY-PROPOSED IN-PILE THERMIONIC SPACE REACTORS. VOLUME I. GENERAL
Davis, J. P., Gronroos, H., Phillips, W.

Technical Memorandum No. 33-262, October 15, 1965
(Unclassified)

For abstract, see Entry D02.

Groudle, T. A.

G17 DEVELOPMENT OF THE *RANGER* BLOCK III
SPACECRAFT PROPULSION SYSTEM
Evans, D. D., Groudle, T. A., Mattson, R. F.
Technical Report No. 32-829, March 15, 1966
(Unclassified)

For abstract, see Entry E09.

G18 DEVELOPMENT OF THE POST-INJECTION
PROPULSION SYSTEM FOR THE *MARINER-C*
SPACECRAFT
Schmitz, B. W., Groudle, T. A., Kelly, J. H.
Technical Report No. 32-830, April 1, 1966
(Unclassified)

For abstract, see Entry S05.

Gutierrez, R.

G19 THE HIGH-ALTITUDE ROCKET RADAR PROJECT
Brown, W. E., Jr., Barath, F. T., Jordan, R. L.,
Laderman, A., Martin, D. P., Friedman, H. L., Gutierrez, R.
Technical Memorandum No. 33-196, June 15, 1965
(Unclassified)

For abstract, see Entry B30.

Haack, R.

H01 EQUILIBRIA BETWEEN METALLIC SODIUM
AND AROMATIC HYDROCARBONS
Rembaum, A., Eisenberg, A., Haack, R.
Technical Report No. 32-765 (Unclassified)
(Reprinted from the *Journal of the American Chemical
Society, Vol. 87, No. 10*, May 20, 1965, pp. 2291–2292)

For abstract, see Entry R08.

Hall, M., Jr.

H02 HADAMARD MATRICES OF ORDER 20
Hall, M., Jr.
Technical Report No. 32-761, November 1, 1965
(Unclassified)

Report studies Hadamard matrices of order 20. Proof is
given that there are exactly three classes of such matrices; the
work done to show this result is discussed, and the classes are
found explicitly. *Class* refers to permutation of rows and
columns, and changing the sign of entire rows and columns.

Hall, W. M.

H03 FAR-INFRARED REFLECTANCE OF SPACECRAFT
COATINGS
Edwards, D. K., Hall, W. M.

Technical Report No. 32-873, January 31, 1966
(Unclassified)

For abstract, see Entry E02.

Hama, F. R.

H04 LOCALIZED-INDUCTION CONCEPT ON A
CURVED VORTEX AND MOTION OF AN
ELLIPTIC VORTEX RING
Arms, R. J., Hama, F. R.
Technical Report No. 32-731 (Unclassified)
(Reprinted from *The Physics of Fluids, Vol. 8, No. 4*,
April 1965, pp. 553–559)

For abstract, see Entry A09.

H05 ESTIMATION OF THE STRENGTH OF LIP SHOCK
Hama, F. R.
Technical Report No. 32-874 (Unclassified)
(Reprinted from *AIAA Journal, Vol. 4, No. 1*, January 1966)

There is a common assumption that the strength of the lip
shock is quite weak both in theories dealing with the base-
pressure problem and in experiments. An experimental result
obtained by Hastings shows that the increase in the static
pressure across the lip shock is only a few percent and thus
supports the assumption.

During an experimental investigation of the base-pressure
problem currently being conducted in the Jet Propulsion Lab-
oratory's 20-in. supersonic wind tunnel, a distinct slip stream
was consistently observed behind the junction between the lip
shock and the compression shock. An attempt therefore was
made to estimate the strength of the lip shock from its orienta-
tion.

Harding, J. T.

H06 FORCE ON A SUPERCONDUCTING SPHERE IN
A MAGNETIC FIELD: THE GENERAL CASE
Harding, J. T.
Technical Report No. 32-806, September 1, 1965
(Unclassified)

Because a superconductor is diamagnetic, it experiences a
force when immersed in a nonuniform magnetic field. This
Report gives the result of the calculation of the force acting
on a sphere of zero permeability in an arbitrary magnetic field.
The solution is obtained by expressing the applied field in a
series of complete spherical harmonic functions, determining
the induced field required to satisfy the boundary condition
$B_{normal} = 0$, then integrating the Maxwell stress tensor over
the sphere's surface. The final result appears as sums of prod-
ucts of the expansion coefficients of the applied field. To make
the result more useful, it is also shown how to express the field
due to an array of coils having concurrent axes in a series of
spherical harmonics and, for the purpose of computing restor-
ing forces, the applied field is expanded in a Taylor series
expansion in the displacements.

Hardy, J. P.

H07 MOLECULAR STRUCTURE AND CONFIGURATION
OF POLYMERS: NMR SPECTRA OF
POLY (ALKYLENE OXIDE) TERMINAL GROUPS
Ingham, J. D., Lawson, D. D., Manatt, S. L.,
Rapp, N. S., Hardy, J. P.
Technical Report No. 32-904 (Unclassified)
(Reprinted from *Journal of Macromolecular Chemistry*,
Vol. 1, No. 1, September 1965, pp. 75–91)

For abstract, see Entry I03.

Harrison, R. G., Jr.

H08 A PRESSURE TELEMETER FOR WIND-TUNNEL
FREE-FLIGHT PRESSURE MEASUREMENT
Harrison, R. G., Jr.
Technical Report No. 32-763, February 1, 1966
(Unclassified)

This Report summarizes the work on a pressure telemeter—
the instrument itself, and the applicable telemetry technique—
developed for use in studying interference-free pressures on
models launched into free flight in a hypersonic, continuous-
flow wind tunnel. Design characteristics, performance and
operational procedures, as well as problems that were delin-
eated during the development phase, are described.

Havlik, A. J.

H09 END-GROUP MODIFICATION OF
POLY(ALKYLENE OXIDES).
VOLUME I. CYANOETHYLATION
Kalfayan, S. H., Havlik, A. J.
Technical Memorandum No. 33-251, December 15, 1965
(Unclassified)

For abstract, see Entry K01.

Hayes, C. D.

H10 POWER SPECTRAL DENSITY ANALYSIS
Hayes, C. D.
Technical Report No. 32-928, June 15, 1966
(Unclassified)

This Technical Report develops the generalized techniques
for determining the equation describing the power spectral
density function (G^2/cps versus frequency, etc.) and the equa-
tion for determining the root mean square of a power spectral
density function. Examples of both types of equations are in-
cluded in the Appendix.

Hays, L. G.

H11 TURBINE EROSION RESEARCH IN GREAT BRITAIN
Hays, L. G.
Technical Memorandum No. 33-271, March 1, 1966
(Unclassified)

The variables influencing erosion in wet-vapor turbines are
identified and discussed in this Memorandum. Information is

presented that was obtained from a visit to research installa-
tions in Great Britain during October of 1965. The applica-
bility of this information to the formulation of an analytical
model of erosion in liquid-metal vapor turbines is indicated.
Phenomena for which results are given are moisture formation,
moisture collection, droplet shedding, droplet breakup, liquid
impact, and material removal. Analytical expressions are indi-
cated for moisture formation, moisture collection, droplet
breakup, and liquid impact. Experimental results for droplet
shedding and material removal are summarized. The sizable
scatter of experimental data from material removal experi-
ments and the lack of sufficiently accurate liquid-metal prop-
erty data will limit the accuracy of the analytical model to be
formulated.

Heacock, R. L.

H12 *RANGER VIII AND IX.*
PART II. EXPERIMENTERS' ANALYSES AND
INTERPRETATIONS
Heacock, R. L., Kuiper, G. P., Shoemaker, E. M.,
Urey, H. C., Whitaker, E. A.
Technical Report No. 32-800, March 15, 1966
(Unclassified)

This Report presents the preliminary results of the analyses
of the *Ranger VIII* and *IX* lunar photographs by the team of
experimenters appointed by the National Aeronautics and
Space Administration, with emphasis on the qualitative in-
terpretations of the photographs. The longer-term quantitative
study of the *Ranger VII* photographs is underway, and the
Ranger VIII and *IX* mission photographs are being added to
that effort.

Hendel, F. J.

H13 REVIEW OF SOLID PROPELLANTS FOR
SPACE EXPLORATION
Hendel, F. J.
Technical Memorandum No. 33-254, October 1, 1965
(Unclassified)

Various families of solid propellants which are or could be
used in space vehicles and spacecraft are reviewed. These in-
clude polyurethane, polybutadiene-acrylic acid, polybutadiene-
acrylic acidacrylonitrile, carboxyl-terminated polybutadiene,
double base, and thermoplastic polymers as fuel and binders
of the crystalline oxidizers with or without aluminum or beryl-
lium powder. Future solid propellants will have improved
physical properties and specific impulse. Improved specific
impulse will result from the use of energetic oxidizers, such
as lithium ozonide, energetic fuel-binders such as nitropolymers
and acetylenic polymers, and energetic fuel ingredients such
as light metal hydrides. An ultra-energetic cryogenic solid pro-
pellant could be made by freezing a mixture of liquid oxygen
and hydrogen or a light metal hydride. A "cold" solid propel-
lant made from BeH_2 and frozen hydrogen peroxide will have
a theoretical vacuum specific impulse of almost 500 sec.

Hess, H. H.

H14 LUNAR AND PLANETARY X-RAY DIFFRACTION PROGRAM
Hess, H. H., Speed, R. C.
Technical Memorandum No. 33-218 (Progress Report of Research and Instrumentation Development July 1964 to March 1965), June 1, 1965 (Unclassified)

Three areas of study are covered: (1) current instrumentation, (2) advanced instrumentation, and (3) X-ray mineralogy and petrology. Included are: (1) a description of the new power supply and electronic systems for Mark 1 diffractometer, (2) operating characteristics of beryllium-window sample cup and the Mark 1 X-ray tube, (3) a comparison of the Seemann-Bohlin and Bragg-Brentano diffractometer designs, (4) discussion of feasibility studies of radioisotope X-ray sources and non-dispersive X-ray fluorescence instrumentation, and (5) the relationship of the aspects of quantitative rock analysis by X-ray diffraction, the results of studies of rock-forming oxide phases and the effects of radiation damage on X-ray diffraction analysis of rock.

Hickey, J. R.

H15 EVALUATION OF THE SIMULATED SOLAR SPECTRUM IN THE JPL 25-FT SPACE SIMULATOR
Drummond, A. J., Hickey, J. R., Schaefle, W. E.
Technical Report No. 32-749, August 31, 1965 (Unclassified)

For abstract, see Entry D07.

Higa, W. H.

H16 A PRACTICAL PHILIPS CYCLE FOR LOW-TEMPERATURE REFRIGERATION
Higa, W. H.
Technical Report No. 32-712 (Unclassified)
(Reprinted from *Cryogenic Technology, Vol. 1, No. 5,* July–August 1965, pp. 203–208)

The machine described combines the simplicity and efficiency of the Philips cycle with the versatility of the related Gifford-McMahon cycle. The new approach is particularly applicable to small low-temperature refrigerators.

A thermodynamic analysis of the cycle, assuming isothermal processes, demonstrates that the coefficient of performance is equal to that of the ideal Carnot cycle.

Higgins, M. D.

H17 THE SPACE FLIGHT OPERATIONS FACILITY DOCUMENT CONTROL DATA STORAGE AND RETRIEVAL SYSTEM
Higgins, M. D., Lunine, L. R.
Technical Memorandum No. 32-288, June 15, 1966 (Unclassified)

The Memorandum explains the data storage and retrieval techniques used at the JPL Space Flight Operations Facility Document Control to handle great volumes of flight and test data. The various types and forms of data received at the Facility are defined and illustrated. Each item of data is indexed, and, depending upon the type of data, stored in original form or on microfilm. A computer-generated catalog is used to locate material on either microfilm, or original magnetic or teletype tapes. The Memorandum contains a complete discussion of the work flow through the data storage system, and concludes with information concerning the efficiency of the retrieval system.

Hilderbrandt, A. F.

H18 SUPERCONDUCTING TRANSITION OF A ROTATING SUPERCONDUCTOR— THE HOLLOW CYLINDER
Hilderbrandt, A. F., Saffren, M. M.
Technical Report No. 32-710 (Unclassified)
(Reprinted from *Low Temperature Physics-LT9 (Part A),* Plenum Press, 1965, pp. 459–465)

A superconductor, when rotated, is expected to generate a magnetic field. Hollow superconducting cylinders of lead and of niobium, when rotated starting from rest, have been found to generate fields in agreement in sign and magnitude with the relation

$$\mathbf{B} = -\frac{2mc}{e}\,\omega = 1.137 \times 10^{-7}\omega[G]$$

where m and e ($e = -\,|\,e\,|$) refer to the electron. Note that $\mathbf{B}$ and ω point in the same direction, a feature that was carefully verified. The field generated by rotation of a solid cylinder of lead, made superconducting while at rest, also followed the above equation.

Here hollow-cylinder experiments are reported, in which the superconducting transition takes place while the cylinders are rotating.

The fields observed in both the present and previous experiments are accounted for in terms of the values of the fluxoid associated with a hollow cylinder. This is done by solving London's equation for the field of a rotating hollow cylinder of infinite length, taking care to make the dependence of the field on the fluxoid explicit. The value assigned the fluxoid cannot be determined from the solution but must be given by a separate argument. The values of the fluxoid predicted by this argument lead to the most stable state, thermodynamically, of the superconductor.

Results are summarized in an expression for the field $\mathbf{B}$ observed in the hollow portion of a long superconducting cylinder whose thickness and inner radius are both very large compared to a penetration depth. The expression is

$$\frac{e\mathbf{B}}{2mc} = -\,(\omega - \omega_0')$$

where $|e|\mathbf{B}/(4\pi mc)$ is the Larmor frequency of the electron, ω is the angular velocity of the cylinder, and ω_0' is a quantity determined at the time the cylinder became superconducting;

ω_0' is equal to $\omega_0' + (e/2mc)\mathbf{B}_\infty$, where ω_0 and $\mathbf{B}_\infty$ are the values of angular velocity and uniform field applied at the time of the transition.

Hoffman, A. R.

H19 PYROTECHNIC SHOCK ANALYSIS AND TESTING METHODS
Hoffman, A. R., Randolph, J. E.
Technical Memorandum No. 33-270, February 15, 1966
(Unclassified)

This Report presents a detailed analysis of certain pyrotechnic shocks. The data used are from the *Ranger* Block III and *Mariner-Mars* 1964 test programs. Shock spectra from the basis of correlation between similar shocks of various spacecraft and assembly testing. Comparisons of shock data using statistical methods are also included. Since a wealth of shock data was available, the statistical analysis is significant.

The results indicate the necessity for a system-level pyrotechnic test program if the environment is to be properly simulated.

Holdridge, D. B.

H20 LEAST SQUARE FIT TO PLOD RECTANGULAR RESIDUALS
Holdridge, D. B.
Technical Memorandum No. 33-244, October 1, 1965
(Unclassified)

A least squares fit to the Planetary Orbit Determination Program (PLOD) rectangular residuals for the outer planets Jupiter, Saturn, and Uranus was undertaken. A linear combination of a cubic equation in time and sinusoidal terms in the mean anomaly of the Earth and of Mars was used in the fit. For all the planets considered, the amplitude of the Earth and of Mars terms was less than that considered by Clemence in his corrections to the outer planets.

Hunter, J. A.

H21 *MARINER-MARS* 1964 TELECOMMUNICATION SYSTEM
Hunter, J. A.
Technical Report No. 32-836, December 1, 1965
(Unclassified)

This Report describes the radio, telemetry, and command subsystems of the *Mariner-Mars* 1964 telecommunication system and presents a summary of system performance during the mission. For this mission the *Mariner IV* required a telecommunications system providing telemetry, command, and doppler tracking capabilities over ranges approaching 260×10^6 km. By utilizing unique characteristics of the Mars 1964 minimum energy trajectories, it was possible to meet this requirement without a pointable antenna and the associated complex spacecraft equipment. Spacecraft equipment design was based on techniques used for the *Mariner II* spacecraft, with modifications to increase reliability and accommodate the increased maximum communication range.

Ingham, J. D.

I01 SYNTHESIS OF CARBON-14 LABELED ISOCYANATES. DETERMINATION OF THE CARBON-14 DISTRIBUTION IN THE ISOCYANATE GROUPS OF 2, 4-TOLYLENE DIISOCYANATE
Kopka, E. F., Rapp, N. S., Ingham, J. D.
Technical Report No. 32-861 (Unclassified)
(Reprinted from the *Journal of Labeled Compounds*, Vol. 1, No. 3, July–September 1965, pp. 1–2)

For abstract, see Entry K21.

I02 THE MECHANISM OF THERMAL DEGRADATION OF CERTAIN POLYETHER-POLYURETHANS
Ingham, J. D., Rapp, N. S.
Technical Report No. 32-880 (Unclassified)
(Reprinted from *Polymer Engineering and Science*, Vol. 6, No. 1, January 1966, pp. 1–6)

Relatively few publications have appeared that describe basic studies of the thermal degradative processes that can occur in polyether-polyurethans. This article is an account of some studies of the mechanism of degradation of uncross-linked polyurethan prepared from poly(propylene oxide) (PPO) and 2,4-tolylene diisocyanate (TDI) at temperatures up to 320°C in a vacuum or inert atmosphere.

I03 MOLECULAR STRUCTURE AND CONFIGURATION OF POLYMERS: NMR SPECTRA OF POLY (ALKYLENE OXIDE) TERMINAL GROUPS
Ingham, J. D., Lawson, D. D., Manatt, S. L., Rapp, N. S., Hardy, J. P.
Technical Report No. 32-904 (Unclassified)
(Reprinted from *Journal of Macromolecular Chemistry*, Vol. 1, No. 1, September 1965, pp. 75–91)

The H^1 and F^{19} spectra of acetates and trifluoroacetates of hydroxy-terminated poly(alkylene oxides) and model diols have been studied, to establish the type and configuration of end-group structures. Because fluorine derivatives produce greatly accentuated chemical shifts, very subtle structural differences were detected. Besides demonstrating the simple determination of the relative concentrations of primary and secondary hydroxyl groups in mixtures of hydroxy compounds, F^{19} NMR was used to establish stereo and positional isomeric configuration of the terminal and next adjacent monomeric units in poly(propylene oxide) and poly(ethylene oxide–propylene oxide) copolymer. Atactic poly(propylene oxide) contains nearly equal concentrations of syndiotactic and isotactic diads at both ends of the polymer chains, showing only a minor amount of stereoselectivity, whereas poly[(+)-λ-propylene oxide] contains only one of the two possible relative stereoconfigurations of the terminal and neighboring asymmetric carbon atoms at the chain ends.

Ditrifluoroacetates of poly(ethylene oxide–propylene oxide) prepared by further addition polymerization of ethylene oxide to poly(propylene oxide) produce different F^{19} chemical shifts, depending on whether only one or more than one ethylene oxide unit is attached to the propylene oxide units. The approach described suggests that even more detailed structural assignments can be established for poly(alkylene oxides), and also for other polymers containing reactive terminal or pendant structures, by application of advanced NMR techniques.

I04 ORGANIC SYNTHESIS USING FUSED SALT
SYSTEMS: PREPARATION OF A
POLYTRIPHENYLENE
Ostrum, G. K., Lawson, D. D., Landel, R. F., Ingham, J. D.
Technical Report No. 32-907 (Unclassified)
(Reprinted from *Chemical Communications,* 1966, p. 53)

For abstract, see Entry O01.

Ivanoff, R. G.

I05 POWER SYSTEMS RELATED TO OPERATIONS
OF A LANDED PLANETARY CAPSULE
Ivanoff, R. G.
Technical Memorandum 33-238, June 1, 1965
(Unclassified)

This Report summarizes the analyses of power sources that have been proposed for use on space capsules to be landed on the planet Mars. The investigation was occasioned by the need to define the advantages and disadvantages of power sources that could provide power for such a landed capsule. The analysis compares the various sources on the basis of weight, operating time, development status, complexity, impact tolerance, and capability to withstand sterilization. Also included is a discussion of the thermal problems that must be considered in the design of radioisotope power systems for this mission. The Appendixes present detailed comparisons between photovoltaic and radioisotopic power systems.

Jaffe, L. D.

J01 DEPTH OF LUNAR DUST.
STRENGTH OF LUNAR DUST.
BEARING STRENGTH OF "FAIRY CASTLE"
STRUCTURES.
Jaffe, L. D.
Technical Report No. 32-856 (Unclassified)
(Reprinted from *Journal of Geophysical Research,*
Vol. 70, No. 24, December 15, 1965, pp. 6129–6270)

The appearance of laboratory craters overlain by various thicknesses of sand has been compared with that of lunar craters, 3 to 13,000 meters in diameter, shown in ten photographs obtained by the *Ranger VII* spacecraft. Results obtained are consistent with an interpretation that at least 5 meters of granular material, and probably considerably more, is deposited on the area of *Mare Cognitum* shown in these photographs.

Lunar surface material must have at least enough strength to permit maintenance, against lunar gravity, of the crater wall slopes and heights observed in the *Ranger VII* photographs. Slopes and heights in craters which appear to be overlain with granular material permit setting lower bounds to its strength. The lower bound for the mass bearing capacity is 10 g/cm^2 on a strip of 0.1-meter width, and 100 g/cm² on a strip of 1-meter width.

To explain the optical properties of the lunar surface, it is suggested that the outer layer is made up of rock particles, a few microns in diameter, which maintain a very high porosity by interparticle adhesion. This is termed a "fairy castle structure." Mechanical property measurements so far published on such structures include compressibility at 14 to 47% solid and cohesion at an undetermined per cent solid measured shear properties at 36 to 44% solid, which is somewhat above the range of interest. Measurements of bearing strength have not previously been reported. The materials used in the present work are silica and alumina.

The primary effect of lunar atmospheric conditions on materials tested is to remove adsorbed surface films and increase interparticle adhesion at the resulting clean surfaces. The values calculated from test results provide only lower bounds for the strength of fairy castles under lunar surface conditions.

J02 LUNAR DUST DEPTH IN *MARE COGNITUM*
Jaffe, L. D.
Technical Report No. 32-896 (Unclassified)
(Reprinted from *Journal of Geophysical Research,*
Vol. 71, No. 4, February 15, 1966, pp. 1095–1103)

A previously reported technique for preparing and imaging laboratory craters overlain by various thicknesses of granular material has been refined. The resulting photographs have been compared with those obtained by *Ranger VII* spacecraft. Results support the earlier conclusion that the appearance of lunar craters in the *Ranger* photographs is consistent with the presence of at least 5 meters of granular overlay, and probably considerably more, in the area of *Mare Cognitum.*

Jaffe, P.

J03 A GENERALIZED APPROACH TO
DYNAMIC-STABILITY FLIGHT ANALYSIS
Jaffe, P.
Technical Report No. 32-757, July 1, 1965
(Unclassified)

A general approach to the analysis of planar flight dynamic-stability investigations is presented and examples are used to discuss the approach. The foundation of the approach is the energy-integral equation, which relates the energy defect during a half cycle, due to the decay, to those factors causing the decay. The equation can accommodate nonlinear aerodynamics, large oscillatory amplitudes, non-symmetric or lift-

ing bodies, and noncontinuous or double-valued aerodynamic coefficients. Examples are presented demonstrating these applications. This Report also suggests that the usual closed-form differential solution may not be properly representing all physical mechanisms producing decay, because of the continuous nature of its formulation.

J04 EFFECT OF BOUNDARY-LAYER TRANSITION ON DYNAMIC STABILITY
Jaffe, P., Prislin, R. H.
Technical Report No. 32-841 (Unclassified)
(Reprinted from *Journal of Spacecraft and Rockets*, *Vol. 3, No. 1*, January 1966, pp. 46–52)

Extensive free-flight dynamic stability measurements of 10° half-angle cones with laminar and "tripped" boundary layers at supersonic speeds are presented. Free-flight measurements showing the effects of Mach number, center-of-gravity position, and angle-of-attack oscillatory amplitude on dynamic stability are also presented. The measurements were obtained by launching 1-in. in diameter models at controlled angles of attack up to 40° into the oncoming wind-tunnel flow with a low-velocity pneumatic gun. This motion and the corresponding flow patterns were recorded with high-speed motion pictures taken through the schlieren system. Because of the low model Reynolds number in the wind tunnel, it was necessary to induce boundary-layer transition artificially with wire rings. The free-flight results show that dynamic stability is not perceptibly affected by the state of the boundary layer (thick boundary layers resulting from extremely low Reynolds numbers were not considered) but is affected by the amplitude of oscillation. The data are compared with Tobak's potential flow solution and a solution using the Newtonian impact theory at all angles of attack. Free-flight drag and static stability results are also included.

James, J. N.

J05 MARINER IV MISSION TO MARS (PART II)
James, J. N., et al.
Technical Report No. 32-782, September 15, 1965
(Unclassified)
(Reprinted from *Astronautics and Aeronautics*, June, July, and August 1965)

This Technical Report is a series of seven individual papers documenting the *Mariner-Mars* project from its beginning in 1962 following the successful *Mariner-Venus* mission. Part I is *pre-encounter* data. It includes papers on the design, development, and testing of *Mariner IV*, as well as papers detailing methods of maintaining communication with and obtaining data from the spacecraft during flight, and expected results during encounter with Mars.

Part II, *post-encounter* data, to be published later, will consist of documentation of the events taking place during *Mariner IV's* encounter with Mars and thereafter. The *Mariner-Mars* mission, the culmination of an era of spacecraft development, has contributed much new technology to be used in future projects.

Jet Propulsion Laboratory

J06 MARINER-MARS 1964 PROJECT REPORT: MISSION AND SPACECRAFT DEVELOPMENT VOLUME I. FROM PROJECT INCEPTION THROUGH MIDCOURSE MANEUVER
Jet Propulsion Laboratory
Technical Report No. 32-740, March 1, 1965
(Unclassified)

This volume, the first of a series of volumes that comprise the *Mariner-Mars* 1964 Project Report, describes the formation and organization of the project, and traces its development up through the time of the midcourse maneuver. The bulk of this volume describes the development of the spacecraft itself, including design concepts and changes, fabrication and procurement history, and flight performance for the early portion of flight.

The *Mariner-Mars* 1964 mission required the use of a great many new techniques in designing, building, and operating unmanned spacecraft. The success of *Mariner IV* has made these techniques significant, particularly in the light of future space programs. It is hoped that the operations and results documented in this volume will be useful reference to those planning future space missions.

J07 RANGER VIII AND IX. PART I. MISSION DESCRIPTION AND PERFORMANCE
Jet Propulsion Laboratory
Technical Report No. 32-800, January 31, 1966
(Unclassified)

The *Ranger VIII* and *IX* missions successfully concluded the *Ranger* unmanned lunar-investigation project. The Block III *Ranger* spacecraft, launched by the *Atlas/Agena* vehicle and tracked by the Deep Space Network, contained a six-camera television package and had the objective of obtaining high-resolution photographs of the lunar surface prior to impact. *Ranger VIII*, launched February 17, 1965, returned 7137 pictures before its impact in southwestern *Mare Tranquillitatis* on February 20. *Ranger IX* was launched on March 21, 1965, and impacted in the crater Alphonsus on March 24. A successful terminal maneuver performed on *Ranger IX* brought the resolution of the final pictures to 0.4 m; a total of 5814 pictures was obtained from this mission. A brief loss of telemetry during *Ranger VIII's* midcourse maneuver, apparently caused by a conducting particle forming a temporary short circuit in the spacecraft radio, was the only significant anomaly observed in the two flights. The initial accuracy of the *Ranger IX* launch made it possible to defer the midcourse maneuver 22 hr; the actual impact was within 5 km of the selected aiming point.

Johnson, B. H.

**J08 AN EXPERIMENTAL INVESTIGATION OF THE
EFFECTS OF COMBUSTION ON THE MIXING
OF HIGHLY REACTIVE LIQUID PROPELLANTS**
Johnson, B. H.
Technical Report No. 32-689, July 15, 1965
(Unclassified)

The effects of combustion on the liquid-phase mixing of
several storable liquid bipropellants were investigated. It was
found that combustion effects were severe when nitrogen
tetroxide was used as the oxidizer with various storable fuels,
including hydrazine, unsymmetrical dimethylhydrazine, and
monomethylhydrazine. Other combinations tested were found
to be less affected by the combustion process. Several attempts
were made to induce propellant mixing by mechanical means,
and the effects of chemical inhibitors on the mixing process
were investigated. None of the mechanical and chemical
techniques studied influenced the prereaction mixing of the
propellants to an appreciable extent.

Johnson, W. R.

**J09 FILTERING TECHNIQUES FOR NOISE
SUPPRESSION IN QUASI-BALANCED CIRCUITS**
Johnson, W. R.
Technical Report No. 32-945, June 15, 1966
(Unclassified)

This Report describes common-mode noise voltages, which
may be present in electrical power and signal circuits, and
submits means of preventing such noise from interfering with
electronic equipment through the proper selection of filters
and/or electrostatically shielded isolation transformers. There
is a distribution of solutions to the problem. If the problem is
generally understood, a solution may be proposed on the basis
of the information in this Report.

Filters offer the best means of noise suppression for
balanced-mode noise voltages, particularly in the medium-
and high-frequency region (> 20 kc). They also yield some
attenuation to common-mode noise voltages and may be used
for this purpose at high frequencies (> 10 Mc).

Isolation transformers with electrostatic shielding can be
effective in eliminating the common-mode noise voltages in
the low- and mid-frequency ranges (≈ 0 to 10 Mc).

Balanced or ungrounded circuitry generally loses its iden-
tity at high frequencies. Occurrence of capacitive coupling to
unwanted grounds results in loss of rejection to common-
mode noise. Consequently, it is very desirable, cost and size
permitting, to use a filter driving an isolation transformer.

An attempt has been made to define test methods for
determining the type of mode present in a circuit. General
application of filters and isolation transformers to balanced-
mode and common-mode noise voltage problems appears in
tabular form.

Johnston, A. R.

**J10 DETERMINATION OF THE LOW-FREQUENCY
LINEAR ELECTRO-OPTIC EFFECT IN
TETRAGONAL Ba Ti0$_3$**
Johnston, A. R., Weingart, J. M.
Technical Report No. 32-760 (Unclassified)
(Reprinted from *Journal of the Optical Society of America,
Vol. 55, No. 7,* July 1965, pp. 828–834)

The magnitude of the linear electro-optic effect at 5461 Å in
single-crystal barium titanate has been determined in the tem-
perature range from 5 to 120°C. The low-frequency or stress-
free values were obtained for r_{42} and $r_c = r_{33} - (n_a/n_c)^3 \, r_{13}$.
The polarimetric measurement did not separate r_{33} from r_{13}.
The quantity r_{42} was found to vary as K_a, the dielectric con-
stant effective for the a-directed electric field. Similarly, r_c
was approximately proportional to $K_c P_s$, the product of the
"c" dielectric constant and spontaneous polarization, but
did not rise quite as fast as $K_c P_s$ with increasing tempera-
ture. The difference was outside experimental uncertainty.
The values found at 25°C were $r_c = 1.08 \times 10^{-8}$ cm/V;
$r_{42} = 16.4 \times 10^{-8}$ cm/V.

**J11 THE STRAIN-FREE ELECTRO-OPTIC EFFECT IN
SINGLE-CRYSTAL BARIUM TITANATE**
Johnston, A. R.
Technical Report No. 32-843 (Unclassified)
(Reprinted from *Applied Physics Letters, Vol. 7, No. 7,*
October 1965, pp. 195–198)

The purpose of this Report is to describe an experimental
determination of the linear electro-optic effect under the
strain-free condition, in single-crystal BaTiO$_3$ as a function of
temperature between 10 and 120°C, and also, to report a
surprisingly large strain contribution to the quadratic electro-
optic response above the Curie transition. These results are
compared to a previously reported measurement of the low-
frequency, or stress-free, response of BaTiO$_3$ in the tetragonal
state.

Jones, D. E.

**J12 THE *MARINER II* MICROWAVE RADIOMETER
EXPERIMENT**
Jones, D. E.
Technical Report No. 32-722, January 1, 1965
(Unclassified)

Aboard the *Mariner II* spacecraft was a dual-channel micro-
wave radiometer, which obtained three scans across the planet
Venus at wavelengths of 13.5 and 19 mm. The relationship of
the peak temperature values of the three scans supports a
hot-surface model for the planet. Several atmosphere–surface
configurations were assumed in an attempt to match the limb-
darkening ratios and temperature values measured at both
wavelengths. The model that agrees most closely with the
data is one that consists of a specular surface and an iso-
thermal cloud-type layer at a temperature near 350°K. The
anomaly that occurred toward the end of scan 2 was in the

same region of the planet as that observed by the terrestrial measurements at 8 to 14 microns and is consistent with a marked increase in opacity of the 350°K cloud layer in this region. The marked difference between the 13.5- and 19-mm temperatures indicates the presence of an abrupt discontinuity in the microwave spectrum of Venus that cannot be due to uncondensed water vapor and hence requires the presence of a molecule or molecules in the atmosphere of Venus that condense or polymerize into liquid form at $T \geq 350°K$ and exhibit line spectra in the vicinity of 13.5 mm and shorter.

The magnitude of the relative dielectric coefficient of the surface is found to lie between 3 and 4. The surface temperature variation that best fits the data is of the form $T_s = 700°K + (80 \pm 5)°K \cos \phi$. An upper limit of ~100 atmospheres for the surface pressure is obtained for an atmosphere containing 20% CO_2 and 80% N_2.

Jordan, R. L.

J13 THE HIGH-ALTITUDE ROCKET RADAR PROJECT
Brown, W. E., Jr., Barath, F. T., Jordan, R. L., Laderman, A., Martin, D. P., Friedman, H. L., Gutierrez, R.
Technical Memorandum No. 33-196, June 15, 1965
(Unclassified)

For abstract, see Entry B30.

Kalfayan, S. H.

K01 END-GROUP MODIFICATION OF POLY(ALKYLENE OXIDES). VOLUME I. CYANOETHYLATION
Kalfayan, S. H., Havlik, A. J.
Technical Memorandum No. 33-251, December 15, 1965
(Unclassified)

Poly(alkylene oxides) terminated mainly by nitrile groups can be prepared by the alkoxide-catalyzed cyanoethylation of either poly(ethylene oxides) or poly(propylene oxides). Conversion of the nitriles to either amino or carboxyl groups gives compounds that upon reaction with diisocyanates or imines, respectively, could form polymers of use in a systematic study of molecular structure needed for the formation of highly extensible elastomers. To establish a firm basis for the functionality of the modified poly (alkylene oxides), the cyanoethylation of a series of hydroxyl-bearing compounds was studied quantitatively. Results suggest that during cyanoethylation, a side reaction, consisting of block polymerization of acrylonitrile, interferes with the one-to-one conversion of the hydroxyl group to nitrile. The importance of catalyst concentration, the molecular weight of the hydroxylic compound, the ratio of acrylonitrile to hydroxyl-group concentrations, and the temperature to the formation of side-products is discussed. Gas-liquid-partition chromatography is found to be a suitable analytical method for kinetic studies on the cyanoethylation of some hydroxylic compounds.

Kapell, G. F.

K02 EXPERIMENTAL ASSEMBLY AND STERILIZATION LABORATORY (EASL) OPERATIONS: PHASE I
Kapell, G. F., McDade, J. J., Gavin, T. R.
Technical Report No. 32-941, April 15, 1966
(Unclassified)

This Report describes the Experimental Assembly and Sterilization Laboratory (EASL) effort initiated at the Jet Propulsion Laboratory. This document, a final report of Phase I of the EASL effort, presents conclusions and recommendations based on this Phase I study.

Kastel, D.

K03 STRESS MEASUREMENTS ON BLAIR HIGH SCHOOL GYMNASIUM: A DEMONSTRATION OF SPACE TECHNOLOGY TRANSFER
Kastel, D.
Technical Report No. 32-837, November 1, 1965
(Unclassified)

This Report describes an actual demonstration of transfer to nonspace use of technologies developed for space programs applications. Techniques used in assessing static and dynamic characteristics of the Blair High School gymnasium involved data by continuous scanning of strain gauge data acquired over a time of wide-temperature range and analysis by a computer routine developed by Jet Propulsion Laboratory. The advantage of this method over conventional structural testing of uniquely designed structures was proved. The process of demonstration was shown to be of great assistance to, and extension of, normal methods of disseminating information of new technologies. It is felt that significant benefit will derive from this improved mode of concept transfer.

Keil, K.

K04 POLYMINERALIC INCLUSIONS IN THE ODESSA IRON METEORITE
Marshall, R. R., Keil, K.
Technical Report No. 32-807 (Unclassified)
(Reprinted from *Icarus: International Journal of the Solar System*, Vol. 4, No. 5/6, December 1965, pp. 461–479)

For abstract, see Entry M12.

Keller, O. F.

K05 ALPS GENERANT TANK AND CELL ASSEMBLY
Keller, O. F., Toth, L. R.
Technical Report No. 32-865, February 28, 1966
(Unclassified)

A development program was carried out to determine the relative advantages and disadvantages of diaphragm-type bladders as opposed to balloon-type bladders for expulsion of hydrazine to an Advanced Liquid Propulsion System (ALPS). Bladder materials used were limited to butyl and ethylene propylene elastomers. Ribs, molded integrally with the diaphragm-type bladders, were used to increase expulsion

efficiencies at the higher expulsion pressures. Water expulsion tests were made at pressures up to 100 psig using a transparent Plexiglas tank as a full-scale working model to simulate the flight-type generant tank. Two heavy-weight AISI 4130 steel generant tanks were fabricated for testing as part of a *Mariner* 1966 photo-type subsystem utilizing a 50-lb thrust rocket. Expulsion pressures used were generally limited to 1300 psig. One test using hydrazine was conducted to the point of propellant depletion. Three flight-type 6AL-4V titanium generant tanks were fabricated for testing in the ALPS pressurization subsystem. Expulsion pressures were again generally limited to 1300 psig. A detailed description of the fabrication procedure for the flight-type titanium generant tank includes: a discussion of the welding parameters, cooling devices used during welding, the method used to attach the elastomeric diaphragm to the generant tank wall prior to the final girth weld operation, and the procedure used in replacing the diaphragm in the tank.

Kelly, A. J.

K06 ELECTRON DENSITY AND TEMPERATURE
MEASUREMENTS IN THE EXHAUST OF
A MPD SOURCE
Kelly, A. J., Nerheim, N. M., Gardner, J. A.
Technical Report No. 32-796, September 15, 1965
(Unclassified)

Electron density and temperature profiles were measured in the exhaust of a Magneto-Plasma-Dynamic (MPD) source, operated in a vacuum facility which provides background pressures of from ~100 to ~1,000 μ. Electron density profile measurements, made at several stations downstream of the source by using a Langmuir probe (flashed prior to each measurement) and a 24-Gc/sec microwave swinging arm probe, show agreement to within a factor of two over their common range of measurement (2×10^{12} cm$^{-3} \rightarrow 7 \times 10^{12}$ cm^{-3}). Spectroscopic measurements, utilizing relative ion line intensities at the exit plane of the source, yield electron temperatures in the range 16,000 to 20,000°K for argon mass flows of 0.2 to 0.5 g/sec and currents of 750 to 2,000 amp. Electron temperature profiles, measured 56 cm downstream of the source, have maximums of 6,000 to 7,000°K, which are consistent with collision frequency data obtained with the microwave probe at this station.

It is concluded that the plasma generated by the MPD source is in a highly nonequilibrium state. The degree of ionization at the exit of the source is lower than the equilibrium value based on the measured electron temperature. In the fully developed plume, electron temperature and density measurements show that the degree of ionization is higher than equilibrium.

K07 AN EXPERIMENTAL FEASIBILITY STUDY OF
INJECTANT MATERIALS TO ALLEVIATE
MARS ENTRY COMMUNICATION BLACKOUT
Kelly, A. J.

Technical Report No. 32-835, November 15, 1965
(Confidential)

An experimental program has been initiated to establish the feasibility of using various appropriate materials, injected into the spacecraft wake, as a means of reducing the free-electron density level sufficiently to eliminate its interference with telemetry. It has been determined that the flow conditions (pressure, temperature, electron density) anticipated behind the bow shock of a blunt Martian entry body can be accurately simulated by the plume from an energetic magneto-plasma-dynamic (MPD) arc source.

Electron density profile data were obtained for various injectant materials. From these data, the most promising injectant material was selected and studied more extensively.

K08 ANALYSIS OF THE INTERACTION OF THE
SURVEYOR RADAR ALTIMETER DOPPLER
VELOCITY SENSOR SYSTEM AND VERNIER
THRUST CHAMBER PLUMES
Kelly, A. J.
Technical Report No. 32-927, April 15, 1966
(Unclassified)

In keeping with guidelines of the study task outlines, this analysis was specifically conducted to provide conservative estimates of the vernier plume/RADVS-system interactions effects. In all instances, operating conditions were assumed which, while consistent with *Surveyor* system specifications, would exaggerate the RADVS-plume interaction. For example, the vernier propellant specifications permit a maximum total impurity concentration of 500 ppm. Actually, the propellant purity level is known, from test, to be at least an order of magnitude less than the specifications. However, for the purpose of this investigation, the propellant was assumed to have 500 ppm of sodium as an impurity. As with all other assumptions made during the course of analysis, this assumption permitted an upper bound to be placed on the interaction of the vernier plumes and the RADVS system. As a consequence, no attempt was made to provide a detailed assessment of the most probable level of RADVS-plume interaction to be expected under nominal *Surveyor* operating conditions.

The maximum calculated two-way attenuation and reflection level are both well below the levels at which the performance of the RADVS system would be significantly influenced. However, the nonstatic two-way phase-shift was found to be in excess of the level above which the operation of the RADVS system would be affected.

Kelly, J. H.

K09 DEVELOPMENT OF THE POST-INJECTION
PROPULSION SYSTEM FOR THE
MARINER-C SPACECRAFT
Schmitz, B. W., Groudle, T. A., Kelly, J. H.
Technical Report No. 32-830, April 1, 1966
(Unclassified)

For abstract, see Entry S05.

Kendall, W. B.

K10 UNAMBIGUOUS ACCURACY OF AN
INTERFEROMETER ANGLE-MEASURING SYSTEM
Kendall, W. B.
Technical Report No. 32-781 (Unclassified)
(Reprinted from *IEEE Transactions on Space Electronics
and Telemetry, Vol. SET-11, No. 2*, June 1965, pp. 62–70)

In this paper the problem of using signals received at three
or four antennas to estimate the direction from which radio-
frequency (RF) radiation is arriving is under consideration.
Though the results are couched in the terminology of angle
measurements, they are applicable to any ambiguous measure-
ments for which the number of ambiguities is inversely pro-
portional to the accuracy. For an interferometric system the
effect of receiver noise is examined. Then the optimum way
to process the received waveforms, and the best spacing for
the antennas, is determined. Next, signal-to-noise ratio (SNR)
requirements are determined which must be met to ensure
that, with a given probability, the final unambiguous mea-
surement is not in error by more than some specified amount.
Finally, a comparison is made between a system which uses
unambiguous measurements and a system which uses ambig-
uous measurements and then resolves the ambiguities.

Kerrisk, D. J.

K11 PLASMA NONUNIFORMITY AND GRID EROSION
IN AN ELECTRON BOMBARDMENT ION ENGINE
Kerrisk, D. J., Masek, T. D.
Technical Report No. 32-738 (Unclassified)
(Reprinted from the *AIAA Journal, Vol. 3, No. 6*,
June 1965, pp. 1060–1066)

The plasma in an electron bombardment ion engine of the
Kaufman type has been found to be very nonuniform at the
ion emission surface. This could lead to a nonuniform sput-
tering erosion and the destruction of the accelerator grid.
The plasma density has been measured with a Langmuir
probe and the ion beam profile with a Faraday probe.
Together with flow-rate measurements, this gives an experi-
mental determination of $N_0 N^+$. Sputtering, as a function of
radial position, was measured using a segmented accelerator
grid, and variations in the erosion rate were correlated to the
variations in $N_0 N^+$. Results indicate that the engine lifetime
estimates based on average grid erosion rates will be high
by a factor of 2 to 3, considering only the charge-exchange
erosion contribution.

King, J., Jr.

K12 THEORY OF THE LOW-TEMPERATURE
CHROMATOGRAPHIC SEPARATION OF
THE HYDROGEN ISOTOPES
King, J., Jr., Benson, S. W.
Technical Report No. 32-870 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*,
Vol. 44, No. 3, February 1966, pp. 1007–1014)

A new electrostatic theory is presented which quantitatively
explains the chromatographic separation of the hydrogen iso-
topes on an alumina column at low temperatures. The theory
is based on the interaction of the surface electric fields of the
alumina with the polarizable hydrogen isotopes. By calcu-
lating the electric fields over an adopted Al_2O_3 surface, it is
found that there are two active adsorption sites at 77.4°K,
one over a vacancy in the Al_2O_3 structure, and the other over
an Al^{3+}. The total interaction potential over either site is a
function of the polarizabilities of the adsorbed molecules and
the distance the molecules are from the surface. A 5–9 poten-
tial over a vacancy site gives results which favorably agree
with experimental values. The rotational barrier, necessary to
explain the separation of the ortho and para species, is shown
to arise from the difference in the parallel and perpendicular
components of the molecular polarizability of the hydrogen
molecule.

K13 ELECTROSTATIC INTERACTIONS IN
GAS-SOLID CHROMATOGRAPHY
King, J., Jr., Benson, S. W.
Technical Report No. 32-905 (Unclassified)
(Reprinted from *Analytical Chemistry, Vol. 38, No. 2*,
February 1966, pp. 261–265)

An electrostatic theory of physical adsorption is applied to
gas-solid chromatography and predicts the elution order of
many gases from columns. When applied to the separation of
the rare gases and methane on a γ-Al_2O_3 column at room
temperature the theory not only gives the correct elution
order, but it also quantitatively explains the behavior of
methane on the column. The theory gives a qualitative expla-
nation of the chromatographic inseparability of argon and
oxygen at room temperature. The application of the theory
to molecular sieve column leads to the suggestion that adsorp-
tion on molecular sieves is very similar to adsorption on other
adsorbents like γ-Al_2O_3 and silica gel. The theory proposes
that adsorption on all of these adsorbents is governed by elec-
trostatic interactions. This concept when applied to sieve
columns leads to refutation of the accepted hypothesis that
the separation of molecules on the column is caused by some
type of "sieve" action.

Kinkel, J. R.

K14 RELIABLE TIME MULTIPLEXING BY
REPLACEMENT
Kinkel, J. R.
Technical Report No. 32-828, November 15, 1965
(Unclassified)

This Report describes a switching array for time multiplex-
ing using active redundancy at the function level and passive
redundancy at the component level to increase reliability. It
has been divided into two parts: (1) a description of the
multiplexer, and (2) a computer verification of its behavior.

`Analysis of the multiplexer is based on failure modes instead of failure probabilities. The computer simulation verifies that failure localization occurs, and that it extends the useful life of the multiplexer.

Kirhofer, W. E.

K15 EARTH–MOON TRAJECTORIES, 1960–70
Richard, R. J., Clark, V. C., Jr., Roth, R. Y., Kirhofer, W. E.
Technical Report No. 32-503 (Rev. 1), September 15, 1965
(Unclassified)

For abstract, see Entry R12.

Klejnot, O. J.

K16 CHLORIDE ALKOXIDES OF PENTAVALENT TUNGSTEN
Klejnot, O. J.
Technical Report No. 32-863 (Unclassified)
(Reprinted from the *Inorganic Chemistry*, Vol. 4, No. 11, November 1965, pp. 1668–1670)

Studies aimed at syntheses of the unknown tungsten hexa- and pentaalkoxides have led to the first isolation of tungsten(V) chloride alkoxides (I–III). The reported green $W_2Cl_1(OC_2H_5)_6$ obtained by reducing pentavalent solutions seems to be tetravalent with two ethanol ligands in place of two ethoxo ligands.

Dissolution of tungsten hexachloride in alcohols gave long-known yellow solution, but the evolution of chlorine in methanol or ethanol has only been noted now

$$WCl_6 + 2C_2H_5OH \rightarrow \tfrac{1}{2}Cl_6 + WCl_3(OC_2H_5)_2 + 2HCl$$

$$Cl_2 + C_2H_5OH \rightarrow CH_3CHO + 2HCl$$
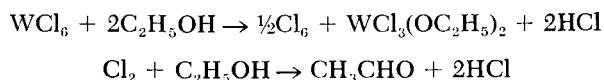
Klevans, E. H.

K17 TEMPERATURE RELAXATION IN A FULLY IONIZED PLASMA
Wu, C.-S., Klevans, E. H., Primack, J. R.
Technical Report No. 32-759 (Unclassified)
(Reprinted from *The Physics of Fluids*, Vol. 8, No. 6, June 1965, pp. 1126–1133)

For abstract, see Entry W32.

Knoell, A. C.

K18 ENVIRONMENTAL AND PHYSICAL EFFECTS ON THE RESPONSE OF BALSA WOOD AS AN ENERGY DISSIPATOR
Knoell, A. C.
Technical Report No. 32-944, June 15, 1966
(Unclassified)

The description includes the balsa-wood development program, balsa-wood specimens, static testing, and an analysis

and discussion of test results. This document also comprises a list of conclusions based on the investigation.

Koester, H.

K19 THE USE OF CONVENTIONAL WIND TUNNELS TO SIMULATE PLANETARY ATMOSPHERIC AERODYNAMICS
Koester, H., Fox, N.
Technical Report No. 32-762, November 15, 1965
(Unclassified)

The aerodynamic effects of planetary atmospheric simulation have been experimentally investigated in the Jet Propulsion Laboratory wind tunnels. Admixtures of carbon dioxide into the conventional dried air working fluid were used to simulate variations of the atmospheric properties. The performance of the wind tunnels, the techniques used, and samples of the data obtained are presented. The results obtained indicate that, within a given range, this approach will yield excellent data for planetary atmosphere entry vehicle design.

Kopf, E. H., Jr.

K20 AN ADAPTIVE NUMERICAL INTEGRATION ROUTINE FOR THE IBM 1620 II
Kopf, E. H., Jr.
Technical Report No. 32-962, June 1, 1966
(Unclassified)

This Report presents a symbolic-programming-system coded numerical integration program designed to be used as a FORTRAN subroutine on the IBM 1620 II Computer. The program will solve differential equations by integration starting with known initial conditions. An adaptive option is available where the speed of integration is automatically varied in accordance with a predicted error.

Kopka, E. F.

K21 SYNTHESIS OF CARBON-14 LABELED ISOCYANATES. DETERMINATION OF THE CARBON-14 DISTRIBUTION IN THE ISOCYANATE GROUPS OF 2,4-TOLYLENE DIISOCYANATE
Kopka, E. F., Rapp, N. S., Ingham, J. D.
Technical Report No. 32-861 (Unclassified)
(Reprinted from the *Journal of Labeled Compounds*, Vol. 1, No. 3, July–September 1965, pp. 1–12)

A practical phosgenation procedure has been devised for the preparation of isocyanates labeled with [14]C. Three such isocyanates: 2-tolyl isocyanate, 4-tolyl isocyanate, and 2,4-tolylene diisocyanate (TDI) were prepared. The ^{14}C distribution in the latter was determined by scintillation counting of some of its derivatives, one of which was 3-amino-4,2',6'-trimethylcarbanilide, from which the fraction of ^{14}C in the 4-isocyanate group of TDI was obtained.

Kotlensky, W. V.

**K22 TENSILE AND STRUCTURAL PROPERTIES
OF GLASSY CARBON**
Kotlensky, W. V., Fischbach, D. B.
Technical Report No. 32-842, November 15, 1965
(Unclassified)

Tensile properties of two different grades of glassy carbon
(GC-20 and GC-30) have been measured from room tempera-
ture to 2900°C. The test specimens had a gauge section
0.08 in. in width by 0.10 in. in thickness with a 0.75-in. gauge
length. Tests were made in a helium atmosphere, and heating
was accomplished by means of an external graphite heater.
Tensile strengths at room temperature for both grades were
approximately 6000 psi. Both grades showed an increase in
strength with increasing test temperature, reaching a maxi-
mum within the 20,000 to 25,000 psi range at 2500°C. At
2900°C, strengths of about 12,000 psi for GC-20 and 16,000
psi for GC-30 were measured. Differences in the deformation
of the two grades were evident from their ductility. At
2700°C, maximum elongations of 33% for GC-20 and 5.4%
for GC-30 were measured. Density, unit cell dimension, hard-
ness, and diamagnetic susceptibility measurements were used
to investigate the structural changes accompanying deforma-
tion and heat treatment. Electron micrographs revealed a
difference in fracture mode for GC-20 and GC-30. The tensile
and structural behavior of glassy carbon has been compared
with that of conventional carbon-base materials. It is sug-
gested that cross-link bonding is responsible for the high
strength of glassy carbon; however, the small crystallite size
and the small pore size may also be contributing factors.

**K23 ANALYSIS OF HIGH TEMPERATURE CREEP
IN PYROLYTIC CARBON**
Kotlensky, W. V.
Technical Report No. 32-889, February 15, 1966
(Unclassified)

Data on short-time high-temperature tensile creep parallel
to the substrate for two pyrolytic carbons (pyrolytic gra-
phites) characterized by their microstructures as substrate
nucleated (SN) and regeneratively nucleated (RN) have
been analyzed by means of the Dorn method. Over the range
of approximately 1.5 to 10% creep strain for the SN material
and for creep strains above 1.5% for the RN material, the
creep data were found to fit the empirical relationships
$\epsilon = A + Bt^n$, where ϵ is the creep strain, t is the time, n is
a constant that depends on the material, and A and B are
parameters that depend on both the material and the test
conditions. The SN material was characterized by $n = 0.60$,
while the RN material had $n = 0.42$. The same apparent
activation energy of about 250 kcal/mole was calculated for
both of these carbons. As assumed in the analysis, the struc-
tural change that occurs during creep was found to be de-
pendent on the total creep strain, and the same structure was
developed at a given load for the same strain, independent

of test temperature. These structural changes are discussed
briefly with reference to the deformation mechanisms.

Kuiper, G. P.

**K24 RANGER VIII AND IX.
PART II. EXPERIMENTERS' ANALYSES AND
INTERPRETATIONS**
Heacock, R. L., Kuiper, G. P., Shoemaker, E. M.,
Urey, H. C., Whitaker, E. A.
Technical Report No. 32-800, March 15, 1966
(Unclassified)

For abstract, see Entry H12.

Kuwada, D.

**K25 PYROLYSIS STUDIES. CONTROLLED THERMAL
DEGRADATION OF MESOPORPHYRIN**
Whitten, D. G., Bentley, K. E., Kuwada, D.
Technical Report No. 32-812 (Unclassified)
(Reprint from the *Journal of Organic Chemistry, Vol. 31,*
1966, pp. 322–324)

For abstract, see Entry W22.

Laderman, A.

L01 THE HIGH-ALTITUDE ROCKET RADAR PROJECT
Brown, W. E., Jr., Barath, F. T., Jordan, R. L.,
Laderman, A., Martin, D. P., Friedman, H. L., Gutierrez, R.
Technical Memorandum No. 33-196, June 15, 1965
(Unclassified)

For abstract, see Entry B30.

Landel, R. F.

**L02 THE TENSILE FAILURE ENVELOPE OF
AMORPHOUS ELASTOMERS: EFFECTS OF
STATISTICAL VARIABILITY AND
CROSSLINK DENSITY**
Landel, R. F., Fedors, R. F.
Technical Report No. 32-633 (Unclassified)
(Reprinted from the *Proceedings of the Fourth
International Congress On Rheology,* Brown University,
Providence, R.I., August 26–30, 1963, Interscience
Publishing Co., New York, 1965, pp. 543–566)

The statistical variability of both rupture stress, σ_b, and
rupture strain, ϵ_b, was studied by breaking 25 ring specimens
of peroxide cured SBR at a strain rate of 2.32/min at 23, −10
and −40°C. The statistical distribution for both σ_b and ϵ_b
can be reasonably described by a double-exponential cumu-
lative distribution function whose parameters are tempera-
ture dependent and presumably depend on the test rate and
the concentration of effective network chains as well. The
rupture points plotted as a Smith failure envelope, $\log \sigma_b T_0/T$
vs $\log \epsilon_b$, where T_0/T is the usual temperature reduction
factor, define the same envelope as that determined by break-
ing single specimens at varying rates and temperatures.

It is demonstrated that the high temperature portions of the failure envelopes of some 12 systems, including butyl, epoxy, SBR, ethylene–propylene, silicone, and Viton B rubbers, could be superposed to a single master curve by normalizing σ_b to unit chain concentration and to a common number of degrees above T_g (T_g + 100 in the present case). The form of the master curve can be described reasonably well by the Martin-Roth-Stiehler expression for the stress-strain curve of an elastomer,

$$\sigma = E\epsilon\lambda^{-2} \exp [0.40 (\lambda - \lambda^{-1})].$$

It is also pointed out that for systems which follow the master curve, the concentration of effective network chains can be rapidly and conveniently determined by breaking multiple specimens at an appropriate rate and temperature and comparing the resulting portion of the failure envelope with the master curve.

L03   STATISTICAL VARIABILITY OF ULTIMATE
PROPERTIES OF SBR GUM VULCANIZATES
Fedors, R. F., Landel, R. F.
Technical Report No. 32-783 (Unclassified)
(Reprinted from *Transactions of the Society of Rheology*,
Vol. 9, No. 1, 1965, pp. 195–218)

For abstract, see Entry F02.

L04   ORGANIC SYNTHESIS USING FUSED SALT
SYSTEMS: PREPARATION OF A
POLYTRIPHENYLENE
Ostrum, G. K., Lawson, D. D., Landel, R. F., Ingham, J. D.
Technical Report No. 32-907 (Unclassified)
(Reprinted from *Chemical Communications*, 1966, p. 53)

For abstract, see Entry O01.

Lang, T. E.

L05   SUMMARY OF THE FUNCTIONS AND
CAPABILITIES OF THE STRUCTURAL
ANALYSIS SYSTEM COMPUTER PROGRAM
Lang, T. E.
Technical Memorandum No. 33-220, June 15, 1965
(Unclassified)

The functions and operations of a large capacity Structural Analysis System Computer Program developed to analyze frame and shell-type structures are described. Included is a summary of the capabilities of the program, and a discussion of certain problems encountered in development of the program. The participation of engineering personnel in the setup and running of a typical shell problem is outlined.

Laudenslager, R. K.

L06   EXPERIMENTAL PROCEDURES FOR
MOLECULAR WEIGHT DETERMINATION
BY LIGHT SCATTERING
Beattie, W. H., Laudenslager, R. K., Moacanin, J.

Technical Memorandum No. 33-242, January 1, 1966
(Unclassified)

For abstract, see Entry B09.

Laue, E. G.

L07   MEASUREMENT DEVICES HAVING
POTENTIAL APPLICATION TO
SOLAR SIMULATION SYSTEMS
Laue, E. G.
Technical Report No. 32-925 (Unclassified)
(Reprinted from *Journal of Spacecraft and Rockets*,
Vol. 3, No. 3, March 1966, pp. 378–382)

The four major parameters of a solar simulation system (radian flux density, uniformity of flux density, decollimation angle, and spectral distribution of energy) require careful evaluation before meaningful testing can be accomplished. Working conditions and schedule problems preclude the use of instruments which require precise and time-consuming adjustments. The use of photovoltaic detectors (silicon solar cells, selenium cells, and modified germanium transistors) with interference filters and simple optical devices provide a means of rapidly acquiring the necessary data but do not eliminate the necessity for careful and thorough preliminary testing using precision instruments.

Lawson, D. D.

L08   MOLECULAR STRUCTURE AND CONFIGURATION
OF POLYMERS: NMR SPECTRA OF
POLY (ALKYLENE OXIDE) TERMINAL GROUPS
Ingham, J. D., Lawson, D. D., Manatt, S. L.,
Rapp, N. S., Hardy, J. P.
Technical Report No. 32-904 (Unclassified)
(Reprinted from *Journal of Macromolecular Chemistry*,
Vol. 1, No. 1, September 1965, pp. 75–91)

For abstract, see Entry I03.

L09   ORGANIC SYNTHESIS USING FUSED SALT
SYSTEMS: PREPARATION OF A
POLYTRIPHENYLENE
Ostrum, G. K., Lawson, D. D., Landel, R. F., Ingham, J. D.
Technical Report No. 32-907 (Unclassified)
(Reprinted from *Chemical Communications*, 1966, p. 53)

For abstract, see Entry O01.

Leipold, M. H.

L10   MASS SPECTROGRAPHIC ANALYSES OF
NONCONDUCTING CERAMICS
Socha, A. J., Leipold, M. H.
Technical Report No. 32-815 (Unclassified)
(Reprinted from the *Journal of the American Ceramic
Society*, Vol. 48, No. 9, September 1965, pp. 463–466)

For abstract, see Entry S21.

Levine, H. B.

L11 MANY-ELECTRON-THEORY *AB INITIO*
CALCULATION FOR THE Be ATOM
Geller, M., Taylor, H. S., Levine, H. B.
Technical Report No. 32-799 (Unclassified)
(Reprinted from *The Journal of Chemical Physics, Vol. 43,
No. 5, September 1965, pp. 1727–1736*)

For abstract, see Entry G06.

Likins, P. W.

L12 EFFECTS OF ENERGY DISSIPATION ON THE
FREE-BODY MOTIONS OF SPACECRAFT
Likins, P. W.
Technical Report No. 32-860, July 1, 1966
(Unclassified)

The objective of this study is the development of methods
of analysis of the motions of spacecraft modeled as nonrigid,
dissipative bodies in a force-free environment. In the absence
of external forces, angular momentum is conserved, but, be-
cause of internal energy dissipation effects, gross changes in
body orientation and rotational motion may occur. Three
analytical methods for the prediction of these changes are
developed or described in this Report.

The first method, based on a model of a spacecraft as a
rigid body with an "energy sink," has been described in
numerous papers in the technical literature. The method is
discussed and documented, and limitations in its application
are noted.

The second method involves the dynamical analysis of a
discrete parameter model of a spacecraft, including discrete
dampers. This method, which, analytically, is the most
straightforward of the three, is described briefly, and its
range of application to spacecraft is defined.

In the third method, a modal model is utilized; i.e., mo-
tions are described in terms of the normal modes of deforma-
tion of a slightly flexible, lightly damped structure. The
primary advantage of this method stems from the improved
likelihood of reasonable estimation of structural damping char-
acteristics in early stages of design and of approximate
measurement of these characteristics prior to launch. Equa-
tions of motion constructed for this model are linearized in
the deformation coordinates, but they remain nonlinear in
"rigid body motion" coordinates, thus accommodating large
angular motions of bodies undergoing small elastic defor-
mations.

Lindley, P. L.

L13 THE PN TECHNIQUE OF RANGING AS APPLIED
IN THE RANGING SUBSYSTEM MARK I
Lindley, P. L.
Technical Report No. 32-811, November 15, 1965
(Unclassified)

Starting with the basic principles of radar, the concepts of
a technique of range determination with pseudo-random codes
are developed. Increasingly complex requirements are con-
sidered and satisfied in turn by the use of the Gedanken-
Experimente approach. The need for ranging codes, their
requirements, synthesis, and detection are discussed. A brief
functional description of the ranging subsystem Mark I is
combined with its performance parameters, including the
maximum unambiguous range determinable and the resolution
and accuracy of the measurement.

Lindsey, W. C.

L14 CODED NONCOHERENT COMMUNICATIONS
Lindsey, W. C.
Technical Report No. 32-739 (Unclassified)
(Reprinted from the *IEEE Transactions on Space
Electronics and Telemetry, Vol. SET-11, No. 1,
March 1965, pp. 6–13*)

This paper presents detailed results on the relative merits
of encoding blocks of binary digits into a set of equiprobable,
equal energy, orthogonal signals each containing n bits of
information. Word and bit error probabilities are graphically
illustrated for various degrees of coding and for various forms
of the channel model. Particular emphasis is placed on the
Gaussian channel. Special cases of Viterbi's results for coded
phase-coherent communications are compared with those
obtained in this paper. Bandwidth considerations are also
discussed.

The results are useful to the engineer who is faced with
the problem of designing coded communications systems
where power is limited to the point that phase coherence
cannot be established at the receiver.

L15 OPTIMUM COHERENT LINEAR DEMODULATION
Lindsey, W. C.
Technical Report No. 32-787 (Unclassified)
(Reprinted from *IEEE Transactions on Communication
Technology, Vol. COM-13, No. 2, June 1965, pp. 183–190*)

Presented is the performance analysis for four types of
linear-modulated communication systems where the message
to be transmitted comes from one of two classes of stochastic
processes, and the additive channel noise is white and Gaus-
sian. The two classes of stochastic processes which are used
to modulate the transmitter are taken to be the "maximally
flat" and "asymptotically Gaussian" processes. Demodulation
is accomplished at the receiver by coherent frequency trans-
lation using a noisy replica of the carrier and filtering the
result with one of two types of Wiener filters. These are
commonly referred to as the zero-lag (realizable) and infinite-
lag (nonrealizable) Wiener filters.

The four types of modulation considered are: linear-
modulation, double-sideband (DSB); linear-modulation,
double-sideband, suppressed carrier (DSB/SC); linear-
modulation, single-sideband (SSB); and linear-modulation,
single-sideband, suppressed carrier (SSB/SC).

Loomis, A. A.

**L16   SOME GEOLOGIC PROBLEMS OF MARS
       (REVISION 1)**
       Loomis, A. A.
       Technical Report No. 32-400 (Unclassified)
       (Reprinted from *Geological Society Bulletin, Vol. 76,*
       October 1965, pp. 1083–1104)

Data on the body of Mars are as yet insufficient to allow computation of meaningful models of the internal structure or density stratification within the planet. The flattening of the solid surface appears to be greater than the flattening of the equipotential surface by about a factor of two. The resultant possibility that the equatorial regions are high compared to the polar areas has many geological and biological implications.

Most of the inner planets—Mercury, Venus, Earth, Moon, and Mars—have bulk compositions which differ from one another as well as from that of the stony meteorites. The thermal histories of the planets have therefore differed because of different original compositions as well as different sizes and distances from the Sun.

More data on the surface topography are required in order to make geological interpretations which are not largely subjective. The dark areas could be either highlands or lowlands relative to surrounding bright areas. Although sharp relief of several thousand feet is probably absent or nearly so, substantial mountain ranges, plateaus, or basins could exist if the slopes on their flanks are gradual. Liquid water cannot exist on the surface of Mars, and aqueous erosion features, if they once existed, have become subdued by aeolian activity.

Winds on Mars may move more and coarser materials than winds on Earth. Deep accumulations of aeolian deposits have formed, at least locally. *Mariner IV* pictures show an impact-crater distribution much like the highland areas of the Moon. Many craters with original depths of less than about 8000–10,000 feet have become obliterated on Mars by windblown dust.

**L17   A LUNAR AND PLANETARY PETROGRAPHY
       EXPERIMENT**
       Loomis, A. A.
       Technical Report No. 32-785, July 15, 1965
       (Unclassified)

A preliminary model of a petrographic microscope for lunar and planetary missions has been fabricated. It is designed primarily for remote operation on soft-landing spacecraft, but could be adapted for support of a manned mission. The sample is not a thin section, but an aggregate of crushed rock particles. The image is projected from an air-gapped 16X refracting objective lens through interchangeable eye-piece lenses onto the faceplate of a television camera. The sample particles are thermally encapsulated between two opposing sheets of a clear isotropic thermoplastic ($n = 1.54$). A television picture is taken both below and above the plane of correct focus as well as in that plane for each field of view

in order to change the Becke line positions. Each grain is viewed in both plane-polarized and cross-polarized light; the spectral width is small enough to provide dark and light interference rings on a black-and-white TV. The primary use of the microscope is observation of rock textures. Secondary uses are determination of bulk mineralogy, observation and compositional estimation of glass, identification of phases which occur in small amounts, and identification of the different rock or mineral types in an originally particulate sample.

Lorell, J.

**L18   LONG TERM BEHAVIOR OF ARTIFICIAL
       SATELLITE ORBITS DUE TO THIRD-BODY
       PERTURBATIONS**
       Lorell, J.
       Technical Report No. 32-851 (Unclassified)
       (Reprinted from *The Journal of the Astronautical Sciences,
       Vol. 12, No. 4,* Winter, 1965, pp. 142–149)

The long term motion of a satellite perturbed only by a third body is studied in detail. Two integrals of the motion are used to classify the possible orbits and to identify the various special cases which represent transition from one family of orbits to another. Results are explained with the help of a set of graphs showing the variation of the Kepler elements along different orbits.

**L19   CHARACTERISTICS AND FORMAT OF THE
       TRACKING DATA TO BE OBTAINED BY THE
       NASA DEEP SPACE INSTRUMENTATION FACILITY
       FOR LUNAR ORBITER**
       Lorell, J., Anderson, J. D., Sjogren, W. L.
       Technical Memorandum No. 33-230, June 15, 1965
       (Unclassified)

This document is intended as an explanatory supplement for users of the data, to explain the meaning of the data, the locations of the instruments, the biases, the precision and accuracy, the reduction to geometrical quantities, and the format for distribution.

Ludwig, A. C.

**L20   LARGE ANTENNA APERTURES AND ARRAYS FOR
       DEEP SPACE COMMUNICATIONS**
       Potter, P. D., Merrick, W. D., Ludwig, A. C.
       Technical Report No. 32-848, November 1, 1965
       (Unclassified)

For abstract, see Entry P11.

Lunine, L. R.

**L21   THE SPACE FLIGHT OPERATIONS FACILITY
       DOCUMENT CONTROL DATA STORAGE AND
       RETRIEVAL SYSTEM**
       Higgins, M. D., Lunine, L. R.
       Technical Memorandum No. 33-288, June 15, 1966
       (Unclassified)

For abstract, see Entry H17.

Lushbaugh, W. A.

L22 DEMONSTRATION OF A QUANTILE SYSTEM FOR
COMPRESSION OF DATA FROM DEEP SPACE
PROBES
Anderson, T. O., Eisenberger, I., Lushbaugh, W. A.,
Posner, E. C.
Technical Report No. 32-772, December 1, 1965
(Unclassified)

For abstract, see Entry A08.

Lyttleton, R. A.

L23 THE EFFECT OF THE LUNAR ORBIT OF
METEORITIC ACCRETION
Lyttleton, R. A.
Technical Report No. 32-293, Part II (Unclassified)
(Reprinted from *Icarus: International Journal of the
Solar System*, Vol. 5, No. 2, March 1966, pp. 162–164)

Reduction of the lunar distance through meteoric impacts
depends only on the amount of incoming material and scarcely
at all on how much may be exploded off the surface to escape.
This is because the incoming material possesses negligible
angular momentum on average, while outgoing material
carries with it the same angular momentum per unit mass as
the Moon. To reduce the lunar distance by ⅓, an amount of
matter of about ⅙ the mass of the Moon would need to have
interacted with it, but rounding up from an eccentric orbit
without change of angular momentum would be a more likely
result.

L24 ON THE PHASE-CHANGE HYPOTHESIS OF THE
STRUCTURE OF THE EARTH
Lyttleton, R. A.
Technical Report No. 32-810 (Unclassified)
(Reprinted from the *Proceedings of the Royal Society*,
Vol. 287, 1965, pp. 471–493)

The hypothesis that the liquid core of the Earth represents
a phase-change at high pressure (and suitable temperature)
of the mantle material is further investigated. A more accu-
rate series of two-zone models have been computed, and also
a new series of three-zone models. The change of over-all
radius as between an original all-solid Earth and the present
size is shown to be at least 370 km.

In the outer regions, greater pressure may be needed with
rising temperature to effect the transition to denser crystal
form (associated with the 20°-discontinuity), and from this
cause acting alone slight expansion of the Earth would result,
but to an extent less than one-tenth the over-all contraction.
Epochs of rapid contraction (mountain-building eras) could
thus be separated by longer intervals of very slow expansion.

The initial liquefaction of the central regions brings about
pressure increase of the boundary of the core that renders the
Earth unstable in that about 6% of the entire mass liquefies
extremely rapidly to cause a sudden collapse of the planet as
a whole. The accompanying decrease of outer radius is about

70 km. Thereafter the planet remains thoroughly stable and
contracts only slowly.

The total contraction to date would have reduced the mo-
ment of inertia by a factor of about 4/5, and the corresponding
reduction in rotation period (through conservation of angular
momentum) would be an effect comparable with tidal fric-
tion. The contraction also leads to release of gravitational
energy at an average rate comparable with that from radio-
active sources.

An important consequence of the phase-change hypothesis
is that the melting-point gradient changes sign after sufficient
depth, thereby permitting melting of the central regions to
occur at moderate temperatures explicable by a reasonable
content of radioactive elements.

MacGlashan, W. F., Jr.

M01 GENERANT CONTROLLER DEVELOPMENT FOR
THE ADVANCED LIQUID PROPULSION SYSTEM
(ALPS)
MacGlashan, W. F., Jr.
Technical Report No. 32-814, November 15, 1965
(Unclassified)

The generant controller is essentially a remote-sensing,
single-stage, spring-loaded regulator. Four controller versions
were built and tested. Controller 4 incorporates the best fea-
tures of the preceding three controllers. Results of water tests
that simulate expected operating conditions are recorded.

Special features of these controllers, such as the diaphragm
backup ring and the Belleville spring package which were
developed as a result of this study, are discussed. The suit-
ability of these special features for scalability and for other
components is pointed out.

An Appendix is included which describes the function of
the generant controller in the ALPS system and in the
Mariner-Mars 1966 system.

M02 FILL VALVE DEVELOPMENT FOR THE ADVANCED
LIQUID PROPULSION SYSTEM (ALPS)
MacGlashan, W. F., Jr.
Technical Report No. 32-875, February 1, 1965
(Unclassified)

A simple, compact, lightweight valve was developed to
satisfy the need for reliable fill valves for the Advanced Liquid
Propulsion System (ALPS). Manually operated valves for
on–off control of Earth-storable propellants and inert gases
were designed, built, and tested.

The preferred valve design consists of a ceramic ball, a
screw, and a tank boss. The screw pushes the ball onto a
spherically lapped seat in the tank boss. With the ground
fitting engaged, the valve can be actuated irrespective of line
pressure. Flow can be either around or through the screw.

Several variations of this ball valve are described. Problems
encountered, refinements, and test results are discussed.

Magistrale, V.

M03 JPL SPACECRAFT STERILIZATION TECHNOLOGY
PROGRAM: A STATUS REPORT
Drummond, D., Magistrale, V.
Technical Report No. 32-853, December 31, 1965
(Unclassified)

For abstract, see Entry D08.

Mallory, F. B.

M04 THE RATES OF SOME DEGENERATE
REARRANGEMENTS AS DETERMINED BY
NUCLEAR MAGNETIC RESONANCE
SPECTROSCOPY
Mallory, F. B., Manatt, S. L., Wood, C. S.
Technical Report No. 32-857 (Unclassified)
(Reprinted from the *Journal of the American Chemical
Society, Vol. 87, No. 23,* December 1965, pp. 5433–5438)

The rates and the activation parameters have been deter-
mined for the degenerate isomerizations of three different
symmetrically disubstituted benzofurazan oxides in order to
provide evidence for the mechanism of this type of intercon-
version. The rates of these very rapid processes were deduced
from the line shapes of the nmr spectra of the three com-
pounds at various temperatures in the range from -40 to
$+50°$. The positive entropies of activation (ranging from $+4$
to $+6$ e.u.), the relatively small energies of activation (rang-
ing from 15.0 to 16.5 kcal/mole), and the correlation of the
relative rates with the size of the substituents at the 4- and
7-positions flanking the N_2O_2 grouping are all considered to
support an interconversion mechanism that involves ring
opening of the furazan oxide to the corresponding o-dinitroso-
benzene as the rate-determining step, followed by very rapid
recyclization of this symmetrical intermediate to the hetero-
cyclic N-oxide.

Mannatt, S. L.

M05 THE RELATIVE SIGNS OF THE NUCLEAR
MAGNETIC RESONANCE PROTON–PROTON
COUPLING CONSTANTS IN STYRENE SULFIDE
AND STYRENIMINE
Manatt, S. L., Elleman, D. D., Brois, S. J.
Technical Report No. 32-746 (Unclassified)
(Reprinted from the *Journal of the American Chemical
Society, Vol. 87, No. 10,* May 20, 1965, pp. 2220–2225)

From nmr double resonance experiments in which a weak
perturbing radio-frequency field was applied to certain spec-
tral lines, it was found that the 1.37-cps geminal proton-proton
coupling of styrene sulfide (III) is a different sign than the
two vicinal couplings of 5.55 and 6.60 cps between protons
in the thiirane ring. Similar experiments on styrenimine (II)
showed that the 0.87-cps geminal coupling in this molecule
is the same sign as the 3.29- and 6-12-cps vicinal couplings
in the aziridine ring. These results are discussed in relation

to the magnitudes and relative signs of other geminal and
vicinal proton-proton coupling constants and their correlation
with substituent electronegatives. It is concluded that the
linear correlations of geminal and vicinal couplings with sub-
stituent electronegativities may be better than previously
expected.

M06 NITROGEN ANALOGS OF SESQUIFULVALENE.
II. THEORETICAL CORRELATION OF
GROUND-STATE PROPERTIES
Berson, J. A., Evleth, E. M., Jr., Manatt, S. L.
Technical Report No. 32-776 (Unclassified)
(Reprinted from the *Journal of the American Chemical
Society, Vol. 87, No. 13,* July 5, 1965, pp. 2901–2907)

For abstract, see Entry B17.

M07 NITROGEN ANALOGS OF SESQUIFULVALENE.
III. THEORETICAL CORRELATION OF EXCITED-
STATE PROPERTIES
Evleth, E. M., Jr., Berson, J. A., Manatt, S. L.
Technical Report No. 32-776 (Unclassified)
(Reprinted from the *Journal of the American Chemical
Society, Vol. 87, No. 13,* July 5, 1965, pp. 2908–2913)

For abstract, see Entry E10.

M08 THE RATES OF SOME DEGENERATE
REARRANGEMENTS AS DETERMINED BY
NUCLEAR MAGNETIC RESONANCE
SPECTROSCOPY
Mallory, F. B., Manatt, S. L., Wood, C. S.
Technical Report No. 32-857 (Unclassified)
(Reprinted from the *Journal of the American Chemical
Society, Vol. 87, No. 23,* December 1965, pp. 5433–5438)

For abstract, see Entry M04.

M09 MOLECULAR STRUCTURE AND CONFIGURATION
OF POLYMERS: NMR SPECTRA OF
POLY (ALKYLENE OXIDE) TERMINAL GROUPS
Ingham, J. D., Lawson, D. D., Manatt, S. L.
Rapp, N. S., Hardy, J. P.
Technical Report No. 32-904 (Unclassified)
(Reprinted from *Journal of Macromolecular Chemistry,
Vol. 1, No. 1,* September 1965, pp. 75–91)

For abstract, see Entry I03.

M10 CHARACTERIZATION OF FUNCTIONAL GROUPS
BY NUCLEAR MAGNETIC RESONANCE.
I. CLASSIFICATION OF ALCOHOLS FROM THE
FLUORINE-19 SPECTRA OF TRIFLUOROACETATES
Manatt, S. L.
Technical Report No. 32-930 (Unclassified)
(Reprinted from the *Journal of the American Chemical
Society, Vol. 88,* pp. 1323–1324, 1966)

This Report intends to describe an nmr scheme for classifi-
cation of hydroxyl compounds in a more reliable and informa-
tive manner than other recently described nmr techniques.

The study of the ^{19}F nmr spectra of the trifluoroacetate (TFA) esters of a large number of alcohols revealed that the TFA groups give sharp ^{19}F signals and that the order of shielding is always primary < secondary < tertiary. The method described here has certain advantages. With this method, one is looking at the signal from three ^{19}F nuclei vs one ^{1}H nucleus which can be a multiplet. Because one observes the ^{19}F spectrum, signals from the other protons in the molecules of interest are far removed and the restrictions on the choice of solvent are removed.

Marsh, H. E., Jr.

M11 STERILIZED SOLID-PROPELLANT ROCKET MOTORS
FOR MARS LANDING MISSIONS (REVISION 1)
Montgomery, L. C., Marsh, H. E., Jr.
Technical Report No. 32-725, June 30, 1965
(Unclassified)

For abstract, see Entry M30.

Marshall, R. R.

M12 POLYMINERALIC INCLUSIONS IN THE
ODESSA IRON METEORITE
Marshall, R. R., Keil, K.
Technical Report No. 32-807 (Unclassified)
(Reprinted from Icarus: International Journal of the
Solar System, Vol. 4, No. 5/6, December 1965, pp. 461–479)

A piece of the Odessa iron meteorite (a coarse octahedrite) was found to contain two types of nodules: globular and elongated ones. The globular nodules have a core of troilite surrounded by a shell of graphite and/or fine-grained graphite–troilite mixture containing some daubréelite, and a thin outer layer of schreibersite and cohenite, in some cases with further localization of schreibersite and cohenite to one side. The relative proportions of the troilite and the intimate mixture of graphite and troilite vary greatly. The mineral content of the elongated nodules is more complex; they consist of troilite, graphite, schreibersite, cohenite, forsterite, calcium-rich chromian clinopyroxene, enstatite, albite, chlorapatite, and daubréelite (listed in the approximate order of their abundances by volume). Magnetite and its small inclusions of nickel-rich iron are probably terrestrial alteration products. Again, schreibersite and cohenite are frequently concentrated on the same side of the elongated nodules. The compositions of the silicates, magnetite, chlorapatite, nickel-rich iron, and daubréelite were measured by electron microprobe techniques. Plots of the small contents of iron in a number of olivine and pyroxene grains show ranges in composition that are narrow but that are outside the limits of uncertainty in the measurements. The consistent elongation in one direction of the nodules containing silicates may be interpreted as the result of solidification of the meteorite under the influence of a gravitational field and/or convection.

Marte, J. E.

M13 AN EXPERIMENTAL STUDY OF THE FLOW FIELD
PRODUCED BY THREE HYPERSONIC JETS
IMPINGING ON A SURFACE IN A VACUUM
ENVIRONMENT
Marte, J. E., Fox, N. L.
Technical Memorandum No. 33-231, July 30, 1965
(Unclassified)

A tuft study to investigate interference phenomena between three jet plumes which impinge on a nearby normal surface was carried out in the Jet Propulsion Laboratory's 25-ft space simulator. The existence of reverse flow in the triangular central region which was interior to three Surveyor-type vernier motors was established. Under certain conditions the reverse flow might provide a mechanism for the transport of surface dust into the central portion of the Surveyor vehicle. A pressure measurement was made in the plane of the nozzle exits on the vehicle centerline at a nozzle-plate height of 4.5-ft full scale. At this point the dynamic pressure in the reverse flow was 30 per cent of the dynamic pressure at the plate on the nozzle centerlines.

Martin, D. P.

M14 THE HIGH-ALTITUDE ROCKET RADAR PROJECT
Brown, W. E., Jr., Barath, F. T., Jordan, R. L.,
Laderman, A., Martin, D. P., Friedman, H. L.,
Gutierrez, R.
Technical Memorandum No. 33-196, June 15, 1965
(Unclassified)

For abstract, see Entry B30.

Masek, T. D.

M15 PLASMA NONUNIFORMITY AND GRID EROSION IN
AN ELECTRON BOMBARDMENT ION ENGINE
Kerrisk, D. J., Masek, T. D.
Technical Report No. 32-738 (Unclassified)
(Reprinted from the AIAA Journal, Vol. 3, No. 6,
June 1965, pp. 1060–1066)

For abstract, see Entry K11.

Mattson, R. F.

M16 DEVELOPMENT OF THE RANGER BLOCK III
SPACECRAFT PROPULSION SYSTEM
Evans, D. D., Groudle, T. A., Mattson, R. F.
Technical Report No. 32-829, March 15, 1966
(Unclassified)

For abstract, see Entry E09.

Maxworthy, T.

M17 AN EXPERIMENTAL DETERMINATION OF THE
SLOW MOTION OF A SPHERE IN A ROTATING,
VISCOUS FLUID
Maxworthy, T.
Technical Report No. 32-601 (Unclassified)

(Reprinted from *Journal of Fluid Mechanics, Vol. 23, No. 2,* 1965, pp. 373–384)

The drag of a sphere has been measured as it moves along the axis of a rotating, viscous fluid. Rotation has been found to modify the classical low-Reynolds-number flow so that the drag is increased and the effects of the finite Reynolds number, R, and of wall proximity are reduced as the rotation parameter, the Taylor number T, increases. The results confirm the theory of Childress when both Reynolds number and Taylor number are small. The rate at which the sphere rotates with respect to the rotating fluid frame has also been measured and was found to be less than the values calculated by Childress for small T and R, but to approach the theoretical values in a reasonable way.

M18 ACCURATE MEASUREMENTS OF SPHERE DRAG
AT LOW REYNOLDS NUMBERS
Maxworthy, T.
Technical Report No. 32-784 (Unclassified)
(Reprinted from *Journal of Fluid Mechanics, Vol. 23, Part 2,* 1965, pp. 369–373)

An accurate measurement of low-Reynolds number sphere drag has been made. Some of the inaccuracies of previous measurements are revealed. Comparison with the theoretical studies shows that the Oseen formula is as accurate as any in predicting sphere drag below a Reynolds number of 0.4.

McDade, J. J.

M19 EXPERIMENTAL ASSEMBLY AND STERILIZATION
LABORATORY (EASL) OPERATIONS: PHASE I
Kapell, G. F., McDade, J. J., Gavin, T. R.
Technical Report No. 32-941, April 15, 1966
(Unclassified)

For abstract, see Entry K02.

Meisenholder, G. W.

M20 A PRACTICAL METHOD FOR SENSOR ABSOLUTE
CALIBRATION
Meisenholder, G. W.
Technical Report No. 32-913 (Unclassified)
(Reprinted from *Applied Optics, Vol. 5, No. 4,* April 1966, pp. 533–536)

This paper describes a method of performing sensor calibrations using an NBS standard of spectral irradiance. The method shown, among others, was used for calibration of the *Mariner IV* Canopus sensor. Agreements of inflight response to preflight calibrations performed by this technique have been found to be well within 10%.

Menard, W. A.

M21 EXPERIMENTAL MEASUREMENTS OF NON-
EQUILIBRIUM AND EQUILIBRIUM RADIATION
FROM PLANETARY ATMOSPHERES
Thomas, G. M., Menard, W. A.

Technical Report No. 32-902 (Unclassified)
(Reprinted from *AIAA Journal, Vol. 4, No. 2,* February 1966, pp. 227–237)

For abstract, see Entry T06.

M22 MEASUREMENT OF THE THERMAL CONDUCTIVITY
OF NOBLE GASES IN THE TEMPERATURE RANGE
1500 TO 5000 deg KELVIN
Collins, D. J., Menard, W.A.
Technical Report No. 32-903 (Unclassified)
(Reprinted from *Journal of Heat Transfer, Transactions of the ASME,* February 1966, pp. 52–56)

For abstract, see Entry C16.

Merrick, W. D.

M23 LARGE ANTENNA APERTURES AND ARRAYS
FOR DEEP SPACE COMMUNICATIONS
Potter, P. D., Merrick, W. D., Ludwig, A. C.
Technical Report No. 32-848, November 1, 1965
(Unclassified)

For abstract, see Entry P11.

Miller, L. W.

M24 *ATLAS-CENTAUR VI* FLIGHT PATH AND ITS
DETERMINATION FROM TRACKING DATA
Miller, L. W., et al.
Technical Report No. 32-911, April 15, 1966
(Unclassified)

This Report describes the best current estimate of the *Atlas-Centaur VI* (*A/C-6*) spacecraft flight path and the way in which the flight path was obtained. This document also includes orbit determination program (ODP) printout data facsimiles.

Miller, R. B.

M25 SPACECRAFT VISIBILITY PROGRAM WITH
CONTOUR PLOTTER
Miller, R. B.
Technical Memorandum No. 33-273, March 1, 1966
(Unclassified)

The spacecraft visibility program has two prime objectives: (1) to produce visibility contour plots of all existing DSIF antennas, and (2) to produce visibility contour plots of any antenna configuration at any location in the world to aid in evaluation of proposed antennas and station locations.

The program was developed for the SDS 930 computer of systems data analysis group located at the Goldstone Echo station. It uses a Benson-Lehner Electro-plotter that has been converted to on-line. The program can be used on other computers because it is written in FORTRAN II, and can easily be adapted for use with other plotters.

Minovitch, M.

M26 UTILIZING LARGE PLANETARY PERTURBATIONS
FOR THE DESIGN OF DEEP-SPACE, SOLAR-PROBE,
AND OUT-OF-ECLIPTIC TRAJECTORIES
Minovitch, M.
Technical Report No. 32-849, November 15, 1965
(Unclassified)

This Report is concerned with three types of free-fall missions that are primarily designed for unmanned vehicles, viz. deep space, solar probe, and out-of-ecliptic missions. The energies required to attain these trajectories are beyond the present direct-transfer capability using available boosters. Solar-impact and 90-deg-inclination trajectories require launch energies so high that second-generation nuclear upper stages or ion engines would be necessary. By utilizing large planetary perturbations, it is possible that a rocket like *Titan II-Centaur* with an extra kick stage can, by sacrificing a few extra pounds for planetary approach guidance, obtain trajectories that a *nuclear Saturn V* cannot obtain.

Moacanin, J.

M27 OUTGASSING RATES IN POLYMERIC FOAMS
Cuddihy, E. F., Moacanin, J.
Technical Report No. 32-840, December 15, 1965
(Unclassified)

For abstract, see Entry C19.

M28 ELECTRON TRANSFER TO VINYLAROMATIC
POLYMERS
Rembaum, A., Moacanin, J.
Technical Report No. 32-791 (Unclassified)
(Reprinted from *Exchange Reaction, International Atomic
Energy Agency*, Vienna, 1965, pp. 173–190)

For abstract, see Entry R09.

M29 EXPERIMENTAL PROCEDURES FOR MOLECULAR
WEIGHT DETERMINATION BY LIGHT
SCATTERING
Beattie, W. H., Laudenslager, R. K., Moacanin, J.
Technical Memorandum No. 33-242, January 1, 1966
(Unclassified)

For abstract, see Entry B09.

Montgomery, L. C.

M30 STERILIZED SOLID-PROPELLANT ROCKET MOTORS
FOR MARS LANDING MISSIONS (REVISION 1)
Montgomery, L. C., Marsh, H. E., Jr.
Technical Report No. 32-725, June 30, 1965
(Unclassified)

A description is given of the chemical approach taken in the initial phase of the program to develop a sterile solid-propellant motor for the planetary and lunar landings. The current objectives which require the heat-sterilization approach and the ultimate test criterion for heat sterilizability of a spacecraft component are considered. The significant crusting of the pro-

pellants, and its related physical effects are evaluated. The development of propellants for heat-sterilization application is described.

Muhleman, D. O.

M31 A REVIEW OF RADAR ASTRONOMY—PARTS I, II
Muhleman, D. O., Goldstein, R., Carpenter, R.
Technical Report No. 32-824 (Unclassified)
(Reprinted from *IEEE Spectrum, Vol. 2, No. 10,*
October 1965, pp. 44–55 and *Vol. 2, No. 11,*
November 1965, pp. 78–89)

The past few years have seen spectacular advances in the science of radar astronomy. This two-part article develops fundamental concepts and equations, describes new measuring techniques, and summarizes significant results from planetary and lunar radar experiments.

In the conclusion of this article the rotational and surface characteristics of several planets, particularly Venus, are considered. Most of the immediate future research will involve the Moon, Mercury, Venus, and Mars.

Narasimha, R.

N01 EXACT NUMERICAL SOLUTION OF THE COMPLETE
BGK EQUATION FOR STRONG SHOCK WAVES
Chahine, M. T., Narasimha, R.
Technical Report No. 32-671 (Unclassified)
(Reprinted from *Rarefied Gas Dynamics, Vol. 1, Sec. 2,*
1965, pp. 140–160)

For abstract, see Entry C06.

Nash, D. B.

N02 A LUNAR X-RAY DIFFRACTION EXPERIMENT
Speed, R. C., Nash, D. B., Nickle, N. L.
Technical Report No. 32-756 (Unclassified)
(Reprinted from *Advances in X-Ray Analysis, Vol. 8,*
Plenum Press, 1965, pp. 400–419)

For abstract, see Entry S23.

N03 THE UTILITY OF UNMANNED PROBES IN LUNAR
SCIENTIFIC EXPLORATION
Speed, R. C., Nash, D. B., Adams, J. B.
Technical Memorandum No. 33-241, July 15, 1965
(Unclassified)

For abstract, see Entry S25.

Nathan, R.

N04 DIGITAL VIDEO-DATA HANDLING
Nathan, R.
Technical Report No. 32-877, January 5, 1966
(Unclassified)

A technique has been developed which makes it possible to perform accurate, detailed operations and analyses upon digitized pictorial data. Television pictures transmitted from the *Ranger* and *Mariner* spacecraft have been significantly im-

·proved in clarity by correcting those system distortions which affect photometric, geometric, and frequency fidelity. Various classes of structured noise have also been detected and removed digitally by means of newly devised two-dimensional filters. Although mathematically the filters are easier to describe in the frequency domain, they are more effectively applied as a convolution operation on the original digitized photographs. The cleaned-up, enhanced pictures are then used by the computer for further interpretive and statistical analyses.

Nerheim, N. M.

N05 ELECTRON DENSITY AND TEMPERATURE MEASUREMENTS IN THE EXHAUST OF A MPD SOURCE
Kelly, A. J., Nerheim, N. M., Gardner, J. A.
Technical Report No. 32-796, September 15, 1965
(Unclassified)

For abstract, see Entry K06.

Nickle, N. L.

N06 A LUNAR X-RAY DIFFRACTION EXPERIMENT
Speed, R. C., Nash, D. B., Nickle, N. L.
Technical Report No. 32-756 (Unclassified)
(Reprinted from Advances in X-Ray Analysis, Vol. 8, Plenum Press, 1965, pp. 400–419)

For abstract, see Entry S23.

Ostrum, G. K.

O01 ORGANIC SYNTHESIS USING FUSED SALT SYSTEMS: PREPARATION OF A POLYTRIPHENYLENE
Ostrum, G. K., Lawson, D. D., Landel, R. F., Ingham, J. D.
Technical Report No. 32-907 (Unclassified)
(Reprinted from Chemical Communications, 1966, p. 53)

The synthesis of polybenzenes has received considerable attention because of the desirable thermal stability of these polymers. It has been pointed out that chain branching could occur during the polymerization of benzene with Lewis acid catalyst–oxidant, but the presence or absence of such branching has not yet been conclusively shown. If such branching occurs, cyclization to produce a triphenylene nucleus in the polymer chain could occur by the same mechanism proposed for chain growth. Therefore, as part of the study of the preparation and characterization of high-temperature polymers using fused salts as reaction media, a polytriphenylene has been prepared using a eutectic mixture of ferric chloride (60 wt%), sodium chloride (26 wt%), and potassium chloride (14 wt%) both as "solvent" and source of Lewis acid.

Petty, S. M.

P01 A PRECISION DC-POTENTIOMETER MICROWAVE INSERTION-LOSS TEST SET
Stelzried, C. T., Reid, M. S., Petty, S. M.
Technical Report No. 32-887, March 15, 1966
(Unclassified)

For abstract, see Entry S28.

Peyret, R.

P02 SUB-ALFVÉNIC FLOW IN A DUCT WITH A NONUNIFORM MAGNETIC FIELD
Peyret, R.
Technical Report No. 32-871, April 15, 1966
(Unclassified)

The flow of a conducting fluid in a duct through a nonuniform magnetic field of the following type is considered: for $x < 0$, the field is uniform and parallel to the axis $0x$ of the duct; for $x > 0$, the field is nonuniform and the magnetic lines are slightly curved, so that it is possible to use a small-perturbation theory. Moreover, the magnetic Reynolds number R_m and the Alfvén number A are assumed small. One calculates the flow field, then the induced magnetic field. It is found that the disturbances which are propagated upstream decay exponentially for the flow and algebraically for the magnetic field.

Phillips, W.

P03 REVIEW OF INDUSTRY-PROPOSED IN-PILE THERMIONIC SPACE REACTORS.
VOLUME I. GENERAL
Davis, J. P., Gronroos, H., Phillips, W.
Technical Memorandum No. 33-262, October 15, 1965
(Unclassified)

For abstract, see Entry D02.

Pickering, W. H.

P04 MARINER IV MISSION TO MARS (PART II)
Pickering, W. H., et al.
Technical Report No. 32-782 (Unclassified)
(Reprinted from Astronautics and Aeronautics, Vol. 3, No. 10, October 1965, pp. 20–43)

This two-part Technical Report is a series of individual papers documenting the Mariner-Mars project. Part I, which has been previously published, detailed the pre-encounter data on design, development and testing of Mariner IV, as well as papers detailing methods of communication with and obtaining data from the spacecraft during flight.

Part II, which consists of post-encounter data, is a documentation of events which took place during the Mariner IV's encounter with Mars and whatever took place subsequently: Mariner's flight to Mars, scientific exploration, maintaining thermal control, maneuver and attitude control, and Mariner IV timing and sequencing.

Pivirotto, T. J.

P05 SIMILARITY IN CONFINED VORTEX FLOWS
Roschke, E. J., Pivirotto, T. J.
Technical Report No. 32-789, August 15, 1965
(Unclassified)

For abstract, see Entry R24.

P06 AN EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF CONCENTRATION RATIO DISTRIBUTIONS IN A BINARY COMPRESSIBLE VORTEX FLOW
Pivirotto, T. J.
Technical Report No. 32-808, March 15, 1966
(Unclassified)

A scheme for containing fissionable material in the gas phase in a gaseous-core, nuclear-reactor propulsion system is considered. The results of a referenced analysis of this concept indicate that a rotating annular cloud of highly concentrated fuel gas can be retained in a steady, two-dimensional, potential vortex flow.

The primary objective was to experimentally determine whether a real vortex flow can sustain an annular cloud of a high-molecular-weight gas at room temperature and to determine analytically and experimentally how this cloud is influenced by several of the flow parameters.

Qualitative agreement between the theoretical radial distributions of the heavy to light gas mass density ratio and the measured distributions was found. The maximum enrichment factor was found experimentally to increase as the heavy gas mass flow rate was decreased at each of three hydrogen mass flow rates tested. This behavior of the maximum enrichment factor was also found for the analytical model. From the analysis based on a two-dimensional potential vortex flow, a critical light gas mass flow rate, with respect to achieving large maximum enrichment factors, was found.

P07 MASS-RETENTION MEASUREMENTS IN A BINARY COMPRESSIBLE VORTEX FLOW
Pivirotto, T. J.
Technical Report No. 32-864, June 15, 1966
(Unclassified)

Confined binary vortex flow fields have been proposed as gaseous-fuel-retention devices for gas-core nuclear reactors. Several such flows have been evaluated in this investigation by measuring the mass flow rate of heavy gas discharging from the vortex tube. Hydrogen and nitrogen were used to generate the vortex flow fields and Freon-13 was used for the heavy gas. An infrared photometer operating at a wavelength of approximately 8.3 μ was developed and used to measure the transient decay of the discharge rate of Freon after an abrupt cutoff of Freon inlet flow. From these measurements the average residence time of the Freon particles in several vortex-tube configurations for several mass flow rates of Freon and hydrogen or nitrogen were determined. The conclusion reached from the results of this investigation was that these particular vortex flow fields do not retain significantly more Freon than would be contained in the same device and under the same conditions of pressure and temperature if no diffusion occurred between the light and heavy species.

Porter, R. N.

P08 ON THE EVOLUTION OF ADVANCED PROPULSION SYSTEMS FOR SPACECRAFT
Dipprey, D. F., Rupe, J. H., Porter, R. N., Evans, D. D.
Technical Report No. 32-735, July 15, 1965
(Unclassified)

For abstract, see Entry D05.

P09 THE FABRICATION OF SEAMLESS TEFLON PROPELLANT EXPULSION BLADDERS
Porter, R. N.
Technical Report No. 32-914, April 14, 1966
(Unclassified)

Seamless Teflon bladders of TFE, FEP, or a combination of both are fabricated by several firms for the NASA space program. The process involves mixing aqueous dispersions of Teflon particles, spraying this dispersion onto a metal mandrel, sintering the particles into a film and then etching out the metal mandrel. Teflon bladders made in this manner are reasonably compatible with propellants and capable of repeatedly expelling propellants, but they are somewhat permeable to propellants. Production of defect-free bladders requires a concerted quality control program to monitor every step in the process.

Posner, E. C.

P10 DEMONSTRATION OF A QUANTILE SYSTEM FOR COMPRESSION OF DATA FROM DEEP SPACE PROBES
Anderson, T. O., Eisenberger, I., Lushbaugh, W. A., Posner, E. C.
Technical Report No. 32-772, December 1, 1965
(Unclassified)

For abstract, see Entry A08.

Potter, P. D.

P11 LARGE ANTENNA APERTURES AND ARRAYS FOR DEEP SPACE COMMUNICATIONS
Potter, P. D., Merrick, W. D., Ludwig, A. C.
Technical Report No. 32-848, November 1, 1965
(Unclassified)

These considerations relating to antennas for deep space communications are treated in detail: (1) the economic balance between large ground antenna apertures and potential spacecraft improvements, (2) the best method of implementing large apertures as a function of size, and (3) the optimum frequency of operation. Report concentrates on economics, because there does not appear to be any serious technical problem. Three conclusions are firmly established: (1) equivalent apertures, large compared with that of a 200-ft-D class paraboloid, are very expensive; (2) either a steerable paraboloid of approximately 200-ft D or an array of these antennas is the ideal type of aperture implementation; and (3) within the present state of the art in structural design the optimum frequency of operation is approximately 2 Gc/s.

Poynter, R. L.

P12 MICROWAVE SPECTRUM, STRUCTURE, AND DIPOLE
MOMENT OF 2, 4-DICARBAHEPTABORANE (7)
Beaudet, R. A., Poynter, R. L.
Technical Report No. 32-823 (Unclassified)
Reprinted from *The Journal of Chemical Physics, Vol. 43,
No. 7, October 1965, pp. 2166–2170)*

For abstract, see Entry B10.

Primack, J. R.

P13 TEMPERATURE RELAXATION IN A FULLY IONIZED
PLASMA
Wu, C.-S., Klevans, E. H., Primack, J. R.
Technical Report No. 32-759 (Unclassified)
(Reprinted from *The Physics of Fluids, Vol. 8, No. 6,*
June 1965, pp. 1126–1133)

For abstract, see Entry W32.

Prislin, R. H.

P14 EFFECT OF BOUNDARY-LAYER TRANSITION
ON DYNAMIC STABILITY
Jaffe, P., Prislin, R. H.
Technical Report No. 32-841 (Unclassified)
(Reprinted from *Journal of Spacecraft and Rockets,
Vol. 3, No. 1,* January 1966, pp. 46–52)

For abstract, see Entry J04.

P15 FREE-FLIGHT AND FREE-OSCILLATION
TECHNIQUES FOR WIND-TUNNEL DYNAMIC-
STABILITY TESTING
Prislin, R. H.
Technical Report No. 32-878, March 1, 1966
(Unclassified)

This Report presents the fundamentals of two wind-tunnel
dynamic-stability testing techniques employed at the Jet Pro-
pulsion Laboratory: the free-flight technique, and the sting-
supported free-oscillation technique. The techniques are
described with reference to testing a body of revolution exhibit-
ing planar motion. Emphasis is put on the data-reduction prob-
lem which arises when one considers nonlinear aerodynamic
coefficients at arbitrary angles of attack. An approach to a gen-
eral nonlinear case is outlined, and a detailed analysis is carried
out for a cubic pitching-moment curve and arbitrary lift and
drag curves. In addition, the advantages and disadvantages of
utilizing the alternate testing methods are discussed. Possible
extensions of both techniques into additional dynamic-stability
testing areas are mentioned.

Randolph, J. E.

R01 PYROTECHNIC SHOCK ANALYSIS AND
TESTING METHODS
Hoffman, A. R., Randolph, J. E.
Technical Memorandum No. 33-270, February 15, 1966
(Unclassified)

For abstract, see Entry H19.

R02 *MARINER-MARS* 1964 FLIGHT DYNAMIC DATA
Randolph, J. E.
Technical Memorandum No. 33-278, May 15, 1966
(Unclassified)

This Memorandum presents an analysis of the dynamic
flight environment of the *Mariner-Mars* 1964 spacecraft. The
reduced data from *Mariner III* and *Mariner IV* are presented
and compared. Nine environmental measurements were taken
for each spacecraft. These consisted of five vibration trans-
ducers within the payload area of each launch vehicle and four
microphones mounted outside the vehicle on the launch com-
plex umbilical tower. These telemetered and recorded data
have been analyzed using the following techniques: oscillo-
grams, bandpass, power spectra, shock spectra, and data com-
pression. The reduced data are discussed with reference to each
appropriate analysis technique. No comparison with ground
test data is made.

Raper, O. F.

R03 PRIMARY PROCESSES IN OZONE PHOTOLYSIS
DeMore, W. B., Raper, O. F.
Technical Report No. 32-906 (Unclassified)
(Reprinted from *The Journal of Chemical Physics, Vol. 44,
No. 5,* March 1966, pp. 1780–1783)

For abstract, see Entry D03.

Rapp, N. S.

R04 SYNTHESIS OF CARBON-14 LABELED ISOCYANATES.
DETERMINATION OF THE CARBON-14
DISTRIBUTION IN THE ISOCYANATE GROUPS OF
2, 4-TOLYLENE DIISOCYANATE
Kopka, E. F., Rapp, N. S., Ingham, J. D.
Technical Report No. 32-861 (Unclassified)
(Reprinted from the *Journal of Labeled Compounds,
Vol. 1, No. 3,* July–September 1965, pp. 1–12)

For abstract, see Entry K21.

R05 THE MECHANISM OF THERMAL DEGRADATION
OF CERTAIN POLYETHER-POLYURETHANS
Ingham, J. D., Rapp, N. S.
Technical Report No. 32-880 (Unclassified)
(Reprinted from *Polymer Engineering and Science, Vol. 6,
No. 1,* January 1966, pp. 1–6)

For abstract, see Entry I02.

R06 MOLECULAR STRUCTURE AND CONFIGURATION
OF POLYMERS: NMR SPECTRA OF
POLY (ALKYLENE OXIDE) TERMINAL GROUPS
Ingham, J. D., Lawson, D. D., Manatt, S. L.,
Rapp, N. S., Hardy, J. P.
Technical Report No. 32-904 (Unclassified)
(Reprinted from *Journal of Macromolecular Chemistry,
Vol. 1, No. 1,* September 1965, pp. 75–91)

For abstract, see Entry I03.

Reid, M. S.

**R07 A PRECISION DC-POTENTIOMETER MICROWAVE
INSERTION-LOSS TEST SET**
Stelzried, C. T., Reid, M. S., Petty, S. M.
Technical Report No. 32-887, March 15, 1966
(Unclassified)

For abstract, see Entry S28.

Rembaum, A.

**R08 EQUILIBRIA BETWEEN METALLIC SODIUM
AND AROMATIC HYDROCARBONS**
Rembaum, A., Eisenberg, A., Haack, R.
Technical Report No. 32-765 (Unclassified)
(Reprinted from the *Journal of the American Chemical
Society*, Vol. 87, No. 10, May 20, 1965, pp. 2291–2292)

This short communication gives a summary of the preliminary results of a quantitative study of the equilibria between sodium and some substituted aromatic hydrocarbons by a spectrophotometric technique.

**R09 ELECTRON TRANSFER TO VINYLAROMATIC
POLYMERS**
Rembaum, A., Moacanin, J.
Technical Report No. 32-791 (Unclassified)
(Reprinted from *Exchange Reaction, International Atomic
Energy Agency*, Vienna, 1965, pp. 173–190)

Aromatic polymers accept electrons from alkali metals to form polyradical anions. These undergo chain scission as a result of electronic interaction between aromatic rings. Spectrophotometric and chemical evidence led to the conclusion that during the chain-breaking process polymeric fragments were formed which had the properties of "living polymers," i.e., the characteristic visible spectra and the capability of initiating the polymerization of a number of vinyl monomers. It was possible to follow the rate of chain scission in the case of poly (4-vinyl biphenyl) and poly (α-vinyl naphthalene) by means of viscosity and spectrophotometric measurements. The postulated mechanism was found to be consistent with the slow decrease in free spin concentration measured by means of the electron spin resonance technique. Chain scission in polyacenaphthalene takes place at a much faster rate than in poly (4-vinyl biphenyl) and this fact is in good agreement with simple LCAO MO calculations. Preliminary experiments indicate that electron transfer to poly-N-vinyl carbazole produces little if any degradation. These investigations led to the examination of the temperature effect on the electron-transfer reaction from sodium to some substituted aromatic hydrocarbons. The details of this effect are discussed.

Renzetti, N. A.

**R10 TRACKING AND DATA ACQUISITION SUPPORT
FOR THE *MARINER-VENUS* 1962 MISSION**
Renzetti, N. A.
Technical Memorandum No. 33-212, July 1, 1965
(Unclassified)

This document summarizes the technical activities of the Deep Space Instrumentation Facility in support of the *Mariner II* mission. It includes a synopsis of the mission, a comprehensive account of the tracking operations, and a performance evaluation. The tracking and data acquisition support are also delineated, and a complete list of reference material is given.

R11 TRACKING AND DATA ACQUISITION REPORT:
MARINER-MARS 1964 MISSION.
VOLUME I. NEAR-EARTH TRAJECTORY PHASE
Renzetti, N. A.
Technical Memorandum No. 33-239, January 1, 1965
(Unclassified)

This document summarizes the technical activities of the AFETR, certain stations of the NASA/GSFC Manned Space Flight Network (MSFN) and Satellite Tracking and Data Acquisition Network (STADAN), and the NASA/JPL Deep Space Network (DSN) in support of the near-Earth trajectory phase of the *Mariner-Mars* 1964 Mission. Included in this document are the tracking and data acquisition requirements and related support plans for all the participating agencies, a comprehensive account of the tracking operations, and a performance evaluation summary.

Richard, R. J.

R12 EARTH–MOON TRAJECTORIES, 1960–70
Richard, R. J., Clarke, V. C., Jr., Roth, R. Y., Kirhofer, W. E.
Technical Report No. 32-503 (Rev. 1), September 15, 1965
(Unclassified)

This Report gives key characteristics of Earth-to-Moon trajectories for the period 1965–1970. It is intended to provide trajectory analysts with data, in volume, so that they may perform preliminary design studies and conduct investigations of the properties of ballistic lunar trajectories. While not exact, these trajectories are sufficiently accurate to be quite useful for the above purpose. The data presented assumed launch to occur at Cape Kennedy, arrival to occur when the Moon is over the meridian of the DSIF tracking station at Goldstone, California, and the flight time to be between 2 and 3 days. An explanation of the analytical model used in the generation of the data, and detailed equations, are presented.

R13 EARTH–MARS TRAJECTORIES, 1971
Richard, R. J., Roth, R. Y.
Technical Memorandum No. 33-100, Vol. IV, Part A
June 15, 1965 (Unclassified)

This volume is one of a set of seven giving key characteristics of Earth-to-Mars ballistic trajectories during the period 1964–1977, which period is divided into seven launch intervals (one interval per volume), spaced about 25 months apart. Within each interval, trajectories are calculated for each launch date and further subdivided into flight time ranges graduated in

· 2-day increments. Launch dates and approximate flight times for this volume are as follows (only trajectories requiring *vis viva* geocentric energies of less than 40 km²/sec² are included).

Launch date (1971), March 6–August 10; Flight time range (days), 70–280.

The applicability of these books may be extended by noting the 15-year cyclic recurrence of Earth–Mars trajectories. Thus trajectories in 1979 approximate 1964 trajectories; 1982 trajectories approximate 1967 trajectories, etc. Simply by updating the trajectories by 15 years, the results may be reapplied.

It is intended that these books provide trajectory and guidance analysts with data, in volume, so that preliminary design studies, investigations of the properties of ballistic interplanetary trajectories, and interplanetary guidance and orbit determination analyses may be performed. While not exact, these trajectories are sufficiently accurate to be quite useful for the above purposes.

R14   EARTH–MARS TRAJECTORIES, 1971
      Richard, R. J., Roth, R. Y.
      Technical Memorandum No. 33-100, Vol. IV, Part B
      June 15, 1965 (Unclassified)

This volume is one of a set of seven giving key characteristics of Earth-to-Mars ballistic trajectories during the period 1964–1977, which period is divided into seven launch intervals (one interval per volume), spaced about 25 months apart. Within each interval, trajectories are calculated for each launch date and further subdivided into flight time ranges graduated in 2-day increments. Launch dates and approximate flight times for this volume are as follows (only trajectories requiring *vis viva* geocentric energies of less than 40 km²/sec² are included).

Launch date (1971), March 6–August 10; Flight time range (days), 70–280.

The applicability of these books may be extended by noting the 15-year cyclic recurrence of Earth–Mars trajectories. Thus trajectories in 1979 approximate 1964 trajectories; 1982 trajectories approximate 1967 trajectories, etc. Simply by updating the trajectories by 15 years, the results may be reapplied.

It is intended that these books provide trajectory and guidance analysts with data, in volume, so that preliminary design studies, investigations of the properties of ballistic interplanetary trajectories, and interplanetary guidance and orbit determination analyses may be performed. While not exact, these trajectories are sufficiently accurate to be quite useful for the above purposes.

R15   EARTH–MARS TRAJECTORIES, 1971
      Richard, R. J., Roth, R. Y.
      Technical Memorandum No. 33-100, Vol. IV, Part C
      June 15, 1965 (Unclassified)

This volume is one of a set of seven giving key characteristics of Earth-to-Mars ballistic trajectories during the period 1964–

1977, which period is divided into seven launch intervals (one interval per volume), spaced about 25 months apart. Within each interval, trajectories are calculated for each launch date and further subdivided into flight time ranges graduated in 2-day increments. Launch dates and approximate flight times for this volume are as follows (only trajectories requiring *vis viva* geocentric energies of less than 40 km²/sec² are included).

Launch date (1971), March 6–August 10; Flight time range (days), 70–280.

The applicability of these books may be extended by noting the 15-year cyclic recurrence of Earth–Mars trajectories. Thus trajectories in 1979 approximate 1964 trajectories; 1982 trajectories approximate 1967 trajectories, etc. Simply by updating the trajectories by 15 years, the results may be reapplied.

It is intended that these books provide trajectory and guidance analysts with data, in volume, so that preliminary design studies, investigations of the properties of ballistic interplanetary trajectories, and interplanetary guidance and orbit determination analyses may be performed. While not exact, these trajectories are sufficiently accurate to be quite useful for the above purposes.

R16   EARTH–MARS TRAJECTORIES, 1971
      Richard, R. J., Roth, R. Y.
      Technical Memorandum No. 33-100, Vol. IV, Part D
      June 15, 1965 (Unclassified)

This volume is one of a set of seven giving key characteristics of Earth-to-Mars ballistic trajectories during the period 1964–1977, which period is divided into seven launch intervals (one interval per volume), spaced about 25 months apart. Within each interval, trajectories are calculated for each launch date and further subdivided into flight time ranges graduated in 2-day increments. Launch dates and approximate flight times for this volume are as follows (only trajectories requiring *vis viva* geocentric energies of less than 40 km²/sec² are included).

Launch date (1971), March 6–August 10; Flight time range (days), 70–280.

The applicability of these books may be extended by noting the 15-year cyclic recurrence of Earth–Mars trajectories. Thus trajectories in 1979 approximate 1964 trajectories; 1982 trajectories approximate 1967 trajectories, etc. Simply by updating the trajectories by 15 years, the results may be reapplied.

It is intended that these books provide trajectory and guidance analysts with data, in volume, so that preliminary design studies, investigations of the properties of ballistic interplanetary trajectories, and interplanetary guidance and orbit determination analyses may be performed. While not exact, these trajectories are sufficiently accurate to be quite useful for the above purposes.

R17 EARTH–MARS TRAJECTORIES, 1971
Richard, R. J., Roth, R. Y.
Technical Memorandum No. 33-100, Vol. V, Part A
June 15, 1965 (Unclassified)

This volume is one of a set of seven giving key characteristics of Earth-to-Mars ballistic trajectories during the period 1964–1977, which period is divided into seven launch intervals (one interval per volume), spaced about 25 months apart. Within each interval, trajectories are calculated for each launch date and further subdivided into flight time ranges graduated in 2-day increments. Launch dates and approximate flight times for this volume are as follows (only trajectories requiring *vis viva* geocentric energies of less than 40 km²/sec² are included).

Launch date (1971), March 6–August 10; Flight time range (days), 70–280.

The applicability of these books may be extended by noting the 15-year cyclic recurrence of Earth–Mars trajectories. Thus trajectories in 1979 approximate 1964 trajectories; 1982 trajectories approximate 1967 trajectories, etc. Simply by updating the trajectories by 15 years, the results may be reapplied.

It is intended that these books provide trajectory and guidance analysts with data, in volume, so that preliminary design studies, investigations of the properties of ballistic interplanetary trajectories, and interplanetary guidance and orbit determination analyses may be performed. While not exact, these trajectories are sufficiently accurate to be quite useful for the above purposes.

R18 EARTH–MARS TRAJECTORIES, 1971
Richard, R. J., Roth, R. Y.
Technical Memorandum No. 33-100, Vol. V, Part B
June 15, 1965 (Unclassified)

This volume is one of a set of seven giving key characteristics of Earth-to-Mars ballistic trajectories during the period 1964–1977, which period is divided into seven launch intervals (one interval per volume), spaced about 25 months apart. Within each interval, trajectories are calculated for each launch date and further subdivided into flight time ranges graduated in 2-day increments. Launch dates and approximate flight times for this volume are as follows (only trajectories requiring *vis viva* geocentric energies of less than 40 km²/sec² are included).

Launch date (1971), March 6–August 10; Flight time range (days), 70–280.

The applicability of these books may be extended by noting the 15-year cyclic recurrence of Earth–Mars trajectories. Thus trajectories in 1979 approximate 1964 trajectories; 1982 trajectories approximate 1967 trajectories, etc. Simply by updating the trajectories by 15 years, the results may be reapplied.

It is intended that these books provide trajectory and guidance analysts with data, in volume, so that preliminary design studies, investigations of the properties of ballistic interplanetary trajectories, and interplanetary guidance and orbit

determination analyses may be performed. While not exact, these trajectories are sufficiently accurate to be quite useful for the above purposes.

R19 EARTH–MARS TRAJECTORIES, 1971
Richard, R. J., Roth, R. Y.
Technical Memorandum No. 33-100, Vol. V, Part C
June 15, 1965 (Unclassified)

This volume is one of a set of seven giving key characteristics of Earth-to-Mars ballistic trajectories during the period 1964–1977, which period is divided into seven launch intervals (one interval per volume), spaced about 25 months apart. Within each interval, trajectories are calculated for each launch date and further subdivided into flight time ranges graduated in 2-day increments. Launch dates and approximate flight times for this volume are as follows (only trajectories requiring *vis viva* geocentric energies of less than 40 km²/sec² are included).

Launch date (1971), March 6–August 10; Flight time range (days), 70–280.

The applicability of these books may be extended by noting the 15-year cyclic recurrence of Earth–Mars trajectories. Thus trajectories in 1979 approximate 1964 trajectories; 1982 trajectories approximate 1967 trajectories, etc. Simply by updating the trajectories by 15 years, the results may be reapplied.

It is intended that these books provide trajectory and guidance analysts with data, in volume, so that preliminary design studies, investigations of the properties of ballistic interplanetary trajectories, and interplanetary guidance and orbit determination analyses may be performed. While not exact, these trajectories are sufficiently accurate to be quite useful for the above purposes.

Rindfleisch, T.

R20 A FIGURE OF MERIT MEASURING PICTURE RESOLUTION
Rindfleisch, T., Willingham, D.
Technical Report No. 32-666, September 1, 1965
(Unclassified)

In order to optimize the quality of data obtained from lunar and planetary photographic missions, a general and versatile resolution measure is needed that accounts for the numerous degrading factors inherent in the facsimile system. A mathematical formalism is developed which leads to a single number or figure of merit measuring a characteristic dimension of the smallest detectable object in a picture of an extended complex scene. The formalism is in modular form and can include the effects on the system resolution due to statistical and photometric properties of the surface being viewed, atmospheric turbulence, image motion, characteristics of the television and recording system, system noises, and properties of the human observer.

The treatment is unified within the framework of linear system analysis and assumes that portions of the transfer

process act as spatial filters and that the human observer functions as a signal-to-noise optimizing low-pass filter. The contrast present in the object scene is determined by the statistical and photometric properties of the scene. A comparison of the figure of merit to conventional resolution measures is made, indicating its advantages for system design and performance evaluation over the conventional engineering comparison techniques, which do not predict absolute performance.

R21 A PHOTOMETRIC METHOD FOR DERIVING LUNAR TOPOGRAPHIC INFORMATION
Rindfleisch, T.
Technical Report No. 32-786, September 15, 1965
(Unclassified)

A general and rigorous treatment is given of the photometric method for deriving lunar surface elevation information from pictures of the surface. In the course of the derivation certain shortcomings inherent in the method are pointed out. The resulting equations are then applied to the *Ranger* pictures as part of a digital processing procedure and examples are given.

Rodemich, E. R.

R22 THE VARIANCE OF SPECTRAL ESTIMATES
Rodemich, E. R.
Technical Report No. 32-892, March 31, 1966
(Unclassified)

In this Report the main result proved is a generalization of a formula of Goldstein who showed that if the estimate $S(\omega)$ for the spectral density is computed by the use of the function $y(x) = \text{sgn}(x)$, and if the spectrum is flat, then the dominant term in the variance of $S(\omega)$ is $\frac{1}{2} \pi^2 K/N$. Theorem 3 evaluates this term for non-flat spectra and for more general functions $y(x)$.

This analysis shows that the loss in accuracy caused by working with $y(x)$ instead of with x itself can be decreased considerably by using, for $y(x)$, a step function with more than two values.

Rogero, R. S.

R23 EXPERIMENTAL MEASUREMENTS ON A ROTATING DETONATION-LIKE WAVE OBSERVED DURING LIQUID ROCKET RESONANT COMBUSTION
Clayton, R. M., Rogero, R. S.
Technical Report No. 32-788, August 15, 1965
(Unclassified)

For abstract, see Entry C14.

Roschke, E. J.

R24 SIMILARITY IN CONFINED VORTEX FLOWS
Roschke, E. J., Pivirotto, T. J.
Technical Report No. 32-789, August 15, 1965
(Unclassified)

Results of an experimental investigation designed to test a simplified theory for obtaining dynamic similarity in confined vortex flows are presented. The simplified model from which similarity is obtained consists of the vortex flow of dissimilar fluids under conditions of exact geometric similarity. Steady, laminar, viscous, compressible flow in a two-dimensional, axisymmetric vortex is considered. The experiment consists of end-wall pressure measurements using the two diatomic gases, nitrogen and hydrogen, in identically the same vortex apparatus. The results of this investigation tend to show that simplified theories of vortex flow are insufficient, but the degree or precise manner of their defect cannot be delineated.

Examination of another set of data using the identical vortex apparatus disclosed that dynamic similarity in static-pressure distributions between tests using nitrogen and hydrogen could be closely approached by conducting the tests at equal values of static pressure at the cylindrical wall. Some of the latter results are presented and discussed.

Roth, R. Y.

R25 DESIGN PARAMETERS FOR BALLISTIC INTER-PLANETARY TRAJECTORIES. PART II. ONE-WAY TRANSFERS TO MERCURY AND JUPITER
Clarke, V. C., Jr., Bollman, W. E., Feitis, P. H., Roth, R. Y.
Technical Report No. 32-77, January 15, 1966
(Unclassified)

For abstract, see Entry C10.

R26 EARTH–MOON TRAJECTORIES, 1960–70
Richard, R. J., Clarke, V. C., Jr., Roth, R. Y., Kirhofer, W. E.
Technical Report No. 32-503 (Rev. 1), September 15, 1965
(Unclassified)

For abstract, see Entry R12.

R27 EARTH–MARS TRAJECTORIES, 1971
Richard, R. J., Roth, R. Y.
Technical Memorandum No. 33-100, Vol. IV, Part A
June 15, 1965 (Unclassified)

For abstract, see Entry R13.

R28 EARTH–MARS TRAJECTORIES, 1971
Richard, R. J., Roth, R. Y.
Technical Memorandum No. 33-100, Vol. IV, Part B
June 15, 1965 (Unclassified)

For abstract, see Entry R14.

R29 EARTH–MARS TRAJECTORIES, 1971
Richard, R. J., Roth, R. Y.
Technical Memorandum No. 33-100, Vol. IV, Part C
June 15, 1965 (Unclassified)

For abstract, see Entry R15.

R30 EARTH–MARS TRAJECTORIES, 1971
Richard, R. J., Roth, R. Y.
Technical Memorandum No. 33-100, Vol. IV, Part D
June 15, 1965 (Unclassified)

For abstract, see Entry R16.

R31 EARTH–MARS TRAJECTORIES, 1971
Richard, R. J., Roth, R. Y.
Technical Memorandum No. 33-100, Vol. V, Part A
June 15, 1965 (Unclassified)

For abstract, see Entry R17.

R32 EARTH–MARS TRAJECTORIES, 1971
Richard, R. J., Roth, R. Y.
Technical Memorandum No. 33-100, Vol. V, Part B
June 15, 1965 (Unclassified)

For abstract, see Entry R18.

R33 EARTH–MARS TRAJECTORIES, 1971
Richard, R. J., Roth, R. Y.
Technical Memorandum No. 33-100, Vol. V, Part C
June 15, 1965 (Unclassified)

For abstract, see Entry R19.

Rowley, R. W.

R34 THE EFFECT OF INJECTOR DESIGN ON THRUST-CHAMBER EROSION
Rowley, R. W., Tyler, W. H.
Technical Report No. 32-750, March 1, 1966
(Unclassified)

Results are presented for an experimental investigation of the relationship between injector design and the erosion of ablative and pyrolytic graphite thrust-chamber throats. Techniques used to determine spray properties and local heat flux are described. It is concluded that injector spray properties, including local mass and mixture-ratio distributions, significantly influence throat erosion, and that proper control of these spray properties can reduce such erosion without recourse to separate film-cooling orifices. Four injectors, each incorporating 10 unlike-impinging-doublet elements, were tested with N_2O_4-N_2H_4 propellants at the 100-lb thrust level. Three different arrangements of the elements were used, one of which demonstrated substantially lower erosion of both ablative and pyrolytic graphite materials. Erosion of pyrolytic graphite, which occurred primarily in regions of high local mixture ratio, can be controlled by proper use of the variation in local mixture ratio observed within the injector spray. Erosion of Refrasil-phenolic occurred primarily in regions of high local heat transfer, but was also affected by the local mixture ratio. Although changing the spray configuration in the boundary flow reduced erosion of the ablative material, the relationship between spray properties and heat transfer or ablation has not been clearly defined.

Rupe, J. H.

R35 AN EXPERIMENTAL CORRELATION OF THE NON-REACTIVE PROPERTIES OF INJECTION SCHEMES AND COMBUSTION EFFECTS IN A LIQUID-PROPELLANT ROCKET ENGINE.
PART I. THE APPLICATION OF NONREACTIVE-SPRAY PROPERTIES TO ROCKET-MOTOR INJECTION DESIGN
Rupe, J. H.
Technical Report No. 32-255, July 15, 1965
(Unclassified)

The properties of the sprays produced by a pair of unlike impinging streams of nonreactive fluids were utilized as the design basis for a series of eight injectors having distinctively different specifications. Particular emphasis was placed on the use of available information and the development of new techniques, where required, to permit quantitative description of the mass and mixture-ratio distributions produced by each injection scheme. Methods of describing the mass-distribution model of an element are presented in detail, together with the properties of injector orifices, the jets they produce, and the combined flows provided by each injector. This information is being utilized as a basis for correlating injection schemes with combustion phenomena.

R36 AN EXPERIMENTAL CORRELATION OF THE NON-REACTIVE PROPERTIES OF INJECTION SCHEMES AND COMBUSTION EFFECTS IN A LIQUID-PROPELLANT ROCKET ENGINE.
PART VI. THE RELATION BETWEEN THE STARTING TRANSIENT AND INJECTION HYDRAULICS
Clayton, R. M., Rupe, J. H.
Technical Report No. 32-255, October 29, 1965
(Unclassified)

For abstract, see Entry C13.

R37 ON THE EVOLUTION OF ADVANCED PROPULSION SYSTEMS FOR SPACECRAFT
Dipprey, D. F., Rupe, J. H., Porter, R. N., Evans, D. D.
Technical Report No. 32-735, July 15, 1965
(Unclassified)

For abstract, see Entry D05.

Russell, D. A.

R38 ELECTRON-BEAM MEASUREMENTS OF SHOCK-WAVE THICKNESS
Russell, D. A.
Technical Report No. 32-751 (Unclassified)
(Reprinted from *Rarefied Gas Dynamics, Vol. 1*, 1965, pp. 265–276)

Shock-wave density profiles have been measured in the GALCIT 17-in. shock tube in argon and helium at Mach numbers between 2 and 8. A 5–15 kv electron beam was injected into the shock tube through a needle and collected by

·a small Faraday cage. The change in cage current was monitored as the shock wave passed the measuring station, and this change was related to the density profile. Maximum-slope shock thicknesses were found to be consistently thinner than the mean of the experimental data of Camac. The measurements are shown to deviate from the Navier-Stokes predictions and to fall between the bimodal model and the BGK model of Liepmann et al.

Saffren, M. M.

S01 SUPERCONDUCTING TRANSITION OF A ROTATING SUPERCONDUCTOR—THE HOLLOW CYLINDER
Hilderbrandt, A. F., Saffren, M. M.
Technical Report No. 32-710 (Unclassified)
(Reprinted from *Low Temperature Physics-LT9 (Part A)*, Plenum Press, 1965, pp. 459–465)

For abstract, see Entry H18.

San Miguel, A.

S02 ON THE CHARACTERIZATION OF MULTIAXIAL DATA IN TERMS OF THE STRAIN ENERGY CONCEPT
San Miguel, A.
Technical Report No. 32-675, October 15, 1965
(Unclassified)

An experimental-theoretical approach based on continuous media theory has been suggested as a means of characterizing the multiaxial mechanical behavior of solid propellants. The applicability of this approach to solid propellants has been the subject of one research program at the Jet Propulsion Laboratory. Two multiaxial experiments that have been developed in this program are the inflated cylinder test and the biaxial sheet test. This Report deals with characterizing the multiaxial data from these tests in terms of strain energy; only the elastic portion of the viscoelastic response is considered. The ultimate aims of the study are to characterize materials with memory.

Schaefle, W. E.

S03 EVALUATION OF THE SIMULATED SOLAR SPECTRUM IN THE JPL 25-FT SPACE SIMULATOR
Drummond, A. J., Hickey, J. R., Schaefle, W. E.
Technical Report No. 32-749, August 31, 1965
(Unclassified)

For abstract, see Entry D07.

Schlue, J. W.

S04 THE DYNAMIC ENVIRONMENT OF SPACECRAFT SURFACE TRANSPORTATION
Schlue, J. W.
Technical Report No. 32-876, March 15, 1966
(Unclassified)

The data in this Report result from a study of the shock and vibration environment imposed on a spacecraft during surface transportation. Acceleration amplitude statistics and predominant frequencies of different locations within a typical air-ride suspension van are presented.

The Appendix discusses instrumentation requirements associated with the acquisition of transportation data.

Schmitz, B. W.

S05 DEVELOPMENT OF THE POST-INJECTION PROPULSION SYSTEM FOR THE *MARINER-C* SPACECRAFT
Schmitz, B. W., Groudle, T. A., Kelly, J. H.
Technical Report No. 32-830, April 1, 1966
(Unclassified)

This Report describes the design, development, and operation of the post-injection propulsion system utilized in the *Mariner C* spacecraft. The propulsion unit consists of a small monopropellant, hydrazine-fueled rocket of 50-lbf vacuum thrust, capable of delivering a variable total impulse in conjunction with a timer-shutoff system. Functionally, the rocket is of the pressure-fed constant-thrust type. Injection pressure is obtained from a compressed gas—nitrogen—that passes through a pressure regulator and forces the propellant from a bladder-tank to the rocket engine. The rocket engine contains a quantity of catalyst to accelerate the decomposition of anhydrous hydrazine. Engine ignition is accomplished through the injection of a small quantity of a hypergolic oxidizer, nitrogen tetroxide. All valving functions for the propulsion unit are accomplished with explosively actuated valves. The propulsion system is capable of two ignitions and thrust terminations. Inflight performance of the propulsion system as a portion of the *Mariner III* and *Mariner IV* missions is described.

Schnopper, H. W.

S06 A RUGGEDIZED THIN-WINDOW PROPORTIONAL-COUNTER TUBE
Shields, R. A., Schnopper, H. W.
Technical Memorandum 33-221, September 15, 1965
(Unclassified)

For abstract, see Entry S11.

Schultz, C. W.

S07 THERMOELECTRIC POWER IN NIOBIUM-ZIRCONIUM ALLOYS
Weinberg, I., Schultz, C. W.
Technical Report No. 32-872 (Unclassified)
(Reprinted from *The Journal of Physics and Chemistry of Solids, Vol. 27*, 1965, pp. 474–476)

For abstract, see Entry W08.

Selvidge, J. E.

S08 RELATIVE INTENSITY CALCULATIONS FOR
CARBON DIOXIDE
Gray, L. D., Selvidge, J. E.
Technical Report No. 32-817 (Unclassified)
(Reprinted from the *Journal of Quantitative Spectroscopy
and Radiative Transfer*, Vol. 5, No. 2, March–April 1965,
pp. 291–301)

For abstract, see Entry G15.

Shapiro, J. L.

S09 DESIGN STUDY OF A FISSION-ELECTRIC CELL
REACTOR
Shapiro, J. L.
Technical Report No. 32-741, August 1, 1965
(Unclassified)

A design approach is developed for the application of a
fission–electric cell reactor to the generation of power in
space. For a graphite-moderated reactor, the total size, tem-
perature, and total power are fixed. The remaining param-
eters, including cell dimensions and voltage, are then selected
to optimize the overall efficiency.

From the standpoint of overall efficiency, it is shown that
the two-region core is advantageous only for low-efficiency
systems and hence offers little promise. Another important
result of these calculations is that the optimum operating
voltage is shifted downward from the optimum as calculated
without considering criticality limitations. This means that the
maximum efficiency achievable is reduced considerably and
indicates that the criticality requirement may be a more
severe limitation on efficiency than the effect of voltage break-
down within the cell.

Sherman, F. S.

S10 EXPERIMENTAL METHODS IN RAREFIED GAS
DYNAMICS: THE STRUCTURE AND UTILIZATION
OF SUPERSONIC FREE JETS IN LOW DENSITY
WIND TUNNELS
Ashkenas, H., Sherman, F. S.
Technical Report No. 32-869 (Unclassified)
(Reprinted from *Rarefied Gas Dynamics*, Vol. 2, 1966,
pp. 84–105)

For abstract, see Entry A10.

Shields, R. A.

S11 A RUGGEDIZED THIN-WINDOW PROPORTIONAL-
COUNTER TUBE
Shields, R. A., Schnopper, H. W.
Technical Memorandum No. 33-221, September 15, 1965
(Unclassified)

The design and testing of a thin-window proportional-
counter tube are described. The objective of this investigation
was the development of a component suitable for use in

space experiments involving the detection of X-rays from light·
elements. The stability, efficiency, and resolution of the tube
described here are consistent with space-application require-
ments. In a series of tests, it was determined that 0.25-mil
aluminum-coated Mylar, supported by a nickel screen, pro-
vided maximum strength with minimum absorption. Two
methods of sealing the window are described: (1) an O-ring
and (2) a potting compound. Sodium $K\alpha$ pulse-height dis-
tributions from the thin-window tubes are compared with
those from a standard commercial tube having a mica
window.

Shlichta, P. J.

S12 EFFECT OF PREDEFORMATION ON THE
MECHANICAL PROPERTIES OF SODIUM
CHLORIDE CRYSTALS
Shlichta, P. J.
Technical Report No. 32-923, April 1, 1966
(Unclassified)

Sodium chloride crystals were grown from melt as uniform
$< 100 >$ rods, 3 to 5 mm in diam with flat $\{100\}$ faces. The
mechanical properties of these as-grown crystals were com-
pared with those of predeformed crystals and with annealed,
water-polished cleavages of comparable size, purity, and dis-
location density. Bend tests were performed using four-point
loading at strain rates of 1.5 to 3×10^{-5}/sec. The load and
deflection data were reduced, under the assumption of quasi-
elastic behavior, to obtain T, the outer-fiber $\{110\} < 110 >$
shear stress and E, the outer-fiber tensile strain.

The stress-strain curves of the as-grown crystals were simi-
lar to those of face-centered cubic metals; they showed a
sharp yield point, a region of easy glide of slope $G_I = dT/dE$,
and a second stage of increased work-hardening rate begin-
ning at 5.5 to 8% strain. A linear relation existed between G_I,
the yield stress (T_y), and the calcium concentration (C):

$$G_I \simeq 33.5 \ (T_y - 18) \simeq 184C$$

This suggests that a pure, as-grown crystal would have a yield
stress of 18 g/mm² and virtually no work hardening during
the first stage of deformation.

In contrast, the stress-strain curves of the predeformed
crystals and cleavages showed numerous idiosyncrasies, such
as anelastic feet and soft vs stiff behavior. Moreover, the G_I
of these specimens was invariably higher than that predicted
for as-grown crystals of comparable yield stress. These idio-
syncrasies are, therefore, attributed to artifacts (e.g., slip
bands) introduced during cleavage or predeformation. The
soft vs stiff effect is attributed to the orientation of the pre-
deformation slip systems with respect to those activated dur-
ing the test; the effect is, therefore, related to the phenomenon
of latent hardening, which apparently persists through
annealing.

Although the as-grown crystals were exposed to diverse
atmospheric environments prior to testing, there was no indi-

cation of embrittlement. This suggests that the embrittlement of cleavages is due to the interaction of emerging slip bands with the atmosphere. The only effect of water polishing was to increase the rate of stage II work hardening. When bent under water, however, the as-grown crystals showed a dramatic increase in ductility and could be tied in knots. This increase in ductility cannot be accounted for by most of the current explanations of the Joffe effect; therefore, it is proposed that this dynamic Joffe effect is a consequence of the enhanced solubility of stressed crystal surfaces.

It is concluded that most of the inconsistencies in the existing literature on the mechanical properties of sodium chloride crystals are the result of artifacts introduced during cleavage or polishing. Therefore, only as-grown crystals, of the highest possible purity and perfection, should be used in future research on the subject.

S13   GROWTH DEFORMATION, AND DEFECT
       STRUCTURE OF SALT CRYSTALS
       Shlichta, P. J.
       Technical Memorandum No. 33-274, February 15, 1966
       (Unclassified)

The growth and deformation of salt crystals are governed by, and in turn cause, defects in the crystal structure. A detailed study of these defects might therefore yield considerable information in which it occurs. This paper presents some examples of the study of these lattice defects and their application to geological problems.

Shoemaker, E. M.

S14   *RANGER VIII AND IX.*
       PART II. EXPERIMENTERS' ANALYSES AND
       INTERPRETATIONS
       Heacock, R. L., Kuiper, G. P., Shoemaker, E. M.,
       Urey, H. C., Whitaker, E. A.
       Technical Report No. 32-800, March 15, 1966
       (Unclassified)

For abstract, see Entry H12.

Shumate, M. S.

S15   INTERFEROMETRIC MEASUREMENT OF LARGE
       INDICES OF REFRACTION
       Shumate, M. S.
       Technical Report No. 32-894 (Unclassified)
       (Reprinted from *Applied Optics, Vol. 5, No. 2,*
       February 1966, pp. 327–328)

A method for determination of refractive indices which may be applied to thin flat plates of optical materials is considered. It is particularly suited for use with materials whose refractive indices are large (> 1.8), but is not limited in the range of refractive index it can determine. The method uses an interferometer to measure the optical pathlength through a sample, and is shown to have moderate accuracy: $\pm 2 \times 10^{-4}$ in refrac-

tive index for a sample 0.5 mm thick. The effect of a nonideal sample is considered, and is shown to have only a small effect on the accuracy. The method has been applied to single-crystal barium titanate in the visible spectrum, and tabulated results are given.

Sjogren, W. L.

S16   THE *RANGER III* FLIGHT PATH AND ITS
       DETERMINATION FROM TRACKING DATA
       Sjogren, W. L.
       Technical Report No. 32-563, September 15, 1965
       (Unclassified)

This Report describes the *Ranger III* tracking data obtained from the Deep Space Instrumentation Facility (DSIF) and the way in which these data were used to determine the spacecraft's orbit. The data are presented in the form of residual plots (i.e., the difference between the actual observed data and theoretical calculated data), and the resulting spacecraft orbit parameters are displayed in summary tables and the Orbit Determination Program (ODP) computer printout.

S17   CHARACTERISTICS AND FORMAT OF THE
       TRACKING DATA TO BE OBTAINED BY THE
       NASA DEEP SPACE INSTRUMENTATION
       FACILITY FOR LUNAR ORBITER
       Lorell, J., Anderson, J. D., Sjogren, W. L.
       Technical Memorandum No. 33-230, June 15, 1965
       (Unclassified)

For abstract, see Entry L19.

Smith, G. E.

S18   CONSTRAINTS-RESTRAINTS ANALOG PLOTTER
       PROGRAM
       Smith, G. E.
       Technical Memorandum No. 33-222, July 15, 1965
       (Unclassified)

The Constraints-Restraints Analog Plotter Program (CRAPP) is a digital computer program for mapping or plotting the various constraints, restraints, statistics and correction capabilities associated with the missions of certain spacecraft. This program, created at JPL, is written in Fortran II language for the IBM 7094 computer, and the primary output is plotting instruction for the SC-4020 Computer Recorder. A discussion of the theoretical basis of the program and flow diagrams of the computing procedures are presented. In addition, a complete discussion of input-output and samples with comments are included.

Smith, G. M.

S19   *RANGER PHOTOMETRIC CALIBRATION*
       Smith, G. M., Willingham, D. E.
       Technical Report No. 32-665, August 15, 1965
       (Unclassified)

An equation is derived which relates collimator luminance values as read with a Pritchard photometer to actual lunar scene luminance values, so that identical *Ranger* camera responses occur. The solution of this equation requires detailed knowledge of emission spectra of the Moon, the collimator, a calibration standard, the spectral response characteristics of the "standard eye," the photometer, and each specific vidicon camera. Calculations are made for six typical *Ranger* cameras, and variations in the results from camera to camera are noted.

S20   EYES ON THE MOON
Smith, G. M., Vrebalovich, T., Willingham, D. E.
Technical Report No. 32-937 (Unclassified)
(Reprinted from *Astronautics and Aeronautics, Vol. 4, No. 3,* March 1966, pp. 74–82)

The *Ranger* program stocked a storehouse with more than 17,000 lunar photographs which supplied valuable aid to the scientific community in expanding its knowledge of the Moon. This Report gives a review of the *Ranger* photographic mission and presents a discussion of the results of the mission and its possible effect upon the future lunar missions.

Socha, A. J.

S21   MASS SPECTROGRAPHIC ANALYSES OF NONCONDUCTING CERAMICS
Socha, A. J., Leipold, M. H.
Technical Report No. 32-815 (Unclassified)
(Reprinted from the *Journal of the American Ceramic Society, Vol. 48, No. 9,* September 1965, pp. 463–466)

A technique for analysis of powdered or densified nonconductive materials by spark source mass spectrography is based on the use of a conducting probe against the compacted sample to initiate sparking.

Results on MgO show significant quantities of anion impurities which are not generally reported. Analysis of CdS powder indicate low contamination from sample preparation.

Space Simulator Staff

S22   SPACE SIMULATOR FACILITIES AT THE JET PROPULSION LABORATORY
Space Simulator Staff
Technical Memorandum No. 33-197, March 1, 1965 (Unclassified)

This Memorandum describes the space simulator facilities currently available at the Jet Propulsion Laboratory. The description includes temperature, pressure, and irradiation capabilities, test instrumentation available, and data handling.

Speed, R. C.

S23   A LUNAR X-RAY DIFFRACTION EXPERIMENT
Speed, R. C., Nash, D. B., Nickle, N. L.
Technical Report No. 32-756 (Unclassified)
(Reprinted from *Advances in X-Ray Analysis, Vol. 8,* Plenum Press, 1965, pp. 400–419)

An X-ray diffraction system is under development for remote analysis of lunar rocks from an unmanned, soft-landed spacecraft. The objective of this experiment is the identification of rock-forming phases and estimation of their abundances, compositions, and other data which are indicative of the nature of genetic processes on the Moon. A 2:1 scanning parafocusing geometry was successfully miniaturized for this purpose, and a complete diffraction system based on the design is in preparation. The diffractometer including high-voltage power supply weighs 18 lb, occupies 0.9 ft³, and requires 56 w of continuous power. A sample acquisition and preparation system will be an integral part of the diffractometer. Diffraction analysis of a rhyolite, basalt, and chondritic meteorite are given as examples of the capabilities and limitations of rock analysis by this method.

S24   LUNAR AND PLANETARY X-RAY DIFFRACTION PROGRAM
Hess, H. H., Speed, R. C.
Technical Memorandum No. 33-218 (Progress Report of Research and Instrument Development July 1964 to March 1965), June 1, 1965 (Unclassified)

For abstract, see Entry H14.

S25   THE UTILITY OF UNMANNED PROBES IN LUNAR SCIENTIFIC EXPLORATION
Speed, R. C., Nash, D. B., Adams, J. B.
Technical Memorandum No. 33-241, July 15, 1965 (Unclassified)

The utility of unmanned lunar survey probes of the *Ranger* and *Surveyor* class in the post-*Apollo* scientific exploration program, *Apollo Extension Systems (AES),* is defined. Missions, measurements, instruments, probe types, and probe requirements are evaluated, and priorities are established. It is shown that the most important role for unmanned probes is one of widespread reconnaissance which attempts to define and amplify broad lunar problems; and to delineate the most significant areas on the Moon for subsequent, detailed investigations by manned vehicles.

Spencer, D. F.

S26   ENGINEERING MODELS OF THE MARTIAN ATMOSPHERE AND SURFACE
Spencer, D. F.
Technical Memorandum No. 33-234, July 1, 1965 (Unclassified)

Engineering models of the Martian atmosphere and surface are developed for application in designing a Mars capsule-lander. Models are presented for various surface pressures and a number of low-altitude and stratospheric temperature profiles. An atmospheric surface pressure of 14 mb is suggested for design use. Mean continuous wind velocities of approximately 100 ft/sec at the surface are recommended with a mean vertical gradient of plus 2 ft/sec/1000 ft. A peak design wind

velocity of 330 ft/sec is recommended consistent with a 14-mb surface pressure. Models of Mars' surface are developed for the bright areas and the dark areas. The significant differences in design requirements for these areas result from: (1) the convex and concave low-scale surface contours in the dark areas; (2) design requirement to accommodate 10-cm rocks in the dark areas.

Stacey, J.

S27   RADIOMETRIC MAPPING OF THE MOON AT 3 MILLIMETERS WAVELENGTH
Gary, B., Stacey, J., Drake, F. D.
Technical Report No. 32-838 (Unclassified)
(Reprinted from *The Astrophysical Journal, Supplement Series, Vol. 12, No. 108,* November 1965, pp. 239–262)

For abstract, see Entry G02.

Stelzried, C. T.

S28   A PRECISION DC-POTENTIOMETER MICROWAVE INSERTION-LOSS TEST SET
Stelzried, C. T., Reid, M. S., Petty, S. M.
Technical Report No. 32-887, March 15, 1966
(Unclassified)

A requirement has existed at the Jet Propulsion Laboratory for an instrument capable of measuring the insertion loss of transmission-line components beyond the normal precision capability of commercially available equipment. These measurements are necessary for the calibration of low-noise microwave receiving systems used in planetary and lunar astronomy and space communications programs. The instrumentation which was developed has a short-term jitter of 0.0004 db peak-to-peak and long-term drift of typically 0.0015 db/hr. Accuracy of the measurements is limited at the higher insertion-loss values by a 0.1% instrumentation nonlinearity. The precision at very low insertion-loss levels is shown to be better than 10^{-4} db.

Stephens, J. B.

S29   SPACE MOLECULAR SINK SIMULATOR FACILITY DESIGN
Stephens, J. B.
Technical Report No. 32-901, March 15, 1966
(Unclassified)

This Report summarizes the results of research, design, and development efforts for a space molecular sink simulation facility now under construction. The longitudinal-wedge-fin, 21°K hydrogen-refrigerated, molecular-trap array has been shown to provide a capture improvement of an order of magnitude over that of smooth-walls, capturing 99.97% of the condensable molecules of O_2, N_2, CO, and CO_2 that emanate from the test item before they can return. An electron-beam titanium sublimator will be used to pump hydrogen and, also, chemically permanently fix the cryo deposits. A 1300-ft³/min

mechanical pump (operated in the viscous-flow regime to eliminate backstreaming) and a 140-1/sec turbo-molecular impact pump will be used to rough pump the double-walled, double-doored 10-ft-diam vacuum chamber and to sustain the guard vacuum. The chamber is decontaminated by glass-bead blasting in conjunction with a 250°C vacuum bake-out. Conventional extreme-high-vacuum and cryogenic instrumentation and controls will be used; cryogenic quartz-crystal microbalances with a sensitivity of 1×10^{-10}g/cm² will be used to measure condensable molecular fluxes; and a cryogenic quadruple mass spectrometer will be used to monitor the molecular specie emanating from the test item.

Surveyor Project Office

S30   *SURVEYOR* MISSION OPERATIONS SYSTEM
Surveyor Project Office
Technical Memorandum No. 33-264, April 4, 1966
(Unclassified)

The purpose of this Technical Memorandum is to provide a basic understanding of the mission operation system (MOS). Treatment of the subject contains sufficient detail to convey an accurate knowledge of the workings of the entire system. Technical data and information about all elements of the MOS are found in the official MOS planning, design and operational documents which this Memorandum summarizes. This publication is made up of five sections. The description of the MOS is developed in the first four. The fifth is a presentation of an over-all view of the communications that take place during the mission and the spaceflight activities controlled by these communications.

Tausworthe, R. C.

T01   A PRECISION PLANETARY RANGE-TRACKING RADAR
Tausworthe, R. C.
Technical Report No. 32-779 (Unclassified)
(Reprinted from *IEEE Transactions on Space Electronics and Telemetry, Vol. SET-11, No. 2,* June 1965, pp. 78–85)

A closed-loop range-locked radar system developed by the Jet Propulsion Laboratory has recently had great success range tracking the planet Venus. It has provided measurements to the planetary mean-tracking point with peak minute-to-minute variations less than 2.25 to 3 km in range. Over a one-hour tracking period, a mean tracking point can be determined to 0.5 km.

A scattering-law calibration of the planet is made each day, measuring the mean-tracking-point-to-planetary-surface distance to within 3 km (nominal). The subearth point-to-radar distance is thus measured to a nominal accuracy of 3.5 km. Tracking behaves as a first-order linear "range-locked" loop with ephemeris aid, and is practically calibration free.

Data obtained during the 1964 conjunction showed that the ephemeris not only contained a range error, but also a range-

rate error of 18 km per day. Deviations from this rate correspond to surface features whose height can be estimated. Such data will be invaluable in determining, to a greater degree of accuracy than ever before attainable, the orbital constants of the Earth and Venus.

T02 THEORY AND PRACTICAL DESIGN OF PHASE-LOCKED RECEIVERS—VOLUME I
Tausworthe, R. C.
Technical Report No. 32-819, February 15, 1966
(Unclassified)

This is Volume I of a two-volume work on the theory of phase-locked receivers with pertinent reference material on practical receiver design. Volume I is primarily devoted to the performance of carrier-tracking loops including treatment of narrow-band systems having IF limiters. The bulk of the work is based on a theoretical linear model.

Part 1 is an exposition of the theory, the resulting equations and design philosophy that have enabled the phase-lock concept to evolve into the basic principle underlying the most sensitive receivers. Part 2 is a condensed version of Part 1, for quick reference to formulas, definitions and salient design considerations.

Taylor, H. S.

T03 MANY-ELECTRON-THEORY AB INITIO CALCULATION FOR THE Be ATOM
Geller, M., Taylor, H. S., Levine, H. B.
Technical Report No. 32-799 (Unclassified)
(Reprinted from The Journal of Chemical Physics, Vol. 43, No. 5, September 1965, pp. 1727–1736)

For abstract, see Entry G06.

Taylor, J. L.

T04 SLIP IN TUNGSTEN AT HIGH TEMPERATURES
Taylor, J. L.
Technical Report No. 32-818, October 15, 1965
(Unclassified)

Single crystals of tungsten grown from powder-metallurgy swaged rod by high temperature annealing were deformed in tension at temperatures from 2500 to 5000°F. Orientation of specimen tensile axis, strained matrix, and deformation bands was determined optically by reflections from {110} etch pits. Slip traces were analyzed and slip direction determined. Results indicate that {110} <111>, {112} <111>, and {123} <111> type slip occur in tungsten over the temperature range investigated. Slip is orientation dependent occurring on that combination of slip plane and direction which has the highest critical resolved shear stress. "Overshooting" appears to be a general occurrence between 2500 and 5000°F. Deformation bands show rotation in a direction opposite to the rotation of the tensile axis.

T05 TENSILE BEHAVIOR OF SAME-LOT SINGLE-CRYSTAL AND POLYCRYSTALLINE TUNGSTEN FROM 2500 TO 5000°F
Taylor, J. L.
Technical Report No. 32-827, November 15, 1965
(Unclassified)

Polycrystalline tungsten of the same lot and chemical composition as the single-crystal material also was tested under the same conditions of strain rate and temperature. The tensile results were consistent with results previously reported by the author for other lots of polycrystalline powder-metallurgy tungsten, including a ductility minimum at $\simeq 3500°F$ and a maximum at $\simeq 4500°F$. It appears that orientation may be a factor in the ductility minimum in polycrystalline tungsten, presuming that the many small crystals making up the core of the polycrystalline specimens exhibit the same preferred orientation as the single-crystal material. The maximum in elongation which also occurs in both polycrystalline and single-crystal tungsten may be similarly related through preferred orientation. Comparison of polycrystalline and single-crystal tungsten indicated an upper limit of $\simeq 2-1$ to the strengthening effect due to gain size at 2500°F and above.

Thomas, G. M.

T06 EXPERIMENTAL MEASUREMENTS OF NON-EQUILIBRIUM AND EQUILIBRIUM RADIATION FROM PLANETARY ATMOSPHERES
Thomas, G. M., Menard, W. A.
Technical Report No. 32-902 (Unclassified)
(Reprinted from AIAA Journal, Vol. 4, No. 2, February 1966, pp. 227–237)

An electric arc-driven shock tube was used to study the effect of composition on the radiation from shock-heated mixtures of 9% CO_2-90% N_2-1% A, 30% CO_2-70% N_2, and 100% CO_2. Measurements were made of the shock-layer radiance at the stagnation point of a flat-faced cylinder in the 0.3- to 2.7-μ region, using a carbon-coated thin film gage for flight velocities from 20,000 to 46,000 fps and initial pressures varying from 0.25 to 2.00 mm Hg. Shock standoff distances were measured by photographic techniques. Photometric measurements were made of the intensity behind the incident shock in the 0.3- to 1.0-μ region, and a tungsten photoelectric gage measured the nonequilibrium intensity in the far ultraviolet region. Shock front integrated nonequilibrium and equilibrium intensities, nonequilibrium relaxation distances, and time to peak intensity were obtained. Stagnation-point radiance results are higher than one current estimate at high temperatures and low densities. Integrated nonequilibrium intensity for 9% CO_2-90% N_2-1% A mixtures was 32w/cm²-2π sr at 25,000 fps. Major radiating species are identified as the CN radical for CO_2-N_2 mixtures and the CO^+ ion for 100% CO_2. Oscillator strengths for the CN red and violet systems are deduced from the measurements. The f value results indirectly give support to a dissociation energy of 7.7 ± 0.1 ev for the CN radial.

Thornton, T. H., Jr.

T07 INJECTION ACCURACY CHARACTERISTICS FOR LUNAR MISSIONS
Thornton, T. H., Jr.
Technical Report No. 32-839, October 15, 1965
(Unclassified)

Report investigates a technique for expressing launch vehicle injection accuracy in terms of spacecraft midcourse correction requirements for Earth–Moon missions. A figure-of-merit is defined which can be used as a measure of injection accuracy. The variables important to guidance accuracy such as injection energy, launch azimuth, lunar declination and Earth–Moon distance are discussed. A "best" target coordinate system is developed and numerical results which enable the engineer to relate launch vehicle injection accuracy to spacecraft mid-course correction requirements are presented. Both "miss-only" type midcourse corrections and "miss-plus-time" corrections are considered.

Toth, L. R.

T08 ALPS GENERANT TANK AND CELL ASSEMBLY
Keller, O. F., Toth, L. R.
Technical Report No. 32-865, February 28, 1966
(Unclassified)

For abstract, see Entry K05.

Trajmar, S.

T09 INDUCED INFRARED ABSORPTION OF SOLUTIONS OF H_2 AND D_2 IN LIQUID NEON
Ewing, G. E., Trajmar, S.
Technical Report No. 32-764 (Unclassified)
(Reprinted from *The Journal of Chemical Physics, Vol. 42, No. 11*, June 1, 1965, pp. 4038–4046)

For abstract, see Entry E12.

T10 THE NEAR-ULTRAVIOLET BANDS OF MgO: ANALYSIS OF THE $D^1\Delta - A^1\Pi$ AND $C^1\Sigma^- - A^1\Pi$ SYSTEMS
Trajmar, S., Ewing, G. E.
Technical Report No. 32-770 (Unclassified)
(Reprinted from *The Astrophysical Journal, Vol. 142, No. 1*, July 1, 1965, pp. 77–83)

The near-ultraviolet bands of $Mg^{16}O$ and $Mg^{18}O$ have been photographed in the second order with a 21-foot concave grating spectrograph using a controlled-atmosphere arc source. It has been found that the $C^1\Delta - A^1\Pi$ system extends from 3766 Å to about 3800 Å, and the bands from 3798 Å to the longer wavelengths belong to the $D^1\Delta - A^1\Pi$ system forming a zero sequence ($\Delta v = 0$). Vibrational and rotational analysis of this latter system yields the following constants for the new $D^1\Delta$ state of $Mg^{16}O$: $\omega_e = 632.5$, $\omega_e\chi_e = 5.3$, $B_0 = 0.4990$, $D_0 = 1.26 \times 10^{-6}$, $B_1 = 0.4942$, and $D_1 = 1.29 \times 10^{-6}$ cm^{-1}. The Λ-doubling is resolved in the (0–0) band and causes double head formation in the R branches.

The assignment of the $C^1\Sigma - A^1\Pi$ system reported earlier has been somewhat modified and extended. The symmetry of the upper state has been changed from $C^1\Sigma^+$ to $C^1\Sigma^-$, the J-numbering in the Q branch of the (0–0) band has been shifted by one, and the assignment of the (1–1) band has been achieved. The constants of the $C^1\Sigma^-$ state of $Mg^{16}O$ are: $\omega_e = 632.4$, $\omega_e\chi_e = 5.2$, $B_0 = 0.4984$, $D_0 = 1.27 \times 10^{-6}$, $B_1 = 0.4936$, and $D_1 = 1.30 \times 10^{-6}$ cm^{-1}.

Trubert, M. R.

T11 USE OF *RANGER* FLIGHT DATA IN THE SYNTHESIS OF A TORSIONAL ACCELERATION TRANSIENT FOR *SURVEYOR* VIBRATION QUALIFICATION TESTING
Trubert, M. R.
Technical Memorandum No. 33-237, April 19, 1966
(Unclassified)

This Technical Memorandum presents a method for the prediction of the flight acceleration at the base of a spacecraft in boost configuration from the flight data of another space-craft using the same first-stage booster. The predicted accelera-tion furnishes a rational basis for the vibration specifications of the spacecraft. The method is illustrated with the tortional acceleration of the *Ranger* and *Surveyor* spacecraft. The study was made in three steps: In Step I, the pulsating transient acceleration, recorded at the base of *Ranger* during Flights *VI* through *IX* (booster engine cutoff event), was analyzed. A pulse-type torque at the gimbal blocks of the *Atlas* engine was assumed to be cause of the transient acceleration and was determined on an analog computer. In Step II, this torque was applied on an analog model of the *Atlas/Centaur/Surveyor* vehicle; the corresponding acceleration at the base of *Surveyor* was deduced. In Step III, the attention was focused on the implementation of the pulse test program. In addition, recom-mendation for a sine sweep test was made by deriving a sine level that is equivalent to the pulses.

Trummel, M. C.

T12 APPLICATION OF GROUND-TEST ACOUSTIC SIMULATIONS OF LIFTOFF AND TRANSONIC VIBRATION TO ACTUAL *RANGER* FLIGHT VIBRATION DATA
Trummel, M. C.
Technical Report No. 32-910, May 1, 1966
(Unclassified)

During the *Ranger* flight program, only a limited amount of in-flight vibration data was obtained. In order to expand the usefulness of this data, a ground test was conducted in which a large number of vibration and acoustic measurements were made. The test approximated, by the use of acoustic fields, the vibration excitation mechanisms existing at the flight periods of maximum vibration: liftoff and transonic. By using the ground test data in conjunction with the flight data, the follow-ing results were achieved: (1) The nature of the vibration caused by the two excitation modes was determined, and the

effect of flight accelerometer characteristics on measured vibration was analyzed. (2) A method of predicting vibration levels was developed and, by comparison with the actual flight data, was shown to be adequate at higher frequencies, but overly conservative at lower frequencies. (3) The flight vibration environment at the *Ranger* spacecraft feet and at two general classes of equipment locations on the spacecraft was estimated and shown to be adequately covered by vibration test specifications.

T13 GROUND TEST SIMULATION OF LIFT-OFF AND TRANSONIC VIBRATION EXCITATION MECHANISMS ON THE *RANGER* SPACECRAFT
Trummel, M. C.
Technical Memorandum No. 33-256, November 1, 1965
(Unclassified)

The results of extensive vibration measurements from ground test acoustic simulations of *Ranger* spacecraft launch and transonic vibration excitation modes are presented. For analysis the measurements are grouped into three structurally similar regions. The data from a typical region are statistically analyzed in narrow frequency bands and the 95-percentile value is compared to the 50-percentile value. A method of using acoustic acceptance measurements to predict launch vibration levels is developed and compared with actual *Ranger* flight data. The distribution of vibration over the spacecraft and the directionality of excited vibration are compared under both modes of vibration excitation.

Tschuikow-Roux, E.

T14 REACTION DWELL TIME AND COOLING RATE IN A SINGLE-PULSE SHOCK TUBE
Tschuikow-Roux, E.
Technical Report No. 32-752 (Unclassified)
(Reprinted from *The Physics of Fluids, Vol. 8, No. 5,*
May 1965, pp. 821–825)

A method for the production of a constant, well-defined reaction dwell time in a single-pulse shock tube is discussed and an expression is derived giving the dwell time in terms of geometric and flow parameters. The effect of finite cooling rate on the reaction rate is considered and a correction factor to the observed rate constant is given. This cooling correction is shown to be directly proportional to T^2, inversely proportional to the cooling rate dT/dt, and the reaction dwell time t_1, and, to a first approximation, independent of the heat-capacity ratio, $\gamma = C_p/C_y$.

T15 THERMAL DECOMPOSITION OF FLUOROFORM IN A SINGLE-PULSE SHOCK TUBE. II. PRESSURE DEPENDENCE OF THE RATE
Tschuikow-Roux, E.
Technical Report No. 32-753 (Unclassified)
(Reprinted from *The Journal of Chemical Physics, Vol. 42,*
No. 10, May 15, 1965, pp. 3639–3642)

The thermal decomposition of CF_3H has been studied in a single-pulse shock tube between 1200 and 1600°K using dilute CF_3H-Ar mixtures at total pressures of about 18.7 and 0.90 atm. The results, together with earlier work at about 4 atm, indicate that the observed rate constants for the rate of disappearance of CF_3H are those of a second-order energy-transfer process, where collisional activation is rate determining. Kassel's model of unimolecular reaction-rate theory is used to show that the observed pressure dependence of the rate constants is not unreasonable. From the classical Kassel theory for such processes, it is calculated that the mean lifetime of a critically energized CF_3H at 1400°K is 1.2×10^{-11} sec with five effective oscillators.

T16 KINETICS OF THE THERMAL DECOMPOSITION OF C_2F_6 IN THE PRESENCE OF H_2 AT 1300–1600°K
Tschuikow-Roux, E.
Technical Report No. 32-826 (Unclassified)
(Reprinted from *The Journal of Chemical Physics, Vol. 43,*
No. 7, October 1965, pp. 2251–2256)

The thermal decomposition of hexafluoroethane in the presence of hydrogen has been studied in a single-pulse shock tube in the temperature range 1300 to 1600°K. The reactants were highly diluted with argon, the composition ratios being $Ar:H_2:C_2F_6 \simeq 7500:17.4:1$. The principal reaction products containing carbon were fluoroform and tetrafluoroethylene. A reaction scheme which accounts for these products is proposed and the first-order rate constant for the primary step $C_2F_6 \rightarrow 2CF_3$ is deduced: $k_1 = 4.3 \times 10^{17} \exp(-94\,400 \pm 4000)/RT \text{ sec}^{-1}$.

Accepting an activation energy of about 1 kcal/mole for the recombination of CF_3 radicals leads to $D(CF_3 - CF_3) \simeq 93 \pm 4$ kcal/mole.

Tyler, W. H.

T17 THE EFFECT OF INJECTOR DESIGN ON THRUST-CHAMBER EROSION
Rowley, R. W., Tyler, W. H.
Technical Report No. 32-750, March 1, 1966
(Unclassified)

For abstract, see Entry R34.

Urey, H. C.

U01 *RANGER VIII* AND *IX.* PART II. EXPERIMENTERS' ANALYSES AND INTERPRETATIONS
Heacock, R. L., Kuiper, G. P., Shoemaker, E. M., Urey, H. C., Whitaker, E. A.
Technical Report No. 32-800, March 15, 1966
(Unclassified)

For abstract, see Entry H12.

Vango, S. P.

**V01 DETECTION OF MICRO-ORGANISMS IN SOIL
BY THEIR CATALATIC ACTIVITY**
Weetall, H. H., Weliky, N., Vango, S. P.
Technical Report No. 32-777 (Unclassified)
(Reprinted from *Nature, Vol. 208, No. 4988,* June 5, 1965
pp. 1019–1021)

For abstract, see Entry W04.

Vrebalovich, T.

V02 EYES ON THE MOON
Smith, G. M., Vrebalovich, T., Willingham, D. E.
Technical Report No. 32-937 (Unclassified)
(Reprinted from *Astronautics and Aeronautics, Vol. 4,
No. 3,* March 1966, pp. 74–82)

For abstract, see Entry S20.

Wada, B.

W01 STIFFNESS MATRIX STRUCTURAL ANALYSIS
Wada, B.
Technical Report No. 32-774, October 31, 1965
(Unclassified)

A computer program is described that solves structural problems having lumped masses connected by weightless members. The program is capable of handling 130 degrees of freedom with the option of using any one of five different member types.

Using the stiffness formulation, static deflections and loads, thermal deflections and loads, eigenvalues and eigenvectors can be evaluated.

Wahlquist, H. D.

W02 RIGID MOTIONS IN EINSTEIN SPACES
Wahlquist, H. D., Estabrook, F. B.
Technical Report No. 32-868, March 15, 1966
(Unclassified)

The dyadic formulation of general relativity is used systematically to discuss rigid congruences in Einstein space–time. For space–time of uniform curvature, the quotient space metrics of rotating and accelerating rigid bodies are obtained. For Einstein space–time of nonuniform curvature, all irrotational, nonisometric, rigid motions are explicitly displayed. They have one degree of freedom, and occur only in degenerate static metrics of Class B. Rotating rigid congruences in Einstein space–time of nonuniform curvature are shown to have no degrees of freedom. Their evolution is, in fact, found to be governed by a complete set of 14 first-order total differential equations, linear in the time derivatives of the dyadic variables. Such rotating motions are shown further to be constrained by a set of algebraic conditions; the implication of this for the validity of the Herglotz–Noether theorem in Einstein space–time is discussed.

Weetall, H. H.

**W03 IMMUNOADSORBENT FOR THE ISOLATION OF
PURINE-SPECIFIC ANTIBODIES**
Weetall, H. H., Weliky, N.
Technical Report No. 32-758 (Unclassified)
(Reprinted from *Science, Vol. 148, No. 3674,*
May 28, 1965, pp. 1235–1237)

An immunoadsorbent for the isolation of purine-specific antibody has been synthesized. The technique is applicable for isolating antibody to any purine or pyrimidine capable of being converted to a derivative which can be coupled to amine groups. The recovery of antibody from a serum sample is better than 82%, and the precipitability of the isolated antibody is as high as 89%.

**W04 DETECTION OF MICRO-ORGANISMS IN SOIL
BY THEIR CATALATIC ACTIVITY**
Weetall, H. H., Weliky, N., Vango, S. P.
Technical Report No. 32-777 (Unclassified)
(Reprinted from *Nature, Vol. 208, No. 4988,*
June 5, 1965, pp. 1019–1021)

Method of detecting and estimating intracellular catalase, an enzyme which catalyzes the decomposition of hydrogen peroxide to water and oxygen, is a simple and convenient indicator of the presence of micro-organisms in soils. Catalase is prevalent in microorganisms, and its activity is insensitive to reaction conditions. To determine the concentrations of intracellular catalase which might be found in various desert soils, the quantity of enzyme found in an "average bacterium" was estimated. The principle of the method was tested by placing equal weights of soil samples in the bottom of each of two test tubes. Buffer was added to the control side and muramidase in an equal volume of buffer to the other. After allowing 20 min for the muramidase to react, the upper reagent vessels were turned so that the hydrogen peroxide solution, previously measured into each, was poured into the test tubes. If the muramidase released catalase, the excess oxygen produced from the hydrogen peroxide increased the pressure on that side, causing the liquid in an interconnecting U-tube to move. This was found to be the case for a garden soil and several desert soils. It is considered that the technique, which has been refined in a manner described, should be applicable to the detection of an enzyme which produces a gas such as carbon dioxide or oxygen.

**W05 THE COUPLING OF BIOLOGICALLY ACTIVE
MOLECULES TO INSOLUBLE POLYMERS:
ANTIBODY ON CELLULOSE**
Weetall, H. H., Weliky, N.
Technical Report No. 32-802 (Unclassified)
(Reprinted from *Biochimica et Biophysica Acta, 107,*
1965, pp. 150–152)

Antibody globulin has been coupled to a diazotized aminoaryl derivative of carboxymethyl-cellulose to form an immunoadsorbent which specifically retains and releases specific antigen. Such substances may be useful for the isolation

of substances with antigenic properties which are difficult to handle by other methods, after optimum conditions for stability and yield have been determined. Insoluble antibody derivatives may be used for antigen–antibody dissociation studies or to investigate antibody denaturation mechanisms by agents which cause loss of activity.

W06 THE CHEMISTRY AND USE OF CELLULOSE DERIVATIVES FOR THE STUDY OF BIOLOGICAL SYSTEMS
Weliky, N., Weetall, H. H.
Technical Report No. 32-859 (Unclassified)
(Reprinted from *Immunochemistry, Vol. 2*, 1965, pp. 293–322)

For abstract, see Entry W14.

W07 A NEW TECHNIQUE FOR THE ENZYMIC DETECTION OF HYDROGEN PEROXIDE
Weetall, H. H., Weliky, N.
Technical Report No. 32-967 (Unclassified)
(Reprinted from *Analytical Biochemistry, Vol. 14, No. 1*, January 1966, pp. 160–162)

Enzymic methods for detecting the presence of small quantities of peroxides have been used since the first reported successful attempt in 1845 by Osann. With peroxidase as the enzyme, he was able to detect 6×10^{-5} M hydrogen peroxide. The method made use of peroxidase to catalyze the oxidation of a colorless hydrogen donor (DH_2) to a colored product (D) which could be determined colorimetrically. Schematically the reaction is as follows:

$$H_2O_2 + DH_2 \xrightarrow{\text{peroxidase}} 2H_2O + D$$
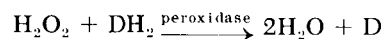
Weinberg, I.

W08 THERMOELECTRIC POWER IN NIOBIUM-ZIRCONIUM ALLOYS
Weinberg, I., Schultz, C. W.
Technical Report No. 32-872 (Unclassified)
(Reprinted from *The Journal of Physics and Chemistry of Solids, Vol. 27*, 1965, pp. 474–476)

The thermoelectric power of niobium exhibits a relatively positive peak at $T \approx 80°K$. Assuming the presence of a phonon drag component, a change in the magnitude of this peak can be anticipated when sufficient amounts of zirconium are added to niobium. Information regarding the transport properties of simpler metals has been obtained by observing quenching of the phonon drag peak in copper-based alloys. A variation in diffusion thermopower with alloying is expected. To obtain information regarding the relatively unexplored transport properties of Nb–Zr alloys, the thermoelectric power of niobium and several Nb–Zr alloys from $T = 9 \cdot 2$ to $330°K$ must be determined. Since the original data extends to the low temperature limit of $14°K$, the current results constitute an extension to lower temperatures of previously published results. Measurements were carried out on niobium and Nb–Zr alloys containing 1, $1 \cdot 8$ and $3 \cdot 8$ at. % zirconium as determined by spectrochemical analysis.

W09 PHONON-DRAG THERMOPOWER IN DILUTE COPPER ALLOYS
Weinberg, I.
Technical Report No. 32-879, April 1, 1966
(Unclassified)

The change in phonon-drag thermopower of copper that occurs with alloying is determined for several dilute copper alloys. These results are then used to determine numerical values for the scattering parameter a, assuming pure Rayleigh scattering of phonons by the solute atoms. The values of a obtained experimentally are compared to the scattering parameter calculated for elastic scattering of long-wavelength phonons by the mechanism of mass difference alone. Solute concentrations employed in this investigation are: 0.03 at. % Au, 0.09 and 0.2 at. % Ag, and 0.44 at. % Si. For Cu-Au, the results indicate that phonons are scattered predominantly through the mass-defect mechanism. The Cu-Si data yield a contribution from the mass-defect term that is of the same magnitude as the contribution from other phonon-scattering mechanisms. For Cu-Ag, the results indicate that phonons are scattered in this alloy predominantly by mechanisms other than mass difference. The relative magnitude of the lattice-distortion contribution is least in Cu-Au, and increases in Cu-Si and Cu-Ag in that order. The Cu-Si data are in agreement with the author's previous results, while for Cu-Ag and Cu-Au, the results are in agreement with qualitative considerations based on the range of solid solubilities in these alloys.

Weingart, J. M.

W10 DETERMINATION OF THE LOW-FREQUENCY LINEAR ELECTRO-OPTIC EFFECT IN TETRAGONAL, Ba TiO₃
Johnston, A. R., Weingart, J. M.
Technical Report No. 32-760 (Unclassified)
(Reprinted from *Journal of the Optical Society of America, Vol. 55, No. 7*, July 1965, pp. 828–834)

For abstract, see Entry J10.

Weliky, N.

W11 IMMUNOADSORBENT FOR THE ISOLATION OF PURINE-SPECIFIC ANTIBODIES
Weetall, H. H., Weliky, N.
Technical Report No. 32-758 (Unclassified)
(Reprinted from *Science, Vol. 148, No. 3674*, May 28, 1965, pp. 1235–1237)

For abstract, see Entry W03.

W12 DETECTION OF MICRO-ORGANISMS IN SOIL BY THEIR CATALATIC ACTIVITY
Weetall, H. H., Weliky, N., Vango, S. P.
Technical Report No. 32-777 (Unclassified)
(Reprinted from *Nature, Vol. 208, No. 4988*, June 5, 1965, pp. 1019–1021)

For abstract, see Entry W04.

,W13 THE COUPLING OF BIOLOGICALLY ACTIVE
MOLECULES TO INSOLUBLE POLYMERS:
ANTIBODY ON CELLULOSE
Weetall, H. H., Weliky, N.
Technical Report No. 32-802 (Unclassified)
(Reported from *Biochimica et Biophysica Acta, 107,*
1965, pp. 150–152)

For abstract, see Entry W05.

W14 THE CHEMISTRY AND USE OF CELLULOSE
DERIVATIVES FOR THE STUDY OF BIOLOGICAL
SYSTEMS
Weliky, N., Weetall, H. H.
Technical Report No. 32-859 (Unclassified)
(Reprinted from *Immunochemistry, Vol. 2,* 1965,
pp. 293–322)

The increasing number of publications dealing with the
coupling of biologically important molecules or their sub-
strates to soluble and particularly insoluble polymers reflects
a growing acknowledgment of the usefulness of such systems
for the isolation and synthesis of molecular species, the study
of chemical and biological mechanisms, and the study of
molecular interactions.

Examples of the uses to which such systems can be put
include: (1) The coupling of antigens, antibodies, enzymes,
enzyme inhibitors and nucleic acids (including fragments or
monomers) in order to purify or isolate complementary sub-
stances with which they form specific or cross-reacting com-
plexes. This includes the "sandwich technique" in which an
antigen is coupled, antibody is complexed to the antigen, and
advantage taken of the bivalence of antibody to detect or
quantitate antigen by further exposure of the immunoad-
sorbent to solutions of that substance. Detection can be
accomplished by radioactive labeling or by dissociation under
appropriate conditions for the detection or recovery of the
antigen.

(2) Study of the bound substance to observe the effect of
coupling at different molecular sites on reactivity. For example
it has been found that bovine serum albumin is as effective in
removing antibody from immune serum, if coupled to cellu-
lose through an azo link by reaction with a diazonium
cellulose derivative, as by reaction with an acidic cellulose
derivative to form an amide.

(3) Study of the bound substance to observe the effect of
coupling on chemical properties such as reactivity of enzymes,
or physical properties such as fluorescence.

(4) The study of the effects of reagents on the binding of
complexed species with polymer bound molecules; e.g., acid
dissociation.

(5) Bound substances may, in favorable cases, be localized
in particular environments where their biological effects can
be observed without the possibility of physical transfer and
the introduction of ambiguities caused by possible inter-
actions at other locations. This technique is applicable to
enzyme, hormone and antibody systems. Potentially, the pos-

sibility exists that deficiencies in organisms may be supple-
mented by biologically active molecules bound to insoluble
or soluble polymers.

(6) Model biological systems may be set up using bound
enzymes, hormones and other biologically active molecules to
study controlled sequential reactions.

(7) The step-wise synthesis of polymers in a controlled
fashion may, in principle, be accomplished by binding a
monomer and successively adding other components in high
yield reactions. Some success has already been achieved in
this area.

Reports of relatively high nonspecific adsorption of proteins
by hydrocarbon polymers induced the re-examination of
cellulose as a carrier for proteins, other polymers and simple
organic molecules. The rest of this paper will be limited to a
survey of the chemistry of cellulose and its derivatives as it
applies to the preparation of systems useful for the study of
biochemical substances and their properties.

W15 IMMUNOADSORBENT: PREPARATION AND USE
OF CELLULOSE DERIVATIVES
Campbell, D. H., Weliky, N.
Technical Report No. 32-900, May 1, 1966
(Unclassified)

For abstract, see Entry C03.

W16 A NEW TECHNIQUE FOR THE ENZYMIC
DETECTION OF HYDROGEN PEROXIDE
Weetall, H. H., Weliky, N.
Technical Report No. 32-967 (Unclassified)
(Reprinted from *Analytical Biochemistry, Vol. 14, No. 1,*
January 1966, pp. 160–162)

For abstract, see Entry W07.

Wells, W. H.

W17 PROPOSED GAS MASER PUMPING SCHEME FOR
THE FAR INFRARED
Wells, W. H.
Technical Report No. 32-616 (Unclassified)
(Reprinted from *Journal of Applied Physics, Vol. 36, No. 9,*
September 1965, pp. 2838–2843)

A scheme that is analogous to the operation of a heat
engine is proposed for exciting maser action in the infrared
and submillimeter parts of the spectrum. A beam of hot
molecules interacts through distant collision with a cold gas
of another species at very low pressure. Certain energy levels
in the hot gas are cooled faster than others owing to coin-
cidental resonances in the spectra of the two gases. In the
partially cooled nonequilibrium state, population inversions
are possible in the hot species.

To demonstrate feasibility, the interaction between pure
rotational states of HCl and HF is discussed in detail. Bar-
ring unforeseen experimental difficulty (e.g., chemical activity

of HF) the Schawlow–Townes condition for maser action can be satisfied by the $J = 3 \rightarrow 2$ transition in HF at 123.1 cm^{-1}, or 81.25 μ.

Welton, J. T.

W18 FREE-FLIGHT TELEMETRY TESTING IN THE JET PROPULSION LABORATORY WIND TUNNELS
Welton, J. T.
Technical Report No. 32-775, September 15, 1965
(Unclassified)

A program has been conducted in the Jet Propulsion Laboratory Hypersonic Wind Tunnel to develop an operational technique for obtaining interference-free base pressure data. The technique developed utilizes a pneumatic launch mechanism to project the models into free flight and an electronic transmitter and receiver system to obtain base pressure data from the model. Both 10- and 15-deg half-angle cone configurations were tested.

Whitaker, E. A.

W19 RANGER VIII AND IX.
PART II. EXPERIMENTERS' ANALYSES AND INTERPRETATIONS
Heacock, R. L., Kuiper, G. P., Shoemaker, E. M., Urey, H. C., Whitaker, E. A.
Technical Report No. 32-800, March 15, 1966
(Unclassified)

For abstract, see Entry H12.

White, A. B.

W20 PREDICTION OF HEAT TRANSFER FROM LAMINAR BOUNDARY LAYERS WITH EMPHASIS ON LARGE FREE-STREAM VELOCITY GRADIENTS AND HIGHLY COOLED WALLS
Back, L. H., White, A. B.
Technical Report No. 32-728, April 1, 1965
(Unclassified)

For abstract, see Entry B01.

Whitten, D. G.

W21 DETECTION OF LIFE-RELATED COMPOUNDS ON PLANETARY SURFACES BY GAS CHROMATOGRAPHY-MASS SPECTROMETRY TECHNIQUES
Bentley, K. E., Giffin, C. E., Whitten, D. G., Wilhite, W. F.
Technical Report No. 32-713 (Unclassified)
(Reprinted from the AAS Science and Technology Series, Vol. 2, 1964, pp. 93–117)

For abstract, see Entry B14.

W22 PYROLYSIS STUDIES. CONTROLLED THERMAL DEGRADATION OF MESOPORPHYRIN
Whitten, D. G., Bentley, K. E., Kuwada, D.
Technical Report No. 32-812 (Unclassified)
(Reprinted from the Journal of Organic Chemistry, Vol. 31, 1966, pp. 322–324)

It was found that pyrolysis of porphyrins at 800–900° caused extensive fragmentation of the porphyrin nucleus. The thermal decomposition of the porphyrin has been investigated under less drastic conditions than those previously reported. The major organic products obtained from thermal decomposition of mesoporphyrin at several temperatures over the range 400–780° were the various alkylpyrroles. Small amounts of acetonitrile and propionitrile were obtained as well as moderate yields of methane, ethylene and ethane. This yield of hydrocarbons and nitriles increased with temperature. Thermal decomposition products of mesoporphyrin at lower temperatures (400–600°) were the same as those formed in reductive degradation. As the temperature of pyrolysis was elevated, the yield of other less characteristic alkylpyrroles increased. The results of this work emphasize the utility of controlled pyrolysis as an adjunct to direct mass spectrometry.

Whittlesey, A. C.

W23 DESCRIPTION AND ANALYSIS OF 890-MHz NOISE-MEASURING EQUIPMENT
Biber, K. W., Whittlesey, A. C.
Technical Report No. 32-898, March 31, 1966
(Unclassified)

For abstract, see Entry B19.

Wiksten, D. B.

W24 DYNAMIC ENVIRONMENT OF THE RANGER SPACECRAFT: I THROUGH IX (FINAL REPORT)
Wiksten, D. B.
Technical Report No. 32-909, May 1, 1966 (Unclassified)

The dynamic environment of the Ranger spacecraft (I through IX) during the launch portion of flight is defined in this Report. Flight data from launches have been reviewed and are included. The environments include liftoff acoustics, liftoff and transonic vibration, and the transient vibrations of the various pyrotechnic and staging events in the launch sequence. Systems for data acquisition and analysis are described. Postflight comparison of flight data and ground test specification levels is made, and the dynamic test program is discussed.

Wilhite, W. F.

W25 DETECTION OF LIFE-RELATED COMPOUNDS ON PLANETARY SURFACES BY GAS CHROMATOGRAPHY-MASS SPECTROMETRY TECHNIQUES
Bentley, K. E., Giffin, C. E., Whitten, D. G., Wilhite, W. F.
Technical Report No. 32-713 (Unclassified)
(Reprinted from the AAS Science and Technology Series, Vol. 2, 1964, pp. 93–117)

For abstract, see Entry B14.

**W26 DEVELOPMENTS IN MICRO-GAS
CHROMATOGRAPHY**
Wilhite, W. F.
Technical Report No. 32-805 (Unclassified)
(Reprinted from *Journal of Gas Chromatography*,
February 1966, pp. 47–50)

A micro-gas chromatographic system has been developed
at the Jet Propulsion Laboratory to analyze the atmosphere
of Mars in a few seconds during the descent of a landing
capsule. The system consists of micro components, including
highly efficient micro-packed columns capable of rapid sep-
aration at flow rates of less than 1 cc per minute, a micro-
thermal conductivity detector with an internal volume of
0.1 μl and sensitivity better than 5 ppm, and a sampling
valve capable of injecting a 1-μl gas sample. The components,
and the new techniques required to develop them, are
described.

Williams, H. E.

**W27 AN EVALUATION OF THE EFFECT OF FINITE
SHEAR STRAIN IN A SHALLOW, SPHERICAL SHELL**
Williams, H. E.
Technical Report No. 32-780, October 1, 1965
(Unclassified)

In an effort to assess the effect of including transverse shear
strain in the analysis of thin shells, the equations proposed by
E. Reissner are specialized for shallow, spherical shells and are
solved for cases of loading for which the effect might be ex-
pected to be appreciable. It is found that, for materials that
are nearly isotropic, the solution for an edge-loaded shell
differs slightly from that of the classical equation. However,
the solution in the neighborhood of a concentrated load
applied at the apex is found to differ significantly from its
classical counterpart.

Willingham, D.

W28 *RANGER* PHOTOMETRIC CALIBRATION
Smith, G. M., Willingham, D.
Technical Report No. 32-665, August 15, 1965
(Unclassified)

For abstract, see Entry S19.

**W29 A FIGURE OF MERIT MEASURING
PICTURE RESOLUTION**
Rindfleisch, T., Willingham, D.
Technical Report No. 32-666, September 1, 1965
(Unclassified)
For abstract, see Entry R20.

W30 EYES ON THE MOON
Smith, G. M., Vrebalovich, T., Willingham, D.
Technical Report No. 32-937 (Unclassified)
(Reprinted from *Astronautics and Aeronautics, Vol. 4,
No. 3*, March 1966, pp. 74–82)

For abstract, see Entry S20.

Wood, C. S.

**W31 THE RATES OF SOME DEGENERATE
REARRANGEMENTS AS DETERMINED BY NUCLEAR
MAGNETIC RESONANCE SPECTROSCOPY**
Mallory, F. B., Manatt, S. L., Wood, C. S.
Technical Report No. 32-857 (Unclassified)
(Reprinted from the *Journal of the American Chemical
Society, Vol. 87, No. 23*, December 1965, pp. 5433–5438)

For abstract, see Entry M04.

Wu, C.-S.

**W32 TEMPERATURE RELAXATION IN A FULLY
IONIZED PLASMA**
Wu, C.-S., Klevans, E. H., Primack, J. R.
Technical Report No. 32-759 (Unclassified)
(Reprinted from *The Physics of Fluids, Vol. 8, No. 6*,
June 1965, pp. 1126–1133)

The times for relaxation of anisotropic ion or electron tem-
peratures to isotropy, and for relaxation of different ion and
electron temperatures to equilibrium, are calculated using the
plasma kinetic equation including dynamic shielding. It is
shown that, in contradiction to the results (or assumptions) of
previous analyses, electron-ion interactions can be more impor-
tant than interactions between particles of the same species in
the relaxation of an anisotropic distribution. The meaning of
relaxation time is discussed and a new time for relaxation is
introduced for the problem of the relaxation of electron and
ion temperatures that are initially greatly different. Detailed
numerical computations are presented for various cases of
special interest.

**W33 HIGH-FREQUENCY CONDUCTIVITY OF A PLASMA
IN QUASI-EQUILIBRIUM. II. EFFECT OF A
UNIFORM MAGNETIC FIELD**
Wu, C.-S.
Technical Report No. 32-821 (Unclassified)
(Reprinted from *The Physical Review, Vol. 140, No. 1A*,
October 1965, pp. A118–A129)

A general expression for high-frequency conductivity is de-
rived to include the effect of an external magnetic field. The
limit of large ion mass is also discussed. For the special case
that the unperturbed plasma is in thermodynamic equilibrium,
the result obtained in the present paper reduces immediately
to that previously discussed by Oberman and Shure.

Zmuidzinas, J. S.

Z01 PARTICLE SYMMETRIES
Zmuidzinas, J. S.
Technical Report No. 32-797, November 1, 1965
(Unclassified)

A theory of particle symmetries is proposed based on gen-
eral principles of quantum mechanics and special relativity.
Starting with a modest generalization of the Poincaré group
and using techniques of group theory and operator algebras,

it is shown how to construct composite-particle state vectors labeled by external (i.e., pertaining to space-time properties) and internal quantum numbers of physical significance. Macroscopic space time behaves in exactly the same manner under both the Poincaré group and its generalization, the augmented Poincaré group. It is found that there exists a hierarchy of groups, Sp (1) $\subset$ Sp (2) $\subset$ Sp (3) $\subset$ $\cdots$, which characterizes internal symmetries of the composite particles. These groups are all noncompact. However, it is argued that *physical* particle states are characterized by the compact subhierarchy of unitary groups U (1) $\subset$ U (2) $\subset$ U (3) $\subset$ $\cdots$. Thus, it is shown that the essential features of fundamental-particle symmetries can be derived in a general way from basic properties of space-time. These results are believed to form a theoretical framework for attacking dynamical problems such as the correlation of masses and spins with internal quantum numbers furnished by the hierarchy of unitary groups.

Space Programs Summary

The *Space Programs Summary* is a six-volume, bimonthly summary report that documents the current project activities and supporting research and advanced development efforts conducted, or managed, by the Jet Propulsion Laboratory for the National Aeronautics and Space Administration space exploration programs. This publication provides the National Aeronautics and Space Administration, other elements of the government, major aerospace contractors, and colleges and universities with technical information concerning the various Jet Propulsion Laboratory programs and projects. An equally important purpose of the *Space Programs Summary* is to provide technical information to Jet Propulsion Laboratory employees and to act as a storage source of information for later use in Laboratory *Technical Reports.*

AB01 THE LUNAR PROGRAM
Space Programs Summary, Volume I (Confidential)
No. 37-34, (May 1 to June 30, 1965), July 1965
No. 37-35, (July 1 to August 30, 1965), September 30, 1965
No. 37-36, (September 1 to October 30, 1965),
November 30, 1965
No. 37-37, (November 1 to December 31, 1965),
January 31, 1966
No. 37-38, (January 1 to February 28, 1966),
March 31, 1966
No. 37-39, (March 1 to April 30, 1966), May 31, 1966

Volume I is a bimonthly summary report of the current flight-project activities that have application to the JPL/NASA Lunar Program; the projects covered are *Ranger* and *Surveyor.* The general areas included are conception, design, research, development, developmental testing, fabrication and assembly, system testing, preflight and flight operations, and engineering and scientific analyses.

AB02 THE PLANETARY-INTERPLANETARY PROGRAM
Space Programs Summary, Volume II (Confidential)
No. 37-34, (May 1 to June 30, 1965), July 31, 1965
No. 37-35, (July 1 to August 30, 1965), September 30, 1965
No. 37-36, (September 1 to October 30, 1965),
November 30, 1965
No. 37-37, (November 1 to December 31, 1965),
January 31, 1965
No. 37-38, (January 1 to February 28, 1966),
March 31, 1966
No. 37-39, (March 1 to April 30, 1966), May 31, 1966

Volume II is a bimonthly summary report of the current flight-project activities that have application to the JPL/NASA Planetary-Interplanetary Program; the projects covered are *Mariner* and *Voyager.* The general areas included are conception, design, research, development, developmental testing, fabrication and assembly, system testing, preflight and flight operations, and engineering and scientific analyses. Study efforts related to future projects are also reported.

AB03 THE DEEP SPACE NETWORK
Space Programs Summary, Volume III (Unclassified)
No. 37-34, (May 1 to June 30, 1965), July 31, 1965
No. 37-35, (July 1 to August 30, 1965), September 30, 1965
No. 37-36, (September 1 to October 30, 1965),
November 30, 1965
No. 37-37, (November 1 to December 30, 1965),
January 31, 1966
No. 37-38, (January 1 to February 28, 1966),
March 31, 1966

Volume III is a bimonthly summary report of the current facility-project activities that have application to the JPL/NASA Deep Space Network (DSN); the facilities covered are the Deep Space Instrumentation Facility, Space Flight Operations Facility, and the DSN Ground Communication System. The general subjects and areas included are (1) *facility* design, fabrication and assembly, and system testing, (2) *communication components and systems* conception, design, research, development, developmental testing, and engineering analysis, and (3) *tracking* conception, design, system testing, preflight and flight operations, and engineering analysis.

AB04 SUPPORTING RESEARCH AND ADVANCED DEVELOPMENT
Space Programs Summary, Volume IV (Unclassified)
No. 37-33, (April 1 to May 31, 1965), June 30, 1965
No. 37-34, (June 1 to July 31, 1965), August 31, 1965
No. 37-35, (August 1 to September 30, 1965),
October 31, 1965
No. 37-36, (October 1 to November 30, 1965),
December 31, 1965
No. 37-37, (December 1, 1965 to January 30, 1966),
February 28, 1966
No. 37-38, (February 1 to March 31, 1966), April 30, 1966

Volume IV is a bimonthly summary report of the current *unclassified* supporting research and advanced development

activities that have application to the JPL/NASA space exploration programs. The general subject areas include aerodynamics, celestial mechanics, chemistry, computers, electrical power supply, electronics, environmental simulators, exobiology, fluid flow, guidance and control, instrumentation, space sciences, materials, mathematics, microbiology, physics, polymers, propellants, propulsion systems, quality assurance and reliability, structural mechanics, telecommunications, test facilities, and thermodynamics and combustion.

AB05 SUPPORTING RESEARCH AND ADVANCED DEVELOPMENT

Space Programs Summary, Volume V (Confidential)
No. 37-34, (June 1 to July 31, 1965), August 31, 1965
No. 37-35, (August 1 to September 30, 1965), October 31, 1965
No. 37-36, (October 1 to November 30, 1965), December 31, 1965
No. 37-38, (February 1 to March 31, 1966), April 30, 1966

Volume V is a bimonthly summary report of the current *classified* supporting research and advanced development activities that have application to the JPL/NASA space exploration programs.

AB06 SPACE EXPLORATION PROGRAMS AND SPACE SCIENCES

Space Programs Summary, Volume VI (Unclassified)
No. 37-34, (May 1 to June 30, 1965), July 31, 1965
No. 37-35, (July 1 to August 30, 1965), September 31, 1965
No. 37-36, (September 1 to October 31, 1965), November 30, 1965
No. 37-37, (November 1 to December 31, 1965), January 31, 1966
No. 37-38, (January 1 to February 28, 1966), March 31, 1966
No. 37-39, (March 1 to April 30, 1966), May 31, 1966

Volume VI is a bimonthly publication consisting of: (1) an unclassified digest of appropriate material from Volumes I, II, and III; (2) a reprint of the space science instrumentation studies of Volumes I and II; and (3) beginning with *Space Programs Summary* No. 37-31, an original presentation of technical supporting activities, including engineering development of environmental-test facilities, and quality assurance and reliability. The purpose of this Volume is to present a brief, generalized report of activities especially suitable for distribution to the scientific community. Additional space science studies are reported in Volume IV.

Astronautics Information Literature Search

The Jet Propulsion Laboratory Library conducts extensive literature searching programs covering subjects selected by the technical staffs of the Laboratory to meet their particular research requirements. Those searches considered to be of interest to persons working in the field of astronautics are published for distribution to their respective organization.

AC01 INTERACTIONS OF SPACECRAFT AND OTHER MOVING BODIES WITH NATURAL PLASMAS
Sterkin, C. K., Compiler
Literature Search No. 541, December 1965
(Unclassified)

Recent space exploration has provided data on the interactions of a moving spacecraft (satellite, rocket or missile) with the surrounding ionized medium—ionosphere, magnetosphere, or interplanetary plasma. The practical aspects of the complex and interrelated electrical and magnetic phenomena are of pri-

mary interest. These include electrical hazards to spacecraft; effects on spacecraft communications, tracking and detection; effects on measurement of environmental plasma parameters.

This search has been prepared at the request of personnel at the Jet Propulsion Laboratory. Although most of the references presented (approximately two-thirds) concern spacecraft phenomena and related ionospheric instrumentation and data, the search also includes literature on interactions of other types of moving man-made bodies and on similar natural phenomena.

JPL Reporting in the Open Literature

This section lists engineering and scientific articles by JPL technical personnel which have been published in the open literature — either domestic or foreign. Articles from the open literature which have been reprinted and published as JPL Technical Reports are included in the preceding section, "Technical Reports and Memorandums."

Aller, L. H.

AD01 PHOTOELECTRIC SPECTROPHOTOMETRY OF SELECTED SOUTHERN STARS

Aller, L. H., Faulkner, D. J., Norton, R. H.
Astrophysical Journal, Vol. 140, November 15, 1964
pp. 1609–1612

As part of an extensive spectrophotometric program on stars, gaseous nebulae, and clusters carried out at Mount Stromlo Observatory, Canberra, Australia, the energy distributions of a number of southern stars have been measured. A photoelectric spectrum scanner was used. Observations of a southern star over a wide range of zenith distances permitted a determination of the atmospheric extinction. Northern or equatorial-zone stars with previously determined energy distributions served as standards for the energy distributions of these southern stars. On a given night, several program stars and northern standard stars could be observed, making possible not only intercomparisons between program and standard stars, but also between the standard stars themselves.

Back, L. H.

AD02 COMPARISON OF MEASURED AND PREDICTED FLOWS THROUGH CONICAL SUPERSONIC NOZZLES, WITH EMPHASIS ON THE TRANSONIC REGION

Back, L. H., Massier, P. F., Gier, H. L.
AIAA Journal, Vol. 3, No. 9, September 1965,
pp. 1606–1614

To understand better equilibrium flows through supersonic nozzles, wall static pressures have been measured in nozzles with circular-arc throats having different ratios of throat radius of curvature to throat radius r_c/r_{th}, circular-arc or conical convergent sections, and conical divergent sections. These measurements were made with air at stagnation temperatures of 530 and 1500°R and over a stagnation pressure range from 45 to 250 psia. The flow through the transonic region was found to depend essentially on local configuration, i.e., on the ratio r_c/r_{th}; two-dimensional isentropic flow predictions agreed with the data in this region for the nozzles with $r_c/r_{th} = 2.0$, but were inadequate for the nozzle with $r_c/r_{th} = 0.625$. By comparison, the simple one-dimensional isentropic flow prediction was as much as 45% high in the throat region for one

nozzle; in the conical sections, deviations of a smaller magnitude were found. The effects of wall cooling and variation in the boundary-layer thickness at the nozzle inlet were investigated, as were differences in pressure readings with taps of various sizes. Some separation pressure data are presented to show the effect of wall cooling. Other flow features that indicate the extent of deviations from one-dimensional flow include flow coefficients, thrust ratios, and local mass fluxes. It is hoped that these comparisons between measurements and predictions will be useful in studying nozzle flows with the additional complexity of chemical reactions.

Baumert, L. D.

AD03 HADAMARD MATRICES OF THE WILLIAMSON TYPE

Baumert, L. D., Hall, M., Jr.
Mathematics of Computation, Vol. 19, No. 91, July 1965,
pp. 442–447

Tabulation of all the known Hadamard matrices of the Williamson type for $n = 4t$ (t odd). Since a Hadamard matrix of an order $2n = 2(4t)$ can be easily constructed from one of order n, the question of existence for all possible orders can be reduced to the case where t is odd. Thus it is noted that Hadamard matrices having the additional structure imposed by Williamson exist for all odd values of $5 \le 27$ and, in particular, that this includes every value of t for which an exhaustive search has been performed.

AD04 BACKTRACK PROGRAMMING

Golomb, S. W., Baumert, L. D.
*Journal of the Association for Computing Machinery,
Vol. 12, No. 4*, October 1965, pp. 516–524

For abstract, see Entry AD16.

AD05 HADAMARD MATRICES OF ORDERS 116 AND 232

Baumert, L. D.
*Bulletin of the American Mathematical Society, Vol. 72,
No. 2*, March 1966, p. 237

A *Hadamard matrix H* is a square matrix of *ones* and *minus ones* whose row (and hence column) vectors are orthogonal.

The order n of a Hadamard matrix is necessarily 1, 2, or $4t$, for some positive integer t. It has been conjecture that this condition ($n = 1$, 2 or $4t$) also insures the existence of a Hadamard matrix. Constructions have been given for particular values of n and even for various infinite classes of values. In that note a Hadamard matrix of order 116, the smallest unsolved case is constructed. Taking the tensor product of this matrix with the Hadamard matrix of order 2 yields a Hadamard matrix of order 232, also previously unsolved. This leaves $n = 188$ as the only unknown case less than 200.

Beaudet, R. A.

AD06 MICROWAVE SPECTRUM, ISOMERIC FORM,
       DIPOLE MOMENT OF 1,1-DIFLUOROBUTADIENE
       Beaudet, R. A.
       The Journal of Chemical Physics, Vol. 42, No. 11,
       June 1, 1965, pp. 3758–3760

The microwave spectrum of 1,1-difluorobutadiene has been studied. The small inertial defect indicates that the molecule is planar. From the allowed transition selection rules and the magnitudes of the moments of inertia, the molecule is shown to exist predominantly as the *trans* isomer. Attempts to find the spectrum of the *cis* were unsuccessful.

Chen, C. J.

AD07 COMMENTS ON "VISIBLE CONTINUUM EMISSION
       FROM SHOCKED NOBLE GASES"
       Chen, C. J.
       The Physics of Fluids, Vol. 8, No. 8, August 1965,
       pp. 1573–1574

The expression for the intensity of electron-ion recombination continuum radiation from a plasma by calculating the coefficient of absorption of a photon interacting with atoms and using the radiational equilibrium argument to get the intensity of radiation has been derived by Kramers and Unsöld. In such an approach the number density of the atoms n_a will appear in the expression for the radiation and the electron density n_c is introduced by eliminating n_a through the use of the Saha equation. The conditions required for the Saha equation to be valid, stated in Griem's paper, are that the plasma be in complete local thermodynamic equilibrium. These conditions usually cannot be expected in most laboratory plasmas. However, the electron–ion recombination continuum intensity theory can be formulated by using the free–bound transition probability of an electron, integrating over all possible electron velocities and summing over only the energy states contributing to the continuum radiation at a given frequency. The assumption made in such a calculation is that the energy of the free electrons have Maxwellian distribution, and the ions are in the ground states. The problem is then reduced to that of a hydrogen-like plasma.

Dayman, B., Jr.

AD08 HYPERSONIC VISCOUS EFFECTS
       ON FREE-FLIGHT SLENDER CONES
       Dayman, B., Jr.
       AIAA Journal, Vol. 3, No. 8, August 1965, pp. 1392–1400

An experimental study was performed in order to determine the effects of various parameters upon cone aerodynamics in the hypersonic regime at Reynolds numbers as low as 7800/in. The use of free-flight models eliminated the need for evaluating sting interference and made practical accurate measurement of drag forces down to 8×10^{-4} lb and pitching moments as low as 2×10^{-4} in.-lb. The effects of model to total temperature ratios of 0.45 (gun launch) and 0.87 (wire release) for 6 through 15° half-angle cones on total drag and static stability were investigated at Mach numbers from 6 to 10 for values of the viscous Knudsen number up to $M_\infty/(R_{D\infty})^{1/2} = 0.28$. Limited nose-blunting effects were also investigated. Conical shock viscous drag theory agrees quite favorably with the experimental data. Use is made of trends predicted by theory in order to compare the data of this paper with available hypersonic viscous cone drag data.

Elliott, D. G.

AD09 DIRECT CURRENT LIQUID-METAL
       MAGNETOHYDRODYNAMIC POWER
       GENERATION
       Elliott, D. G.
       AIAA Journal, Vol. 4, No. 4, April 1966, pp. 627–634

A constant-pressure dc magnetohydrodynamic generator was tested with NaK at inlet velocities up to 300 ft/sec. The maximum output power was 10.8 kw (18,250 amp at 0.59 v), and the efficiency was 48%. The theoretical efficiency, considering ohmic heating, fluid friction, boundary-layer shunting, and end effects, was 58%. The theoretical ultimate efficiency of liquid-metal MHD generators, of the type considered, ranges from 60 to 70%.

Faulkner, D. J.

AD10 PHOTOELECTRIC SPECTROPHOTOMETRY OF
       SELECTED SOUTHERN STARS
       Aller, L. H., Faulkner, D. J., Norton, R. H.
       Astrophysical Journal, Vol. 140, November 15, 1964,
       pp. 1609–1612

For abstract, see Entry AD01.

Forney, R. G.

AD11 *RANGER VII, A NEW SPACE INSTRUMENT*
       Forney, R. G., Kindt, D. H., Kirhofer, W. E.,
       Schurmeier, H. M., Wolfe, A. E.
       Astronautica Acta, Vol. 11, No. 1, Springer-Verlag,
       New York, 1965, pp. 13–35

This paper describes some of the characteristics of the basic *Ranger* system and what considerations were involved in deter-

mining these specific characteristics. The design and perform-
ance of several of the key subsystems are covered in some
detail. In addition to explaining how the spacecraft is used,
the flight of *Ranger VII* is described along with the results
that were obtained.

Fowle, A. A.

**AD12 THERMAL SCALE MODELING OF SPACECRAFT:
AN EXPERIMENTAL INVESTIGATION**
Fowle, A. A., Gabron, F., Vickers, J. M. F.
Journal of Spacecraft and Rockets, Vol. 3, No. 4,
April 1966, pp. 577–581

A one-half and a one-fifth scale model of the prototype were
built and tested within a "cold-wall" vacuum chamber to
examine the applicability of a set of thermal modeling laws
which specifies different materials of construction to achieve
identical temperatures at homologous locations in model and
prototype. Another one-half scale model was built and tested
to examine the application of another set of thermal modeling
laws which allows the use of identical materials but predicts
different temperature fields in model and prototype. The ex-
perimental results proved that either a half-scale thermal
model could be used to predict the temperatures of the proto-
type configuration with an accuracy of approximately 1%
(3°C) of the absolute temperature level of the prototype, or
temperatures of the one-fifth scale thermal model could be
predicted to within 3% (10°C), which represents a 14% error
in T^4 for radiant energy exchange.

Gabron, F.

**AD13 THERMAL SCALE MODELING OF SPACECRAFT:
AN EXPERIMENTAL INVESTIGATION**
Fowle, A. A., Gabron, F., Vickers, J. M. F.
Journal of Spacecraft and Rockets, Vol. 3, No. 4,
April 1966, pp. 577–581

For abstract, see Entry AD12.

Gier, H. L.

**AD14 COMPARISON OF MEASURED AND PREDICTED
FLOWS THROUGH CONICAL SUPERSONIC
NOZZLES, WITH EMPHASIS ON THE
TRANSONIC REGION**
Back, L. H., Massier, P. F., Gier, H. L.
AIAA Journal, Vol. 3, No. 9, September 1965,
pp. 1606–1614

For abstract, see Entry AD02.

Goldstein, R. M.

AD15 MARS: RADAR OBSERVATIONS
Goldstein, R. M.
Science, Vol. 150, No. 3704, December 24, 1965,
pp. 1715–1717

Radar studies of Mars indicate that certain areas are quite
smooth. Rough, strongly reflecting regions have also been
found, as well as poorly reflecting ones. Mars as a whole is
significantly smoother to radiation of 12.5-centimeter wave-
length than Venus.

Golomb, S. W.

AD16 BACKTRACK PROGRAMMING
Golomb, S. W., Baumert, L. D.
Journal of the Association for Computing Machinery,
Vol. 12, No. 4, October 1965, pp. 516–524

A widely used method of efficient search is examined in
detail. This examination provides the opportunity to formulate
its scope and methods in their full generality. In addition to a
general exposition of the basic process, some important refine-
ments are indicated. Examples are given which illustrate the
salient features of this searching process.

Gray, L. D.

**AD17 CALCULATIONS OF ATMOSPHERIC RADIATION
FROM 4.2μ TO 5μ**
Gray, L. D., McClatchey, R. A.
Applied Optics, Vol. 4, No. 12, December 1965,
pp. 1624–1631

In the 4.2-μ to 5-μ region of the spectrum, the absorption
in the Earth's atmosphere is primarily due to the 4.3-μ bands
of CO_2, the 4.6-μ bands of N_2O, and the 4.7-μ bands of CO.
These minor constituents appear to be uniformly distributed
in the atmosphere. As a result, the absorption in a small
frequency interval can be written as a function of amospheric
pressure and temperature. The spectral absorption is calcu-
lated for homogeneous absorber path lengths representative
of various heights in the telluric atmosphere. Application of
the Curtis-Godson approximation allows the calculations to be
extended to real, nonhomogeneous atmospheric paths. The
spectral energy distribution of the radiation passing through
various isobaric levels of the Earth's atmosphere is presented
for several model atmospheres. The quasi-statistical band
model is used to compute the spectral absorption in the region
2000 cm^{-1} to 2400 cm^{-1} at intervals of 5 cm^{-1}. A normal
abundance of isotopic molecules is assumed and a total of
ninety-nine vibrational transitions are considered. Spectral
absorption computed for the individual molecules is shown
to be in good agreement with laboratory data.

Hall, M., Jr.

**AD18 HADAMARD MATRICES OF THE WILLIAMSON
TYPE**
Baumert, L. D., Hall, M., Jr.
Mathematics of Computation, Vol. 19, No. 91, July 1965,
pp. 442–447

For abstract, see Entry AD03.

Harding, J. T.

AD19 DENSITY OF NIOBIUM
Harding, J. T.
Journal of Applied Physics, Vol. 37, No. 2,
February 1966, p. 928

Values of the density of niobium as reported in the literature and in standard reference texts differ by 2% or more. These discrepancies are due to purity variations and porosity in all niobium available until recently; high-temperature, high-vacuum outgassing of niobium is presently capable of producing niobium with consistent mechanical properties. Data are given here for the density of six niobium spheres which are intended for use as rotors in a superconducting gyroscope.

Kindt, D. H.

AD20 *RANGER VII*, A NEW SPACE INSTRUMENT
Forney, R. G., Kindt, D. H., Kirhofer, W. E.,
Schurmeier, H. M., Wolfe, A. E.
Astronautica Acta, Vol. 11, No. 1, Springer-Verlag,
New York, 1965, pp. 13–35

For abstract, see Entry AD11.

Kirhofer, W. E.

AD21 *RANGER VII*, A NEW SPACE INSTRUMENT
Forney, R. G., Kindt, D. H., Kirhofer, W. E.,
Schurmeier, H. M., Wolfe, A. E.
Astronautica Acta, Vol. 11, No. 1, Springer-Verlag,
New York, 1965, pp. 13–35

For abstract, see Entry AD11.

Kotlensky, W. V.

AD22 TENSILE PROPERTIES OF GLASSY CARBON TO 2,900 deg C
Kotlensky, W. V., Martens, H. E.
Nature, Vol. 206, No. 4990, June 19, 1965, pp. 1241–1247

Glassy carbon is a turbostrate form of carbon. Tensile properties of two grades of glassy carbon called GC 20 GC 30 have been measured from room temperature to 2,900°C. Specimens were heated in an inert atmosphere to test temperature by means of an external graphite heater; the ultimate tensile strengths are not markedly different.

Fracture elongations at 2,500°C and above is markedly greater for GC 20 than for GC 30. The difference is due to cyclic heat treatment. Tensile properties of carbons and graphites are closely associated with structures and processing. Heat treatment on GC 20 showed a growth in crystallite diameter; changes in crystallite diameter were qualitatively confirmed by magnetic susceptibility measurements. These results suggest that non-graphitizing behavior and strong cross-link bonding give glassy carbon its good strength properties.

Lardner, T. J.

AD23 STRESSES IN A THICK PLATE WITH AXIALLY SYMMETRIC LOADING
Lardner, T. J.
The Journal of Applied Mechanics, Transactions of ASME,
Series E, Vol. 32, No. 2, June 1965, pp. 458–459

The problem of the thick elastic plate with a symmetric circular pressure loading is considered. The normal stress distribution on the midplane and for two positions off the midplane is obtained by a numerical integration of the solutions. A comparison of the stress distribution on the midplane is made with previous results.

Lindsey, W. C.

AD24 CODING FOR SPECULAR AND SCATTER CHANNELS
Lindsey, W. C.
IEEE Transactions On Communication Technology,
Vol. COM-13, No. 2, June 1965, pp. 237–238

Briefly, systems are considered which transmit one of $N = 2^n$ orthogonal equiprobable, equi-energy, narrow-band waveforms of duration $T = nT_b$ seconds into a single-link channel perturbed by slowly varying Rician fading and statistically independent white Gaussian noise of single-sided spectral density $N_0 W/(c/s)$. On reception, one of two (coherent or noncoherent) receivers is used to process the observed data.

Results are presented which were derived in Lindsey for $n = 1$, i.e., binary transmission and coherent reception. For a given γ^2, the limiting cases $n = 1$ and $n = \infty$ show the possible reduction in transmitter power which could ultimately be achieved by coding. Comparison of the two sets of curves indicates that coding is more effective in channels whose specular components are large when compared to the mean-squared value of the scatter component. For channels which are largely scatter in nature, i.e., $0 < \gamma^2 < 2$, improvement achieved by coding is relatively small. Given a value for the total average received SNR, $(1 + \gamma^2)\beta$ per bit of transmitted information and a value for γ^2, one may determine the ultimate gain in signal power relative to the noise (or equivalently the reduction in error probability) resulting from coding.

Similar results could be given for $N = 2$ and the noncoherent detector; however, it may be shown that, even though the coherent detector performance is bounded from above by that for noncoherent detection, the same general conclusions may be reached.

AD25 ERROR PROBABILITY FOR INCOHERENT DIVERSITY RECEPTION
Lindsey, W. C.
IEEE Transactions on Information Theory, Vol. IT-11,
No. 4, October 1965, pp. 491–499

The problem of computing error probabilities for multichannel communications using an incoherently terminated receiver is analyzed. The signaling alphabet is composed of two equal energy, equiprobable, correlated waveforms and the multichannel model is presumed to be of the slowly fading "Rician" type, i.e., each subchannel is presumed to be composed of a fixed or specular component and a scatter-like or Rayleigh fading component. The main result of this paper is a generalization of an earlier result derived by Helstrom. Novel by-products of this generalization include, as special cases, results derived by Turin, Pierce, Price, and Lindsey. Also closed-form solutions to very general integrals involving Bessel function products are presented as part of the main result. These integrals are known to arise in the analysis of multichannel adaptive communication systems.

Numerical computations for the error probabilities are given for special values of the signal cross-correlation coefficient λ and multichannel order. These results graphically illustrate that the optimum set of equal-energy binary signals which minimize the error rate for the Rayleigh fading multichannel are orthogonal. Specifically, to maintain the same error probability in two systems, one employing nonorthogonal signals having correlation coefficient λ, the other employing orthogonal signals, the transmitter power must be increased in the former. In fact, for large SNR's, the graphical data indicate that the required increase in transmitter power is approximately $10 \log_{10} (1 - \lambda^2)^{-1}$ dB.

Loomis, A. A.

AD26 INTERPRETATION OF LUNAR
ALPHA-SCATTERING DATA
Loomis, A. A.
Journal of Geophysical Research, Vol. 70, No. 16,
August 15, 1965, pp. 3841–3849

Many ambiguities are inherent in the interpretation of chemical analyses if such analyses are used alone to interpret a rock genetically. Furthermore, rocks at the surface of the Moon may differ from rocks below the surface because of contamination by meteoritic infall, bombardment by charged particles, and extensive mixing by impact. Nevertheless, the broad categories of igneous rocks and meteorites which are familiar on the Earth are the best compositional models for rocks on the Moon. Anhydrous igneous rocks and meteorites may be categorized on the basis of the atomic percentage of oxygen: (1) below 50%, sputtered rocks and those with free metal in excess of that in chondrites; (2) 50 to 56%, chondritic meteorites; (3) 57 to 58½%, dunites and olivine-rich peridolites; (4) 58½ to 60%, peridolites and pyroxenites; (5) 60 to 61%, basalts, some alkalic derivatives; (6) 61 to 64%, siliceous derivatives, some alkalic rocks. The Si/Na ratio is another reliable chemical parameter on which to base further subdivisions of genetic importance; terrestrial anhydrous igneous rocks and meteorites occupy well-defined fields in a plot of oxygen percentage versus Si/Na. The best parameter for resolving ambiguities in such a plot is the Mg/Si ratio. The concurrence of high Mg/Si and Mg/Na ratios with oxygen contents of over 59 to 60% will indicate water in the sample. The amount of water can be estimated by balancing the cations and anions in the actual analysis.

Martens, H. E.

AD27 TENSILE PROPERTIES OF GLASSY CARBON
TO 2,900 deg C
Kotlensky, W. V., Martens, H. E.
Nature, Vol. 206, No. 4990, June 19, 1965, pp. 1241–1247

For abstract, see Entry AD22.

Massier, P. F.

AD28 COMPARISON OF MEASURED AND PREDICTED
FLOWS THROUGH CONICAL SUPERSONIC
NOZZLES, WITH EMPHASIS ON THE
TRANSONIC REGION
Back, L. H., Massier, P. F., Gier, H. L.
AIAA Journal, Vol. 3, No. 9, September 1965,
pp. 1606–1614

For abstract, see Entry AD02.

McClatchey, R. A.

AD29 CALCULATIONS OF ATMOSPHERIC RADIATION
FROM 4.2μ TO 5μ
Gray, L. D., McClatchey, R. A.
Applied Optics, Vol. 4, No. 12, December 1965,
pp. 1624–1631

For abstract, see Entry AD17.

Melbourne, W. G.

AD30 CONSTANT-ATTITUDE THRUST PROGRAM
OPTIMIZATION
Melbourne, W. G., Sauer, C. G., Jr.
AIAA Journal, Vol. 3, No. 8, August 1965, pp. 1428–1431

The analysis for the optimization of a space vehicle thrust program with prespecified directions of thrust is presented. The criteria for optimizing the values of the prespecified thrust directions are also developed. A numerical comparison in vehicle performance is made between a constant-attitude thrust program and the optimum variable direction program by means of a series of Earth-Mars rendezvous and flyby trajectories, using a power-limited propulsion system. The sensitivity of vehicle performance to departures in thrust direction from the optimum prespecified direction is discussed. It is shown that a constant-attitude thrust program with two or more optimized thrust directions is competitive in vehicle performance with the variable direction program for typical interplanetary missions.

Münch, G.

AD31 VISIBLE AND NEAR-INFRARED SPECTROPHOTOMETRY OF SATURN'S RINGS
Younkin, R. I., Münch, G.
The Astronomical Journal, Vol. 71, No. 3, April 1966,
No. 1338, p. 188

For abstract, see Entry AD60.

Nash, D. B.

AD32 PROTON-EXCITED LUMINESCENCE OF SILICATES: EXPERIMENTAL RESULTS AND LUNAR IMPLICATIONS
Nash, D. B.
Journal of Geophysical Research, Vol. 71, No. 10,
May 15, 1966, pp. 2517–2534

Spectral energy distributions and excitation efficiencies as functions of mineral composition, irradiation time, proton energy, proton flux, sample geometry, and sample temperature have been determined from laboratory measurements of silicate luminescence by low-energy proton excitation. The maximum of the luminescence spectrum of many silicates under continuous excitation by 5-kev protons is in the red when the mineral is first excited; the luminescence intensity decreases, and the maximum shifts from red to blue with time. This phenomenon is here described as a red flash. After the initial red flash, a second flash, subsequent intensity decay, and blue shift can be produced by a sudden increase of incident ion energy. In both cases the red flash has a principal decay period of about 15 to 20 min. The intensity of both the flash and aged luminescence response is directly proportional to incident ion energy and flux. Small particle size for powders, high roughness for solid surfaces, and low mineral temperature favor high luminescence intensity. These data qualitatively agree with the concept of solar-ion excitation as the origin of reported transient lunar reddening near Aristarchus and Kepler. However, these measurements show that the energy efficiency for proton excitation of silicate luminescence is between 10^{-4} and 10^{-6}; this range is several orders of magnitude lower than values previously reported. In view of the known solar-ion flux, the low efficiencies indicate that luminescence on the sunlit lunar surface resulting from solar-ion excitation is far below the sensitivity of earth-based detection apparatus and that other energy sources or other explanations for the origin of lunar color flashes must be sought.

Newburn, R. L., Jr.

AD33 FURTHER STUDIES OF THE INFRARED SPECTRA OF COOL STARS, THE WATER DEFICIENCY IN S STARS AND VARIATION OF WATER ABUNDANCE WITH MIRA'S PHASE
Spinrad, H., Pyper, D. M., Newburn, R. L., Jr.,
Younkin, R. L.
The Astrophysical Journal, Vol. 143, No. 2,
February 1966, pp. 291–298

For abstract, see Entry AD45.

Nishimura, T.

AD34 ON THE A PRIORI INFORMATION IN SEQUENTIAL ESTIMATION PROBLEMS
Nishimura, T.
Proceedings of the National Electronics Conference,
Vol. 21, 1965, pp. 511–515

The optimal filter introduced by Kalman into the field of system theory yields the minimum variance estimate of states of linear systems, which are contaminated by white gaussian noises, when a set of sequential observations is carried out. The original theory assumes an *a priori* information of the initial states and their variances. Soong examined the effect of the error in the *a priori* data on the *a posteriori* variance of estimates for the case of a single-stage observation and derived the deviations of the calculated and actual variances from the true minimum variance.

In this paper, the same problem is studied for the multi-stage case. Then this optimal filter is connected to the existing analog filter in tandem. By means of this tandem configuration of analog filter and digital filter, the detection of states as well as signals can be speeded up. A phase-locked loop receiver is used as an example of the analog filter. The practical importance of the extended results on the effect of errors in the *a priori* information is demonstrated in a specific example.

The effect of errors in the *a priori* information has been investigated for the sequential estimation problem, and the three theorems which specify the mutual relations among the three covariance matrices P_o, P_c and P_a have been derived. The phase-locked loop receiver is picked up as an example of analog filter, for which a suitable digital filter is designed. The technique developed in this paper is useful for the estimation problem of deterministic signals in the presence of stochastic noise. Although the signal (phase) input has been treated as a state in this analysis, it is possible to describe the input contribution in an explicit form.

Norton, R. H.

AD35 PHOTOELECTRIC SPECTROPHOTOMETRY OF SELECTED SOUTHERN STARS
Aller, L. H., Faulkner, D. J., Norton, R. H.
Astrophysical Journal, Vol. 140, November 15, 1964,
pp. 1609–1612

For abstract, see Entry AD01.

Patapoff, M.

AD36 VALIDITY AND LIMITATIONS OF THE GAS TITRATION OF ATOMIC NITROGEN WITH NITRIC OXIDE
Von Weyssenhoff, H., Patapoff, M.
The Journal of Physical Chemistry, Vol. 69, No. 5,
May 1965, pp. 1756–1758

For abstract, see Entry AD52.

Pfeiffer, C.

AD37 ON THE SEQUENTIAL ESTIMATION TECHNIQUE
Pfeiffer, C.
IEEE Transactions On Automatic Control, Vol. AC-11,
No. 1, January 1966, pp. 132–133

Recent work in linear filtering and prediction theory has been based upon the postulated existence of a linear dynamic model of the stochastic process being observed, with white-noise disturbances to the systems and white-noise measurement errors. With this model it is possible to explicitly construct the filter in terms of the given system parameters, and, hence, to solve some important practical problems with an elegant sequential estimation technique. The result is not the most general form of the linear, unbiased, minimum variance (LUMV) estimate, since all stochastic processes cannot be represented by such a model. Thus, in those applications where there is given only an empirical description of the statistics of the stochastic process to be observed, which would normally consist of numerical results obtained from an ensemble of system tests, two questions arise when it is sought to design an optimal linear filter:

1) Under what conditions does it make sense to employ a sequential estimation technique, similar to the Kalman-Bucy approach?

2) How does one construct the estimation equation from empirical test data?

It is the purpose of this correspondence to describe an analysis of the estimation problem which at least partially resolves these questions.

Pickering, W. H.

AD38 SOME NEW METHODS FOR PLANETARY EXPLORATION
Pickering, W. H.
Proceedings of the National Academy of Sciences,
Vol. 54, No. 6, December 1965, pp. 1471–1479

Exploration of the solar system has entered a new era. This paper is concerned primarily with two new tools for planetary research. The two examples discussed — planetary radar experiments from the Earth and spacecraft experiments at other planets—offer spectacular opportunities for investigating our neighboring planets.

Radar experiments show: (1) that solar system geometrical relationships are determined with extreme accuracy, and (2) that extensive new information on planetary surfaces is obtained to supplement that from observations with visible or infrared light.

Unmanned spacecraft traveling to the planets have demonstrated that complex experiments operate successfully at planetary distances. Information which can be obtained includes: (1) detailed trajectory analysis which makes possible more precise determinations of solar system parameters, such as the masses of the planets; (2) actual close-up observations

of the planets; and (3) data from instruments landed on the planet. Although this last has not been demonstrated, the results from *Mariner* give every indication this type of mission can succeed.

Pyper, D. M.

AD39 FURTHER STUDIES OF THE INFRARED SPECTRA OF COOL STARS, THE WATER DEFICIENCY IN S STARS AND VARIATION OF WATER ABUNDANCE WITH MIRA'S PHASE
Spinrad, H., Pyper, D. M., Newburn, R. L., Jr.,
Younkin, R. L.
The Astrophysical Journal, Vol. 143, No. 2,
February 1966, pp. 291–298

For abstract, see Entry AD45.

Sauer, C. G., Jr.

AD40 CONSTANT-ATTITUDE THRUST PROGRAM OPTIMIZATION
Melbourne, W. G., Sauer, C. G., Jr.
AIAA Journal, Vol. 3, No. 8, August 1965, pp. 1428–1431

For abstract, see Entry AD30.

Schurmeier, H. M.

AD41 *RANGER VII,* A NEW SPACE INSTRUMENT
Forney, R. G., Kindt, D. H., Kirhofer, W. E.,
Schurmeier, H. M., Wolfe, A. E.
Astronautica Acta, Vol. 11, No. 1, Springer-Verlag,
New York, 1965, pp. 13–35

For abstract, see Entry AD11.

Scull, J. R.

AD42 GUIDANCE AND CONTROL OF THE *MARINER* PLANETARY SPACECRAFT
Scull, J. R.
Ékspress-informatsiya, Astronavtika i raketodinamika,
No. 41, November 3, 1965, Moscow, pp. 325–331
(Paper presented at the Symposium of the International Federation of Automatic Control on the Peaceful Uses of Space. Stavanger, Norway, June 21–24, 1965)

The unmanned exploration of the Moon and nearby planets imposes very significant requirements on the guidance and control system of both the booster rocket and the spacecraft. The booster rocket must be launched into a narrow, moving corridor with great precision within a limited period of time. After separation, the spacecraft must be capable of providing corrections to the trajectory and controlling the orientation of solar panels, antennas, and scientific instruments.

The guidance and control systems of the *Mariner* planetary spacecraft are described. Some of the techniques developed to provide redundant operation during the long interplanetary flight are discussed. Flight performance of the *Mariner* guidance and control systems is reported.

Sehgal, R.

AD43 LOW-PRESSURE COMBUSTION OF SOLID PROPELLANTS
Sehgal, R., Strand, L.
AIAA Journal, Vol. 3, No. 8, August 1965, pp. 1524–1525

Experimental studies conducted with polyurethane-type composite propellants indicated that the extinction pressure, although independent of the burning geometry, was strongly dependent upon motor L and certain other parameters, such as the aluminum concentration in the propellant. For non-aluminized propellants, the slope of L vs extinction pressure (P_e) was $-2n$ as predicted theoretically; however, the slope became steeper with the addition and increased concentration of aluminum in the propellant.

Some of the conclusions, which can be drawn from the various phases of the experimental program conducted at JPL can be summarized briefly as follows: (1) for a given propellant, the L vs extinction pressure relationship is a valid parameter for determining the low-pressure stable combustion limit; (2) for nonaluminized propellant, the slope of L vs P_e is $-2n$, as predicted theoretically for critical pressure; (3) the slope of L vs P_e relationship is affected by the presence of Al, the concentration of Al, and the Al particle size in propellant; (4) the effect of coarser Al in propellant is to cause incomplete combustion at low pressures, and the burning and extinction characteristics tend to approach those of non-aluminized propellant; and (5) the variation in oxidizer particle size has a negligible effect on the L vs P_e relationship; the small differences in extinction pressure at a given L are attributed to the variation in packing density.

Sjogren, W. L.

AD44 RESULTS ON PHYSICAL CONSTANTS AND RELATED DATA FROM THE RADIO TRACKING OF *MARINER* (VENUS) AND *RANGER III–VI* MISSIONS
Sjogren, W. L., Trask, D. W.
Journal of Spacecraft and Rockets, Vol. 2, No. 5, September–October 1965, pp. 689–697

The "real-time" flight-path analysis and performance are described for *Ranger VI* and *VII* missions. Over a large region of injection points for a *Ranger* mission, the midcourse maneuver can be based on an orbit with a 10–30 km uncertainty in the impact parameter B plane. The main problem in orbit determination is to obtain verification of data consistency between stations. As *Ranger VI* results show, small errors can perturb the orbit well beyond the 1-sigma target uncertainties. The *Ranger VII* photographs demonstrated that the impact point agreed to within 3 km. The predicted and observed impact times agreed to within 0.1 sec. The doppler measurements gave a real-time verification that the maneuver execution errors on *Ranger VI* and *VII* were well within design specifications. Determination of physical constants from earth-based radio tracking has resulted in improved knowl-

edge of the mass of the Moon of one order of magnitude and a factor of 4 for the Earth. Station locations can be determined to 10 m in the radial direction normal to the Earth's spin axis and in longitude differences to 20 m. The lunar radius at the impact points was determined to $\pm$ 0.3 km and in both cases was found to be approximately 3 km less than the previously accepted value.

Spinrad, H.

AD45 FURTHER STUDIES OF THE INFRARED SPECTRA OF COOL STARS, THE WATER DEFICIENCIES IN S STARS AND VARIATION OF WATER ABUNDANCE WITH MIRA'S PHASE
Spinrad, H., Pyper, D. M., Newburn, R. L., Jr., Younkin, R. L.
The Astrophysical Journal, Vol. 143, No. 2, February 1966, pp. 291–298

Low-dispersion near-infrared spectra of a variety of cool stars were obtained at the Kitt Peak National Observatory. The late-type S stars seem definitely deficient in water vapor compared to M giants of the same temperature. The spectral characteristics of the S stars in the infrared seem best explained by a slightly lower atmospheric O/C ratio than is found for normal M stars.

The variation of the strength of the λ 9400 water band in the spectrum of Mira during its light cycle seems to be in the direction expected from the known photospheric temperature changes. The water lines may have been stronger at the 1963 minimum than at corresponding 1964 phases.

AD46 INFRARED BANDS OF VANADIUM OXIDE IN THREE MIRA STARS
Spinrad, H., Younkin, R. L.
Publications of the Astronomical Society of the Pacific, Vol. 78, No. 460, February 1966, pp. 66–67

The purpose of this note is to illustrate the extremely large range in the strength of the λ 10,500 series of vanadium oxide bands in the near-infrared spectra of the coolest stars.

The infrared vanadium oxide bands were observed first in o Ceti and R Leonis by Kuiper, Wilson, and Cashman (1947) using a PbS detector. They have been observed photographically in these two stars and other Mira variables, generally near their light minima, by Miller (1953), McKellar (1955, 1956), and Frederick (1961). All these measurements were at low dispersion. The VO head wavelengths quoted by McKellar are $\lambda\lambda$ 10,459, 10,484, 10,510, 10,547, and 10,566; the bands degrade to the red.

Stearns, J. W., Jr.

AD47 TEST REQUIREMENTS OF ELECTRIC PROPULSION SYSTEMS LEADING TO EXTENDED FLIGHT TIME MISSIONS
Stearns, J. W., Jr.

Low-thrust characteristics of electric propulsion result from system power limitations. Optimized low-thrust flight trajectories require large thrust periods, culminating in less efficient trajectories than high-impulse trajectories. Because of this, the most useful electric propulsion missions are high-energy, high-specific-impulse missions, characterized by extended mission times, typically in the range of 5000 to 50,000 hr.

Like other forms of propulsion, the electric propulsion system includes a primary power source. The primary electrical powerplant has a strong influence on electric propulsion spacecraft applications because it represents the largest weight and structure in the spacecraft system. Utilizing electric propulsion for space exploration without a light-weight compact power source is not feasible. Results of trajectory analyses show that electric propulsion becomes potentially useful for planetary missions when the combined weight of primary power and propulsion system is less than 100 lb/kwe. Application of electric propulsion is limited, however, until total system weight is reduced to less than 50 lb/kwe.

Electric propulsion performance exceeds that of chemical propulsion when mission flight time approaches 10,000 hr. Thus, a 10,000-hr lifetime is a reasonable goal for initial development of electric propulsion and power. However, it is for missions requiring lifetimes greater than 20,000 hr and high electrical power levels that the fullest capabilities of electric propulsion spacecraft can be realized.

Absolute time scale of a development test program is dependent upon resources available and priorities assigned. Such a program must precede any mission launch date by at least five years. Presently, for instance, planetary missions for 1970 and 1971 are being defined, and final flight prototype design will be initiated within two years.

Strand, L.

AD48 LOW-PRESSURE COMBUSTION OF SOLID PROPELLANTS
Sehgal, R., Strand, L.
AIAA Journal, Vol. 3, No. 8, August 1965, pp. 1524–1525

For abstract, see Entry AD43.

Trask, D. W.

AD49 RESULTS ON PHYSICAL CONSTANTS AND RELATED DATA FROM THE RADIO TRACKING OF *MARINER* (VENUS) AND *RANGER III-VI* MISSIONS
Sjogren, W. L., Trask, D. W.

For abstract, see Entry AD44.

Vickers, J. M.F.

AD50 THERMAL SCALE MODELING
Vickers, J. M. F.
Astronautics and Aeronautics, Vol. 3, May 1965, pp. 34–39

This article is a description of the test methods using scale models to predict the thermal behavior of spacecraft. Discussed are the (1) effects of mission and spacecraft considerations on modeling requirements, (2) modeling techniques and associated problems, (3) applications of spacecraft thermal modeling and (4) the current status of the technique.

AD51 THERMAL SCALE MODELING OF SPACECRAFT: AN EXPERIMENTAL INVESTIGATION
Fowle, A. A., Gabron, F., Vickers, J. M. F.
Journal of Spacecraft and Rockets, Vol. 3, No. 4, April 1966, pp. 557–581

For abstract, see Entry AD12.

Von Weyssenhoff, H.

AD52 VALIDITY AND LIMITATIONS OF THE GAS TITRATION OF ATOMIC NITROGEN WITH NITRIC OXIDE
Von Weyssenhoff, H., Patapoff, M.
The Journal of Physical Chemistry, Vol. 69, No. 5, May 1965, pp. 1756–1758

One of the standard methods for measuring the concentration of nitrogen atoms in active nitrogen is gas titration with nitric oxide. Two other techniques in which the atomic nitrogen was titrated with ethylene or molecular oxygen were found to yield consistent results which were considerably lower than the values given by the nitric oxide titration.

The nitric oxide titration may not be valid unless there is a sufficiently long time interval between the discharge and titration zone to permit deactivation of excited species.

Weetall, H. H.

AD53 PRECIPITATION OF SALMON SPERM DEOXYRIBONUCLEIC ACID WITH PURINE-SPECIFIC ANTIBODY
Weetall, H. H., Weliky, N.
Nature, Vol. 207, No. 4999, August 21, 1965, pp. 858–860

Deoxyribonucleic acids (DNA) have been found to react with antisera prepared by immunizing animals to Gram-negative bacteria, DNA, nucleosides, nucleotides, purines and pyrimidines. This was first demonstrated by complement fixation and then by precipitin reaction.

It has been found that samples of salmon sperm and *Clostridium* DNA, thermally denatured in the absence of formaldehyde, precipitated with anti-purinoyl antibody and showed only slight hyperchromicity after re-heating past the thermal transition temperature and cooling slowly, thus re-

sembling formaldehyde denatured calf thymus and chick embryo DNA in their immunochemical reactions. Comparison of the reported base composition of salmon sperm DNA with those of calf thymus and chick embryo DNA disclosed little difference.

Weliky, N.

AD54 PRECIPITATION OF SALMON SPERM DEOXYRIBONUCLEIC ACID WITH PURINE-SPECIFIC ANTIBODY
Weetall, H. H., Weliky, N.
Nature, Vol. 207, No. 4999, August 21, 1965, pp. 858–860

For abstract, see Entry AD53.

Wolfe, A. E.

AD55 *RANGER VII, A NEW SPACE INSTRUMENT*
Forney, R. G., Kindt, D. H., Kirhofer, W. E., Schurmeier, H. M., Wolfe, A. E.
Astronautica Acta, Vol. 11, No. 1, Springer-Verlag, New York, 1965, pp. 13–35

For abstract, see Entry AD11.

Wrobel, J. R.

AD56 SOME EFFECTS OF GAS STRATIFICATION ON CHOKED NOZZLE FLOWS
Wrobel, J. R.
Journal of Spacecraft and Rockets, Vol. 2, No. 6, November–December 1965, pp. 918–922

The influence of the difference in properties of the constituents of a stratified multicomponent ideal gas on the flow through a nozzle is investigated analytically. The characteristic velocity c and the specific impulse l_s are computed and compared with values appropriate to the cases of thoroughly mixed gas constituents and equilibrium flow. These predictions are compared with the results of an approximate method using average properties, to illustrate the validity of the approximate method presented. The limited comparison indicates that the approximate method is virtually exact in predicting the c and l_s values appropriate to stratified flow, provided that the specific heat ratios of the constituent gases are nearly equal. The assumption of thoroughly mixed gases yields results that lie between the stratified-flow predictions and the equilibrium-flow predictions for the examples studied.

Younkin, R. L.

AD57 SPECTRAL ENERGY DISTRIBUTIONS AND REFLECTIVITIES OF MARTIAN MARIA AND CONTINENTS IN THE VISIBLE AND NEAR INFRARED
Younkin, R. L.
The Astronomical Journal, Vol. 70, No. 9, November 1965, Number 1334, pp. 666–698

(Abstracts of Papers presented at the 119th Meeting of the American Astronomical Society, held August 3–6, 1965 at the University of Michigan, Ann Arbor)

Photoelectric measurements were carried out on 17 and 18 February 1965 to determine the ratio of the specific intensity of the Martian maria to that of the continents at a series of wavelengths from 5000 to 11 125 Å. The measurements were made with the Mt. Wilson 60-in. reflector and the Mt. Wilson Ebert spectrometer.

Syrtis Major was selected as the representative mare, and Aeria as the continent. The ratio of their intensities, corrected for normal incidence, increased monotonically from 1.25 at 5000 Å to 2.1 near 8000 Å. Beyond this wavelength it was very nearly constant.

The measurements on Syrtis Major and Aeria were also reduced independently to determine their relative spectral energy distributions and reflectivities. In the visible spectral region, 5000 to 7000 Å, the energy distribution of both areas increased sharply to the red, although that of Syrtis Major less than Aeria. The reflectivity of each area is very nearly constant at longer wavelengths. As λ decreases the two merge together in accordance with the results of previous observers who have found a complete obliteration of surface details by the atmosphere below 4200 Å.

The laboratory limonite absorption band near 8000 Å is totally lacking from the reflection spectrum of Aeria with an uncertainty of no more than 2%. It may be concluded the continents of Mars are not covered with pure limonite.

AD58 FURTHER STUDIES OF THE INFRARED SPECTRA OF COOL STARS, THE WATER DEFICIENCY IN S STARS AND VARIATION OF WATER ABUNDANCE WITH MIRA'S PHASE
Spinrad, H., Pyper, D. M., Newburn, R. L., Jr., Younkin, R. L.
The Astrophysical Journal, Vol. 143, No. 2, February 1966, pp. 291–298

For abstract, see Entry AD45.

AD59 INFRARED BANDS OF VANADIUM OXIDE IN THREE MIRA STARS
Spinrad, H., Younkin, R. L.
Publications of the Astronomical Society of the Pacific, Vol. 78, No. 460, February 1966, pp. 66–67

For abstract, see Entry AD46.

AD60 VISIBLE AND NEAR-INFRARED SPECTROPHOTOMETRY OF SATURN'S RINGS
Younkin, R. L., Münch, G.
The Astronomical Journal, Vol. 71, No. 3, April 1966, No. 1338, p. 188

Measurements of the narrow-band spectral energy distribution of the rings of Saturn have been made at the Mount Wilson Observatory using the 60-in. reflector and the Fastie–

.Ebert spectrometer. Special scans from 0.51 to 1.1 μ were made of a segment of the rings at the western end of the semimajor axis.

The energy distribution was determined at 54 points in this wavelength region. The color sensitivity of the system was determined from scans of α Lyr and the α Lyr energy distribution of Oke. The relative reflectance of the rings was calculated by use of the solar intensity values of Labs and Neckel, converted to solar flux by the ratios of Minnaert.

The reflectance of the rings is very nearly constant from 0.78 to 1.05μ. Shortward of this region it falls slowly to 0.60 μ, then more rapidly to a value at 0.51 μ some $0^{\underline{m}}45$ below the maximum. There is a slight decrease in reflectance ($0^{\underline{m}}03 - 0^{\underline{m}}05$) from 1.05 to 1.08 μ. This is marginally outside of the experimental error. Owen has recently reported a drop in the reflectance of the rings from 1.04 to 1.09 μ, which he identified as due to water ice. This drop was determined on the basis of a drop in the ratio of the intensity of the rings to the intensity of Saturn in this region. Separate measurements at Mount Wilson of the reflectance of Saturn show a continuous strong absorption from 0.97 to 1.04 μ. This unfortuitous coincidence yields a large drop in the ratio beyond 1.04 μ which will completely mask any possible ice absorption which by the results above will be only a few percent at most.

AD61 A SEARCH FOR LIMONITE NEAR-INFRARED SPECTRAL FEATURES ON MARS

Younkin, R. L.

Previous authors have found limonite to be the only mineral whose polarization, color, and albedo duplicate those of the bright areas of Mars in the visual spectral region. Recent measurements of spectral reflectance show in the near-infrared that powdered limonite exhibits two characteristics, a wideband absorption with minimum reflectance in the 8200–9500-Å region and, just beyond this absorption, a rise in reflectance.

Spectrophotometric measurements from 0.5 to 1.1 μ have been made at Mount Wilson of the integral intensity of the disk of Mars and of a bright area and a dark area. Comparison of the intensities of the two areas gives no indication of any difference in limonite content. The integral intensity has been reduced to relative reflectance by means of the energy distribution of α Lyr, and independently it has been compared directly to the intensity of the lunar crater Plato. An upper limit of 2% may be placed on the strength of the limonite spectral features in the reflectance of Mars.

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