Bibliography No. 39-6

Publications of the Jet Propulsion Laboratory July 1964 through June 1965

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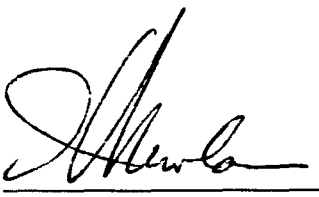

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PASADENA, CALIFORNIA

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PREFACE

JPL Bibliography No. 39-6 is a compilation of official reports of the Jet Propulsion Laboratory released July 1, 1964 through June 30, 1965. 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.

Acord, J. D.

A01 THEORETICAL AND PRACTICAL ASPECTS OF SOLAR PRESSURE ATTITUDE CONTROL FOR INTERPLANETARY SPACECRAFT
Acord, J. D., Nicklas, J. C.
Technical Report No. 32-467, May 15, 1964 (Unclassified)

This Report briefly covers the theory of photon momentum transfer to the exposed surfaces of a space vehicle, and gives an engineering derivation of the essential equations and parameters for dealing with the resulting forces in a practical manner. Various configurations of spacecraft equipment and control surfaces are examined as to magnitudes and directions of solar pressure torques and the necessary conditions for control.

Some of the major system-integration considerations are discussed, with particular emphasis on a minimum-interface combination of the solar pressure control system with an impulsive mass-expulsion system. System parameter optimization by graphical parametric analysis is illustrated, with the combined impulsive solar-pressure system as an example. Some of the special considerations and peculiarities involved in mechanizing such a low-torque low-response control system are also discussed.

Anderson, H. R.

A02 IONIZING RADIATION MEASURED BETWEEN EARTH AND VENUS BY *MARINER II*
Anderson, H. R.
Technical Report No. 32-693 (Unclassified)
(Reprinted from *Space Research V: Proceedings of the Fifth International Space Science Symposium, Florence, May 8–20, 1964*, Vol. 3, North-Holland Publishing Co., 1965

An ionization chamber and two GM tubes on *Mariner II* measured the ionization rate and average omnidirectional flux of interplanetary radiation during September–December 1962 at distances of 1.0 to 0.71 AU from the Sun and 0.55 to 80.2×10^6 km from the Earth. The ion chamber and one GM tube were shielded with 0.2 g/cm² of Fe, and the second GM tube with 0.11 g/cm² of Be so that protons with $E > 10$ MeV and electrons with $E > 0.5$ MeV penetrated all detectors. The two GM tubes' response to X-rays and nonpenetrating electrons differed. Near the Earth the ionization rate averaged 667 ion pairs/(sec cm³ of STP air) and both GM tubes measured about 2.9 particles/cm² sec.

It was concluded that only penetrating particles were detected. Their average specific ionization was 2.9 times minimum, which is consistent with measured charge and energy spectra of galactic cosmic radiation. Gradients of 9.3%/AU in ion rate and 0%/AU in flux at 0.81 to 0.72 AU from the Sun were obtained; but at 0.72 to 0.70 AU, −2.6%/AU and −17.9%/AU were computed.

Anderson, J. D.

A03 THE EVALUATION OF CERTAIN ASTRONOMICAL CONSTANTS FROM THE RADIO TRACKING OF *MARINER II*
Anderson, J. D., Null, G. W., Thornton, C. T.
Technical Report No. 32-476 (Unclassified)
(Reprinted from *Progress in Astronautics and Aeronautics*, Vol. 14, Academic Press, Inc., 1964)

The mathematical techniques used to obtain astronomical constant information from the *Mariner II* data are described from the viewpoint of the parameter estimation procedure, the calculation of the residuals, and the variational coefficients for oribtal parameters and physical constants. Numerical illustrations of the reduction are included for data taken (1) during that portion of the flight when the spacecraft was

controlled by the Sun, (2) during the Venus encounter, and (3) during the entire mission. Provisional values for the mass of both the Moon and Venus are given.

Armstrong, R. S.

A04 ERRORS ASSOCIATED WITH SPINNING-UP AND THRUSTING SYMMETRIC RIGID BODIES
Armstrong, R. S.
Technical Report No. 32-644, February 15, 1965 (Unclassified)

The equations defining errors generated during the spin-up of symmetric rigid bodies and the subsequent thrusting of these spinning bodies are derived from Euler's dynamical equations and transformed into inertial coordinates. Examples of both spin-up and thrust errors are given for the *Ranger* lunar landing capsule and an *Apollo*-shaped planetary entry capsule.

The stability of nonrigid spinning symmetrical bodies is also discussed. Equations describing the precessional motion are given, and a simple mathematical model is analyzed. Results indicate that to minimize errors in the spin-up and thrust phase, a high spin-rate is desired, whereas a low spin-rate is needed to minimize errors during coast.

Ashlock, J. C.

A05 APPLICATION OF THE STATISTICAL THEORY OF EXTREME VALUES TO SPACECRAFT RECEIVERS
Ashlock, J. C., Posner, E. C.
Technical Report No. 32-737, May 15, 1965 (Unclassified)

This Report considers the problem of error probability estimation in systems involving a threshold detector. Extreme-value theory is used to monitor not only the occurrence of errors but also how close the detection scheme comes to making errors even when no error is made. Thus, the maximum amplitude deviation in a large number of bits is recorded as a new datum. The distribution of these extreme data then has an extreme-value distribution. The parameters of the extreme-value distribution are estimated, and thus in turn yield an estimate of the error probability. There is a saving of a factor of ten in test time over mere bit error testing. The distributions obtained from actual threshold systems are shown to fit the theoretical distribution very well. The method was used to test the command receivers in *Rangers VII, VIII,* and *IX*.

Babineaux, T. L.

B01 HYPERVELOCITY SHOCK TUBE
Collins, D. J., Livingston, F. R., Babineaux, T. L. Morgan, N. R.
Technical Report No. 32-620, June 15, 1964 (Unclassified)

For abstract, see Entry C15.

Back, L. H.

B02 CONVECTIVE HEAT TRANSFER IN A CONVERGENT-DIVERGENT NOZZLE
Back, L. H., Massier, P. F., Gier, H. L.
Technical Report No. 32-415 (Revision No. 1), February 15, 1965 (Unclassified)

Investigated was convective heat transfer from turbulent boundary layers accelerated under the influence of large pressure gradients in a cooled convergent–divergent conical nozzle. The investigation covered a range of stagnation pressures from 30 to 250 psia, stagnation temperatures from 1030 to 2000°R, and nozzle-inlet boundary-layer thickness between 5 and 25% of the inlet radius. Steady-state heat-transfer rates from air heated by the combustion of methanol were determined from measurements, using thermocouples embedded in the nozzle wall. The most significant result is the reduction in the heat-transfer coefficient.

B03 COMPARISONS OF EXPERIMENTAL WITH PREDICTED WALL STATIC-PRESSURE DISTRIBUTION IN CONICAL SUPERSONIC NOZZLES
Back, L. H., Massier, P. F., Gier, H. L.
Technical Report No. 32-654, October 15, 1964 (Unclassified)

Measured wall static-pressure distributions are presented for conical nozzles to show both the dependence of the deviations from one-dimensional isentropic flow on nozzle configuration and the region over which these deviations extend. The conical nozzles investigated have 30- and 45-deg half-angles of convergence, 15-deg half-angles of divergence, circular-arc entrance and throat sections, and expansion-area ratios up to 6.6:1. The ratios of throat radius of curvature to throat radius were 2.0:1 and 0.625:1. The effect of inlet configuration was investigated in other nozzles with the convergent sections formed by circular arcs.

Barnett, R. M.

B04 DEVELOPMENT OF THE JET PROPULSION LABORATORY SOLAR SIMULATOR, TYPE A
Bartera, R. E., Barnett, R. M.
Technical Report No. 32-638, July 15, 1964 (Unclassified)

For abstract, see Entry B05.

Bartera, R. E.

B05 DEVELOPMENT OF THE JET PROPULSION LABORATORY SOLAR SIMULATOR, TYPE A
Bartera, R. E., Barnett, R. M.
Technical Report No. 32-638, July 15, 1964 (Unclassified)

This Report describes the solar simulation development activities of late 1962 through 1963 which culminated in the production of the Jet Propulsion Laboratory solar simulator, Type A. A brief history of this development, together with the outstanding actual performance of the JPL-SS-A6, is presented.

Barth, C. A.

B06 ROCKET MEASUREMENT OF THE NITRIC OXIDE DAYGLOW
Barth, C. A.
Technical Report No. 32-640 (Unclassified)
(Reprinted from *Journal of Geophysical Research*, Vol. 69, No. 15, August 1, 1964)

Details of the measurement experiment are given, and the instrumentation used is described.

B07 CALCULATIONS OF ULTRAVIOLET MOLECULAR NITROGEN EMISSIONS FROM THE AURORA
Green, A. E. S., Barth, C. A.
Technical Report No. 32-723 (Unclassified)
(Reprinted from *Journal of Geophysical Research*, Vol. 70, No. 5, March 1, 1965)

For abstract, see Entry G13.

Baumgartner, W. S.

B08 HIGH-POWER CW RADAR TRANSMITTER
Baumgartner, W. S.
Technical Report No. 32-656, September 1, 1964
(Unclassified)

The design parameters for a high-power CW radar transmitter are delineated, and the history of its development is traced. Special attention is given to problems encountered and to their solutions. The hardware involved is detailed, and the system in which the transmitter functions is described. The present plans for increasing the radiated power and upgrading the transmitter system in general are presented.

To properly orient this transmitter with the NASA-JPL space program, some preliminary discussion is presented of the space telecommunications problem, the existing Deep Space Network, and, in particular, the continuing program of advanced system development.

Beaudet, R. A.

B09 MICROWAVE SPECTRUM, BARRIER TO INTERNAL ROTATION, AND QUADRUPOLE COUPLING CONSTANTS OF *CIS*-1-CHLOROPROPYLENE
Beaudet, R. A.
Technical Report No. 32-613 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, Vol. 40, No. 9, May 1, 1964)

The microwave spectrum of *cis*-$CH_3CH = CHCl$ was studied in the region from 8–35 kMc. From the splittings of the rotational transitions, a barrier height of 620 cal/mole was found and confirmed from the first-order Stark splitting of the E component of the $3_{12} \leftarrow 2_{11}$ transition. The quadrupole coupling constants of ^{35}Cl were obtained from the hyperfine splittings due to the coupling of the quadrupole moment of the Cl nucleus with the surrounding electric field.

Becker, R. A.

B10 ANALYSIS OF SOLAR PANEL EFFECT ON LOUVER PERFORMANCE
Becker, R. A.
Technical Report No. 32-687, June 1, 1965
(Unclassified)

The influence which a solar panel exerts on the thermal performance of an array of temperature control louvers is investigated analytically. Although the analytical results apply specifically to the *Mariner Mars* 1964 configuration, many of the concepts included in the analysis are valid for other spacecraft geometries.

The algebraic equations are formulated and solved yielding results which are presented in graphical form. The solar panel was found to have a significant negative effect on the thermal performance of the louvers, but the *Mariner Mars* 1964 configuration is such that this effect can be minimized. The technique for minimization is also presented.

B11 DESIGN AND TEST PERFORMANCE OF *MARINER IV* TELEVISION OPTICAL SYSTEM
Becker, R. A.
Technical Report No. 32-773, July 1, 1965
(Unclassified)

The design, development and testing of the television optical system for *Mariner IV* are discussed. Included is a description of the system performance under simulated conditions of launch and space environment, and analyses of the specific capability requirements and design considerations.

The special problems of the filter-shutter mechanism, the selections of lubricants, and the use of nonmetallic materials for certain parts in the system are also discussed. The expected results of the photographic mission are explained.

Beilock, M.

B12 *SURVEYOR* LANDER MISSION AND CAPABILITY
Beilock, M.
Technical Report No. 32-618, August 1, 1964
(Unclassified)

The organization, purpose, and general engineering nature of the *Surveyor* lunar soft-lander project are reviewed in the context of unmanned lunar exploration and anticipated needs of manned lunar programs. Flight and lunar-surface operations are discussed for both test and operational missions. An estimate of the nature and capability of the engineering payload and each experiment of the scientific payload is presented. In addition, the possibilities of follow-on missions are discussed briefly.

Benson, M. A.

B13 DESCRIPTION AND FLIGHT ANALYSIS OF THE *RANGER VII* TV SUBSYSTEM
Benson, M. A., Williams, R. D.
Technical Report No. 32-680, February 15, 1965 (Unclassified)

The major assemblies and the operation of the *Ranger VII* TV subsystem are described, along with the engineering and technical aspects of the subsystem. The subsystem included two full-scan and four partial-scan cameras. A detailed evaluation of the subsystem and performance is given.

All aspects of system operation were normal and the mission goals were surpassed, as evidenced by the quality of the lunar photographs obtained. Samples of these photographs are included.

Berman, A. L.

B14 *RANGER VII* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Wollenhaupt, W. R., Trask, D. W., Sjogren, W. L., Piaggi, E. G., Curkendall, D. W., Winneberger, R. A., Liu, A. S., Berman, A. L.
Technical Report No. 32-694, December 15, 1964 (Unclassified)

For abstract, see Entry W22.

B15 TRACKING SYSTEM DATA ANALYSIS REPORT *RANGER VII* FINAL REPORT
Berman, A. L.
Technical Report No. 32-719, June 1, 1965 (Unclassified)

This Report is an analysis of the Deep Space Instrumentation Facility tracking performance during the *Ranger VII* mission. Included are ground system configurations, station view periods, and a discussion by station and view period of all tracking data (angular and doppler) taken by the tracking stations. A summary is given of the tracking data which were actually used to determine the spacecraft orbit. The noise statistics of the tracking data are also given.

Blaylock, R. B.

B16 CALIBRATION OF A COMPACT SURVEY PROBE FOR PITOT PRESSURE, MACH NUMBER, AND FLOW ANGULARITY MEASUREMENTS
Fox, N. L., Blaylock, R. B.
Technical Memorandum No. 33-179, March 15, 1965 (Unclassified)

For abstract, see Entry F05.

Bollman, W. E.

B17 EARTH–MARS TRAJECTORIES, 1964
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum No. 33-100, Vol. 1, Part B, March 15, 1964 (Unclassified)

For abstract, see Entry C10.

B18 EARTH–MARS TRAJECTORIES, 1964
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum No. 33-100, Vol. 1, Part C, April 1, 1964 (Unclassified)

For abstract, see Entry C11.

Boone, D. H.

B19 EFFECT OF GRAIN SIZE AND IMPURITIES ON TENSILE STRENGTH AND DUCTILITY OF TUNGSTEN FROM 2500 TO 5000°F IN VACUUM
Taylor, J. L., Boone, D. H., Simmons, O. W.
Technical Report No. 32-632, July 1, 1964 (Unclassified)

For abstract, see Entry T02.

Breshears, R. R.

B20 SPACECRAFT PROPULSION REQUIREMENTS FOR LUNAR MISSIONS
Breshears, R. R.
Technical Report No. 32-628 (Unclassified)
(Reprinted from *Journal of Spacecraft and Rockets*, Vol. 2, No. 1, January–February, 1964)

Spacecraft propulsion requirements for both lunar orbiting and landing missions are considered; included are requirements imposed by the flight path, accelerometer errors, altitude determination errors, and impulse errors. Particular attention is given to minimizing the number of maneuvers, number of engines, and throttling requirements.

It appears that a single fixed-thrust engine will satisfy the requirements for an orbiting mission. For landing from lunar orbit, a single regeneratively cooled engine with a throttling range as low as 3.5:1 appears acceptable; alternatively, if the system has a separate landing engine, a throttling range as low as 2:1 appears to be acceptable.

Brothers, A. J.

B21 PROPERTIES OF WELDED HIGH-STRENGTH TITANIUM ALLOY SHEET
Brothers, A. J., Martens, H. E., Wood, H. L.
Technical Report No. 32-39, Revision 1 (Unclassified)
(Reprinted from the *Proceedings of the American Society for Testing and Materials*, Vol. 63, 1963)

A three-point free- and guided-bend test was used to evaluate the ductility of various combinations of base metals and filler wires in weld joints of high-strength, heat-treatable titanium alloys. This test used an easily prepared specimen and employed the results of longitudinal and transverse weld tension tests.

Broucke, R.

B22 REGULARIZATIONS OF THE PLANE RESTRICTED THREE-BODY PROBLEM
Broucke, R.
Technical Report No. 32-626, February 28, 1964
(Unclassified)

It is shown that the two nonessential but removable singularities of the plane circular restricted three-body problem can be removed simultaneously by a coordinate transformation, which is defined by the conformal mapping

$$Z = \tfrac{1}{4}\left(\zeta^n + \frac{1}{\zeta^n}\right)$$

where n is any finite and nonzero real number. Another regularization is obtained by the mapping

$$Z = \tfrac{1}{2}\cos n\,\zeta$$

which is related to the preceding one by substituting $e^{i}\zeta$ for ζ.

The first mapping gives Birkhoff's transformation when $n = 1$; however, when n has the value 2, this transformation is related to a coordinate system which has been introduced by Lemaitre in the general three-body problem. This transformation for $n = 2$ is also essentially equivalent to the regularization introduced by Arenstorf. The second transformation gives Thiele's well-known regularization when n takes the value $+1$.

Cain, D. L.

C01 DETERMINATION OF SOME PHYSICAL PROPERTIES OF THE ATMOSPHERE OF MARS FROM CHANGES IN THE DOPPLER SIGNAL OF A SPACECRAFT ON AN EARTH-OCCULTATION TRAJECTORY
Kliore, A., Cain, D. L., Hamilton, T. W.
Technical Report No. 32-674, October 15, 1964
(Unclassified)

For abstract, see Entry K10.

Campbell, D. H.

C02 THE SYNTHESIS AND USE OF SOME INSOLUBLE IMMUNOLOGICALLY SPECIFIC ADSORBENTS
Weliky, N., Weetall, H. H., Gilden, P. V., Campbell, D. H.
Technical Report No. 32-607 (Unclassified)
(Reprinted from *Immunochemistry*, Vol. 1, Pergamon Press, 1964)

For abstract, see Entry W09.

Carr, R. E.

C03 DIPOLAR COORDINATES
Carr, R. E.
Technical Report No. 32-696, April 1, 1965 (Unclassified)

Theoretical solutions to magnetohydrodynamics problems, where a dipole magnetic field is assumed, should provide more appropriate models for investigating the magnetosphere than solutions to problems where a uniform field has been used. One approach needing consideration is the use of dipolar coordinates. A detailed derivation of dipolar coordinates is given, with a demonstration of how to express the commonly used vector formulas in dipolar coordinates. It is shown how spherical coordinates can be expressed analytically in terms of dipolar coordinates. It has been concluded that another approach might be more fruitful in attempting to solve magnetohydrodynamics problems in which a dipole field is assumed.

Chen, C. J.

C04 ANOMALOUS DIFFUSION AND INSTABILITIES OF AN ARGON PLASMA IN A STRONG MAGNETIC FIELD
Chen, C. J.
Technical Report No. 32-695, December 15, 1964
(Unclassified)

By using electron continuum intensity, ion current probe, and microwave techniques, the rate of electron density decay with time in an argon discharge tube energized with a capacitor bank of energy up to 3,000 **J** was measured. The discharge tube was oriented along a magnetic field of up to 30 kG. The electron temperature decay was obtained by the spectral-line intensity ratio method. The oscillation or instability in the plasma was monitored with electrostatic and magnetic probes. The coefficient of ambipolar diffusion is evaluated from the decay data obtained in the diffusion-dominated region. The data thus obtained indicate that the coefficient of ambipolar diffusion agrees with the prediction of the collision theory up to the magnetic field of about 1 kG. Beyond 1 kG the onset of oscillations is detected and the coefficient of diffusion is much higher than the collision-theory prediction. For $\mathbf{B} > 1$ kG, the coefficient of diffusion varies as $\mathbf{B}^{-1}$, and the absolute values are quite close to those of Bohn.

C05 VALID CONDITIONS FOR THE KRAMERS-UNSÖLD CONTINUUM THEORY IN A NON-EQUILIBRIUM PLASMA
Chen, C. J.
Technical Report No. 32-707, December 30, 1964
(Unclassified)

The Kramers-Unsöld theory of continuum intensity for electron-ion recombination is formulated by quantum mechanics. The valid conditions for the theory in a non-equilibrium plasma are deduced by using Griem's criterion for partial local thermodynamic equilibrium. The results indicate that the conditions are much less restricted than those required for the Saha equation to be valid.

Christiansen, W.

C06 SEEDED-GAS PLASMA FOR LOW DENSITY WIND-TUNNEL USE
Christiansen, W.
Technical Report No. 32-704 (Unclassified)
(Reprinted from *The Review of Scientific Instruments*, Vol. 36, No. 1, January 1965)

A low-density plasma source has been constructed utilizing thermally ionized cesium seeded into an argon gas stream. The essential component of this system is the heat exchanger which uses graphite as the primary element of construction. A resistance-heated helical element and adiabatic stagnation chamber result in a compact unit. Preliminary measurements of the plasma-ion density and electron temperature are presented.

Clark, J. R.

C07 *SURVEYOR* FOLLOW-ON STUDY SCIENTIFIC OBJECTIVES—PHASE 1: SIGNIFICANCE OF A SUCCESSFUL *SURVEYOR* BLOCK 1 LANDING
Clark, J. R., Dunk, A. C., Horowitz, S. M., Le Croissette, D. H., Silverstein, E. M.
Technical Memorandum No. 33-192, December 1, 1964 (Unclassified)

Scientific information regarding lunar properties may be derived from engineering data received from the *Surveyor* Block 1 spacecraft. (The information that will be obtained from the scientific payload is specifically excluded from this Report since it is detailed in Technical Memorandum No. 33-166, Phase 2 of this study.)

Listed are the engineering sensors which are possible scientific information sources. The data transmission modes are given, as well as brief descriptions of the sensors, components, and subsystems. The manner in which the scientific information is extracted is briefly considered.

The lunar approach and landing phase of the *Surveyor* will provide information on surface hardness, bearing strength, and surface friction at the landing point. Continuous operation of the spacecraft on the Moon will give some information on lunar thermal properties, dust and micrometeorite impact.

Several minor modifications to the present *Surveyor* would increase the amount of scientific data which could be obtained from the engineering telemetry. It is suggested (1) that these and other recommended modifications be considered in the design of later spacecraft, and (2) that on future missions, a panel of engineers and scientists be appointed to review the opportunity for obtaining scientific information through interpretation of engineering telemetry.

Clarke, V. C., Jr.

C08 TRAJECTORY DESIGN FOR *RANGER* AND *MARINER* MISSIONS
Clarke, V. C., Jr.
Technical Report No. 32-471 (Unclassified)
(Reprinted from *Progress in Astronautics and Aeronautics*, Vol. 14, Academic Press, Inc., 1964)

This paper relates the general trajectory engineering effort that was accomplished for the *Ranger* lunar and *Mariner* interplanetary missions.

C09 EARTH–MOON TRAJECTORIES, 1964–69
Richard, R. J., Clarke, V. C., Jr., Roth, R. Y., Kirhofer, W. E.
Technical Report No. 32-503, May 1, 1964 (Unclassified)

For abstract, see Entry R08.

C10 EARTH–MARS TRAJECTORIES, 1964
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum No. 33-100, Vol. 1, Part B, March 15, 1964 (Unclassified)

This is the second of a series of volumes giving key characteristics of Earth-to-Mars ballistic trajectories during the period 1964–1977. This period is divided into seven launch intervals 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. It is intended that these volumes provide trajectory and guidance analysts with data, in quantity, so that they may perform preliminary design studies, conduct investigations of the properties of ballistic interplanetary trajectories, and make interplanetary guidance and orbit determination analyses; while not exact, these trajectories are sufficiently accurate to be quite useful for these purposes.

C11 EARTH–MARS TRAJECTORIES, 1964
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum No. 33-100, Vol. 1, Part C, April 1, 1964 (Unclassified)

This is the third part of a series of volumes giving key characteristics of Earth-to-Mars ballistic trajectories during the period 1964–1977. This period is divided into seven launch intervals 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. It is intended that these volumes provide trajectory and guidance analysts with data, in quantity, so that they may perform preliminary design studies, conduct investigations of the properties of ballistic interplanetary trajectories, and make interplanetary guidance and orbit determination analyses; while not exact, these trajectories are sufficiently accurate to be quite useful for these purposes.

Clauss, R. C.

C12 TOTAL SYSTEM NOISE TEMPERATURE: 15°K
Clauss, R. C., Higa, W., Stelzried, C., Wiebe, E.
Technical Report No. 32-691 (Unclassified)
(Reprinted from *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-12, No. 6, November 1964)

An operational maser system is evaluated, and the results are found to be of particular interest in regard to accurate noise temperature measurements.

Cleven, G. C.

C13 RELIABILITY CONSIDERATIONS IN THE DESIGN, ASSEMBLY, AND TESTING OF THE *MARINER IV* POWER SYSTEM
Dawson, K. M., Cleven, G. C., Fredrickson, C. D.
Technical Report No. 32-729, July 1, 1965
(Unclassified)

For abstract, see Entry D06.

Coleman, P. J., Jr.

C14 MAGNETIC MEASUREMENTS NEAR VENUS
Smith, E. J., Davis, L., Jr., Coleman, P. J., Jr., Sonett, C. P.
Technical Report No. 32-732 (Unclassified)
(Reprinted from *Journal of Geophysical Research*, Vol. 70, No. 7, April 1, 1965

For abstract, see Entry S15.

Collins, D. J.

C15 HYPERVELOCITY SHOCK TUBE
Collins, D. J., Livingston, F. R., Babineaux, T. L., Morgan, N. R.
Technical Report No. 32-620, June 15, 1964 (Unclassified)

The design and performance of the Jet Propulsion Laboratory's hypervelocity 6-in. shock tube are described. The facility is capable of simulating planetary entry velocities of 45,000 ft/sec. Shock velocities of 32,000 ft/sec into 0.250 mm Hg of air were achieved in the 6-in. tube, with a test time of 12 μsec. Investigations of both convective and radiant heat transfer were completed.

C16 CONVECTIVE HEAT TRANSFER IN PLANETARY ATMOSPHERES
Collins, D. J.
Technical Report No. 32-629, July 1, 1964 (Unclassified)

Convective heat transfer rates were obtained for three model planetary atmospheres that are characteristic of Mars and Venus. Atmospheres comprised of nitrogen and carbon dioxide gave heat transfer rates similar to those of air. The presence of argon materially increased the heat transfer rate. The effects of different gauge materials on the convective heat transfer were also measured. No major differences were found for the experimental conditions studied.

Coltharp, C.

C17 JPL TRACKING DATA EDITING PROGRAM FOR THE IBM 7094
Holzman, R., Coltharp, C.
Technical Memorandum No. 33-170, August 1, 1964
(Unclassified)

For abstract, see Entry H17.

Cuddihy, E.

C18 SOME UNUSUAL PROPERTIES OF GRAFT COPOLYMERS AND POLYBLENDS OF β-VINYLNAPHTHALENE AND ETHYLENE OXIDE
Cuddihy, E., Moacanin, J., Rembaum, A.
Technical Report No. 32-708 (Unclassified)
(Reprinted from *Journal of Applied Polymer Science*, Vol. 9, No. 4, April 1965)

It was found that poly-β-vinylnaphthalene and poly(ethylene oxide) (54:46 wt %) form homogeneous blends or graft copolymers when prepared under conditions which inhibit the crystallization of poly(ethylene oxide). Such preparations can be obtained from solutions in a good solvent for both components, either by precipitation procedures which lead to coacervation rather than fractionation, or by freeze-drying. Preparations containing more than 46 wt % poly(ethylene oxide) were characterized by modulus versus temperature curves exhibiting a minimum at about 60°C. This behavior was interpreted as due to microphase separation taking place with increasing temperature, a process which becomes irreversible above 120°C.

A graft copolymer having the 54:46 wt % composition was rubbery at room temperature, and in contrast to polyblends did not exhibit the poly-β-vinylnaphthalene glass transition at 138°C. The marked difference in behavior between polyblends and graft copolymers is due to the fact that in the latter irreversible microphase separation cannot take place. The above described properties seem to be peculiar to poly-β-vinylnaphthalene.

Curkendall, D. W.

C19 THE *RANGER VI* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Sjogren, W. L., Curkendall, D. W., Hamilton, T. W., Kirhofer, W. E., Liu, A. S., Trask, D. W., Winneberger, R. A., Wollenhaupt, W. R.
Technical Report No. 32-605, December 15, 1964
(Unclassified)

For abstract, see Entry S13.

C20 *RANGER VII* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Wollenhaupt, W. R., Trask, D. W., Sjogren, W. L., Piaggi, E. G., Curkendall, D. W., Winneberger, R. A., Liu, A. S., Berman, A. L.
Technical Report No. 32-694, December 15, 1964 (Unclassified)

For abstract, see Entry W22.

Curtis, H. D.

C21 OPTIMIZATION OF SYSTEM OPERATING PARAMETERS FOR HEAT STERILIZABLE LIQUID PROPULSION SYSTEMS
Curtis, H. D., Harper, A. D.
Technical Memorandum No. 33-211, June 1, 1965 *(Unclassified)*

As a means of attaining a sterile spacecraft, design information is required for liquid propulsion systems which can be heat sterilized in the loaded condition without venting. An analysis was performed to determine the values of the system operating parameters which minimize the system mass. Results are presented for both internally and externally pressurized tankage systems. The tankage mass for sterilizable systems is approximately twice that for nonsterilizable systems.

Dahlgren, A. C.

D01 MATHEMATICAL MODELS OF MISSILE LAUNCHING
Dahlgren, A. C.
Technical Report No. 32-655, Part I, August 21, 1964 (Unclassified)

By means of a mathematical model of the situation, including assumptions about the nature of the delays encountered, this Report (the first of a three-part series) presents an estimate of the expected number of days required to launch three missiles, each from its own pad, allowing no simultaneous (i.e., same-day) countdowns or launches.

D02 MATHEMATICAL MODELS OF MISSILE LAUNCHING
Dahlgren, A. C.
Technical Report No. 32-655, Part II, August 21, 1964 (Unclassified)

This is the second of a series of Reports investigating the question introduced in Part I (preceding entry).

D03 MATHEMATICAL MODELS OF MISSILE LAUNCHING
Dahlgren, A. C.
Technical Report No. 32-655, Part III, August 21, 1964 (Unclassified)

By means of a mathematical model of the situation (including assumptions about the nature of the delays encountered), an estimate is presented of the expected number of days required to launch four missiles from two pads, allowing no simultaneous (i.e., same-day) countdowns or launches.

Dallas, S. S.

D04 MOON-TO-EARTH TRAJECTORIES
Dallas, S. S.
Technical Report No. 32-412, Revision 1 (Unclassified)
(Reprinted from *Progress in Astronautics and Aeronautics*, Vol. 14, Academic Press, Inc., 1964)

The design and characteristics of trajectories that initiate on the surface of the Moon and terminate at a specific landing site on the surface of the Earth are presented, along with techniques for computing such trajectories. Results from an analytic trajectory-computing program are used for the qualitative discussions, and results from a precision integrating program are used for the quantitative discussions.

Davis, L., Jr.

D05 MAGNETIC MEASUREMENTS NEAR VENUS
Smith, E. J., Davis, L., Jr., Coleman, P. J., Jr., Sonett, C. P.
Technical Report No. 32-732 (Unclassified)
(Reprinted from *Journal of Geophysical Research*, Vol. 70, No. 7, April 1, 1965)

For abstract, see Entry S15.

Dawson, K. M.

D06 RELIABILITY CONSIDERATIONS IN THE DESIGN, ASSEMBLY, AND TESTING OF THE *MARINER IV* POWER SYSTEM
Dawson, K. M., Cleven, G. C., Fredrickson, C. D.
Technical Report No. 32-729, July 1, 1965 (Unclassified)

Power for the *Mariner IV* spacecraft is supplied from a system consisting of solar panel, battery, energy conversion, and load switching equipment. Operation of this equipment is presented and related to overall system reliability. Criteria for sizing solar panel and battery capacities are given, as well as the present power and energy margins for the *Mariner IV* power system. Particular emphasis is placed on those items that were included in the system design to increase overall reliability.

High reliability was obtained by providing redundant functional elements and appropriate failure-sensing and switching circuits; by designing a flexible system that can meet unexpected problems using ground commands and on-board logic; by using parts that have proven reliable in space environment; by screening these parts and applying them with considerable derating; and by thoroughly testing the resultant product before flight. In addition, an adequate amount of telemetry was made available to provide information for diagnosing problems and to aid in their solution, the power system telemetry point selection is reviewed and related to overall system reliability.

Dayman, B., Jr.

D07 A PNEUMATIC MODEL LAUNCHER FOR FREE-FLIGHT TESTING IN A CONVENTIONAL WIND TUNNEL
Holway, H. P., Herrera, J. G., Dayman, B., Jr.
Technical Memorandum No. 33-177, July 30, 1964
(Unclassified)

For abstract, see Entry H16.

DeMore, W. B.

D08 DEACTIVATION OF O(^1D) IN THE ATMOSPHERE
DeMore, W. B., Raper, O. F.
Technical Report No. 32-612 (Unclassified)
(Reprinted from *The Astrophysical Journal*, Vol. 139, No. 4, May 15, 1964)

This note gives a semi-quantitative evaluation of the rate constant ratio k_4/k_5, and thereby shows that quenching of $O(^1D)$ by N_2 is probably important in the atmosphere.

Devine, C. J.

D09 PLOD II: PLANETARY ORBIT DETERMINATION PROGRAM FOR THE IBM 7094 COMPUTER
Devine, C. J.
Technical Memorandum No. 33-188, April 15, 1965
(Unclassified)

The IBM 7094 computer uses a double-precision numerical fitting program in the computation of the Jet Propulsion Laboratory's planetary ephemerides. The method of integration, the least-squares fitting technique and all mathematical equations used in the computation are described in detail.

Dunk, A. C.

D10 *SURVEYOR* FOLLOW-ON STUDY SCIENTIFIC OBJECTIVES—PHASE 1: SIGNIFICANCE OF A SUCCESSFUL *SURVEYOR* BLOCK 1 LANDING
Clark, J. R., Dunk, A. C., Horowitz, S. M., Le Croissette, D. H., Silverstein, E. M.
Technical Memorandum No. 33-192, December 1, 1964
(Unclassified)

For abstract, see Entry C07.

Easterling, M.

E01 METHODS FOR OBTAINING VELOCITY AND RANGE INFORMATION FROM CW RADARS
Easterling, M.
Technical Report No. 32-657, September 1, 1964
(Unclassified)

Continuous wave radars are particularly suited for obtaining velocity and range information on single targets at extreme ranges. These targets may be (1) spacecraft in orbit about the Earth enroute to the Moon or another planet, or (2) natural celestial bodies such as the Moon or inner planets. The carrier itself provides the means for velocity determination because of the doppler shift of the returned signal. Ways of measuring this doppler shift for both coherent and noncoherent returned signals are discussed. The determination of range requires that the carrier be modulated. Methods are given for deriving modulating waveforms from pseudo-random sequences which are suitable for achieving high resolution and accuracy and resolving ambiguity. Ways of extracting the range from a returned signal are also given. Techniques are described for both the coherent and noncoherent carriers and have been embodied in actual radar systems and used to track appropriate targets. Experimental results are given to show the performance which can be attained.

Eisenberger, I.

E02 GENESIS OF BIMODAL DISTRIBUTIONS
Eisenberger, I.
Technical Report No. 32-676 (Unclassified)
(Reprinted from *Technometrics*, Vol. 6, No. 4, November 1964)

The distribution of a mixture of two normal distributions is considered, and the conditions for which the distribution is bimodal are investigated.

E03 TESTS OF HYPOTHESES AND ESTIMATION OF THE CORRELATION COEFFICIENT USING QUANTILES I
Eisenberger, I.
Technical Report No. 32-718, June 1, 1965
(Unclassified)

This Report presents some of the results of the continuing investigation into the use of sample quantiles for data compression of spacecraft telemetry. The first two tests are concerned with the value of one of the parameters of a normal distribution when the value of the other is known. The third one tests both parameters simultaneously. The next two tests are two sample tests: one tests the hypothesis that $\mu_2 = \mu_1$, and the other tests the hypothesis that $\sigma_2 = \sigma_1$. Finally, pairs of sample values are tested for independence and, in addition, estimators of the correlation coefficient are given. The tests and estimators are all based on sample quantiles, and the sample sizes are assumed to be large.

Elleman, D. D.

E04 JPL INTENSE FIELD AIR CORE MAGNET
Rust, R., Elleman, D. D., Noble, R. M.
Technical Report No. 32-652, August 31, 1964
(Unclassified)

For abstract, see Entry R20.

E05 RELATIVE SIGNS OF THE NUCLEAR SPIN COUPLING CONSTANTS IN PROPYLENE OXIDE AND INDENE OXIDE
Elleman, D. D., Manatt, S. L., Pearce, C. D.
Technical Report No. 32-706 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, Vol 42, No. 2, January 15, 1965)

The 60-Mc high-resolution NMR spectrum of propylene oxide was analyzed as an $ABCD_3$ nuclear spin system in the conventional iterative manner utilizing double resonance to decouple the D_3 (methyl group) protons from the ABC protons. A fit was obtained by two sets of parameters whose main difference was that either both long-range couplings J_{BD} and J_{CD} are positive with respect to the other couplings or only J_{CD} is negative. By use of a weak perturbing RF field to irradiate a particular resonance transition, it was determined that J_{CD} has a different sign than the other couplings.

The 60-Mc spectrum of the protons of the five-membered ring of indene oxide was analyzed as an ABCD system with the aid of triple-irradiation experiments. The results of these experiments determined the energy level scheme and indicated that if this spectrum is truly first order then all the coupling constants in the four-spin system are positive except J_{CD}. However, complete iterative analysis using the Swalen and Reilly program showed that the spectrum of indene oxide was definitely not first order and the J_{AD} is almost zero and J_{BC} very small.

A description is given of the field-frequency lock spectrometer used in this work.

Ellion, M. E.

E06 A STUDY OF ELECTRICAL DISCHARGE IN LOW-PRESSURE AIR
Ellion, M. E.
Technical Report No. 32-678, April 1, 1965 (Unclassified)

A review was made of the available literature describing the mechanisms of electrical breakdown in gases. The mechanisms suggested by various investigators were then modified or expanded to a form suitable for determining the maximum allowable voltage that can be applied, at any given air pressure, across any gap between conductors in a spacecraft. The final results, giving breakdown voltage as a function of gas pressure for typical gap spacings, are presented in graphical and tabular form. These results indicate that electrical discharge will not occur at air pressures of less than 10^{-2} mm Hg.

A bibliography of the literature is included.

Ervin, G. F.

E07 *VOYAGER* CAPSULE STERILIZATION PART 1. STATUS, RECOMMENDATION, PLANNING
Ervin, G. F.
Technical Memorandum No. 33-213, February 24, 1965 (Unclassified)

This is the first of a two-part document which describes the status of various Jet Propulsion Laboratory activities related to the planned sterilization of a *Voyager* capsule.

E08 *VOYAGER* CAPSULE STERILIZATION PART 2. SUPPLEMENTARY DOCUMENTATION
Ervin, G. F.
Technical Memorandum No. 33-213, February 24, 1965 (Unclassified)

This document supplements the material which is introduced in Part 1.

Estabrook, F. B.

E09 DYADIC ANALYSIS OF SPACE-TIME CONGRUENCES
Estabrook, F. B., Wahlquist, H. D.
Technical Report No. 32-682 (Unclassified)
(Reprinted from *Journal of Mathematical Physics*, Vol. 5, No. 11, November 1964)

A physical 3-vector and dyadic formalism for treatment of general relativistic problems is derived by systematic introduction of a proper tetrad field. This method is especially appropriate when there exists a physically or geometrically preferred timelike congruence; all quantities in the formalism are then shown to have immediate physical interpretation as proper local observables. A complete and nonredundant set of equations for analysis of timelike congruences is developed in this operational language.

Filice, A.

F01 QUARTZ GLASS PRESSURE VESSELS FOR HYDROTHERMAL STUDIES
Speed, R., Filice, A.
Technical Report No. 32-649 (Unclassified)
(Reprinted from *The American Mineralogist*, Vol. 49, July–August 1964)

For abstract, see Entry S19.

Finnie, C. J.

F02 AC RATIO TRANSFORMER TECHNIQUE FOR PRECISION INSERTION LOSS MEASUREMENTS
Finnie, C. J., Schuster, D., Otoshi, T. Y.
Technical Report No. 32-690, November 30, 1964 (Unclassified)

A simple high-precision insertion loss measuring system has been developed which can be made to approach the accuracy of a high-quality standard ratio transformer. It is believed that an overall accuracy of ± 0.003 db has been obtained for a measurement of approximately 0.5 db. Relative accuracies to 0.001 db should be obtainable at this level. Detection is accomplished by means of a conventional dual-channel bolometer system; comparison is by an ac ratio transformer. Because of the normal bolometer limitations, measurements in one step are limited to insertion loss values of 20 to 30 db. Excellent

agreement was obtained between measured and theoretical attenuations of specially developed rotary vane attenuators.

Fisher, P. S.

F03 SPACE—SINGLE PRECISION COWELL TRAJECTORY PROGRAM
White, R. J., Rosenberg, A. D., Fisher, P. S., Harris, R. A., Newhall, N. S.
Technical Memorandum 33-198, January 15, 1965 (Unclassified)

For abstract, see Entry W12.

F04 SFPRO—SINGLE PRECISION COWELL TRAJECTORY PROCESSOR
Rosenberg, A. D., White, R. J., Fisher, P. S., Harris, R. A., Newhall, N. S.
Technical Memorandum No. 33-199, January 15, 1965 (Unclassified)

For abstract, see Entry R14.

Fox, N. L.

F05 CALIBRATION OF A COMPACT SURVEY PROBE FOR PITOT PRESSURE, MACH NUMBER, AND FLOW ANGULARITY MEASUREMENTS
Fox, N. L., Blaylock, R. B.
Technical Memorandum No. 33-179, March 15, 1965 (Unclassified)

A pressure survey probe, designed to evaluate the flow field between a body in hypersonic flow and its shock wave, has been fabricated and experimentally calibrated. The probe geometry consisted of a 60-deg total angle cone with a maximum diameter of 0.234 in. A concentric pitot pressure port and four symmetrical cone static pressure ports were calibrated in terms of pitot pressure, Mach number, and flow angularity in the vertical plane. The calibration included Mach numbers of 1.33 to 3.26, Reynolds numbers of 3×10^4 to 3×10^5/in., and flow angles to 10 deg. This probe and calibration departed from the conventional wind-tunnel cone static probe and calibration in two ways: (1) the cone static pressure ports were quite close to the cone nose which was blunted by the pitot pressure port, and (2) the calibration extended to both sides of the theoretical sharp-cone bow-shock detachment Mach number of 1.48.

Fredrickson, C. D.

F06 RELIABILITY CONSIDERATIONS IN THE DESIGN, ASSEMBLY, AND TESTING OF THE *MARINER IV* POWER SYSTEM
Dawson, K. M., Cleven, G. C., Fredrickson, C. D.
Technical Report No. 32-729, July 1, 1965 (Unclassified)

For abstract, see Entry D06.

Gardner, F. M.

G01 FIELD-EFFECT TRANSISTORS AS DC AMPLIFIERS
Gardner, F. M.
Technical Report No. 32-670, November 15, 1964 (Unclassified)

The characteristics and operation of field-effect transistors as dc amplifiers are reviewed, and circuit techniques for providing low drift performance are discussed. Some considerations are given to questions of temporal stability and to methods of measuring field-effect transistor characteristics; a short discussion of future trends is also included.

Gates, C. R.

G02 PLANETARY APPROACH GUIDANCE
Gates, C. R., Gordon, H. J.
Technical Report No. 32-631, June 30, 1964 (Unclassified)

An on-board optical guidance system for a planet-bound spacecraft functions as the spacecraft approaches the target. Such a system should attain an accuracy greater than that obtainable from Earth-based radio guidance. This Report considers (1) the need for planetary approach guidance, (2) a set of orbital parameters developed especially for the problem, (3) analytic differential corrections, (4) covariance matrices for orbital parameters, (5) a specific mechanization, (6) measurement errors, and (7) parametric curves showing accuracy.

Geller, M.

G03 ZERO-FIELD SPLITTING, ONE- AND TWO-CENTER COULOMB-TYPE INTEGRALS
Geller, M., Griffith, R. W.
Technical Report No. 32-549 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, Vol. 40, No. 8, April 15, 1964)

Evaluated in closed analytical form are one- and two-center coulomb-type integrals of the form

$$\int [N, L, M]_{a1} O_{1,2} [N', L', M']_{b2} \, d\tau_1 \, d\tau_2,$$

where O_1 and O_2 are the two-particle operators $\frac{1}{2} r_{12}^{-5} (3z_{12}^2 - r_{12}^2)$ and $3r_{12}^{-5} (x_{12}^2 - y_{12}^2)$, respectively, needed in the examination of zero-field splitting.

G04 TWO-CENTER COULOMB INTEGRALS
Geller, M.
Technical Report No. 32-673, October 1, 1964 (Unclassified)

One of the difficulties in the application of nonrelativistic quantum mechanics to molecular systems has been the evaluation of the integrals that arise from the use of trial wavefunctions, This investigation is concerned with a derivation and expression for the general two-center coulomb integral (over Slater-type atomic orbitals) based on the Fourier-convolution method. All of the coulomb integrals through $N=4$ are given in terms of an auxiliary function $W_{m,n}^{p,q}$, which is a simple one-dimensional integral.

Gier, H. L.

G05 CONVECTIVE HEAT TRANSFER IN A CONVERGENT–DIVERGENT NOZZLE
Back, L. H., Massier, P. F., Gier, H. L.
Technical Report No. 32-415 (Revision No. 1), February 15, 1965 (Unclassified)

For abstract, see Entry B02.

G06 COMPARISONS OF EXPERIMENTAL WITH PREDICTED WALL STATIC-PRESSURE DISTRIBUTIONS IN CONICAL SUPERSONIC NOZZLES
Back, L. H., Massier, P. F., Gier, H. L.
Technical Report No. 32-654, October 15, 1964 (Unclassified)

For abstract, see Entry B03.

Gilden, P. V.

G07 THE SYNTHESIS AND USE OF SOME INSOLUBLE IMMUNOLOGICALLY SPECIFIC ADSORBENTS
Weliky, N., Weetall, H. H., Gilden, P. V., Campbell, D. H.
Technical Report No. 32-607 (Unclassified)
(Reprinted from *Immunochemistry*, Vol, 1, Pergamon Press, 1964)

For abstract, see Entry W09.

Goldstein, R.

G08 RADAR EXPLORATION OF VENUS: GOLDSTONE OBSERVATORY REPORT FOR OCTOBER–DECEMBER 1962
Goldstein, R., Stevens, R., Victor, W. K.
Technical Report No. 32-396, March 1, 1965 (Unclassified)

Venus returned for another conjunction with the Earth in the fall of 1962 and was once again the object of extensive study by the Goldstone radar observatory. Radiometer and spectral studies, frequency-time mapping, amplitude-modulated ranging, automatic frequency tracking, and polarization studies were undertaken.

Three separate methods were used to determine the rotation period of Venus: (1) tracking of a spectral feature across the disk, (2) estimation of a set of spectral base-bandwidths, and (3) measuring the widths of range-gated spectrums. The estimated period is 250 ± 50 days *retrograde*, with the axis of rotation nearly perpendicular to the orbit.

G09 THE ANALYSIS OF UNCOOPERATIVE RADAR TARGETS
Goldstein, R. M. (Goldstein, R.)
Technical Report No. 32-658, September 1, 1964 (Unclassified)

Due to the tremendous distances involved, the Moon and the planets are most "uncooperative" as radar targets. This paper discusses the special modulation and detection processes which enable the target to be analyzed.

Golomb, S. W.

G10 ROOK DOMAINS, LATIN SQUARES, AFFINE PLANES, AND ERROR-DISTRIBUTION CODES
Golomb, S. W., Posner, E. C.
Technical Report No. 32-466 (Unclassified)
(Reprinted from *IEEE Transactions on Information Theory*, Vol. IT-10, No. 3, July 1964)

This paper introduces the concept of "rook packing," and applies the viewpoint to unify several areas of coding theory. It is shown how various concepts in the theory of Latin squares, and also in coding theory, are best expressed in the form of questions about the placing of rooks on k-dimensional hyperchessboards of side n. A new species of combinational design suggested by this is the concept of "optimal coloring." It is shown that the optimal colorings in certain cases correspond to duals of desarguian projective planes. Consequently, more clarity is given the problems of the existence of both finite projective planes and close-packed single-error-correcting codes. In particular, the existence of a certain close-packed nonbinary single-error-correcting code, listed by Golay as the first unknown case, has been ruled out by a well-known result concerning Latin squares.

Gordon, H. J.

G11 PLANETARY APPROACH GUIDANCE
Gates, C. R., Gordon, H. J.
Technical Report No. 32-631, June 30, 1964 (Unclassified)

For abstract, see Entry G02.

G12 A STUDY OF THE PROBABILITY OF DEPOSITING VIABLE ORGANISMS ON MARS DURING THE *MARINER* 1964 MISSION
Haynes, N. R., Gordon, H. J.
Technical Memorandum No. 33-194, October 23, 1964 (Unclassified)

For abstract, see Entry H11.

Green, A. E. S.

G13 CALCULATIONS OF ULTRAVIOLET MOLECULAR NITROGEN EMISSIONS FROM THE AURORA
Green, A. E. S., Barth, C. A.
Technical Report No. 32-723 (Unclassified)
(Reprinted from *Journal of Geophysical Research*, Vol. 70, No. 5, March 1, 1965)

The experimental data on inelastic collisions in atmospheric gases are used in conjunction with a phenomenological generalization of the Born approximation to arrive at a model set of excitation and ionization cross sections for N_2. Then Bethe's theory of stopping power is extended to arrive at a fractional energy loss function for low energy electrons in molecular nitrogen. These functions are used to calculate the energy deposited in various discrete and continuous states of nitrogen resulting from the slow down of electrons. Particular attention is given to the energies in the thousand-electron-volt region

which are probably of considerable importance in auroral phenomena. The results of a sample calculation indicate that a large fraction of the energy ultimately ends up in ultraviolet emitting states. The implications of these results with respect to the ultraviolet aurora are discussed.

Griffith, R. W.

G14 ZERO-FIELD SPLITTING, ONE- AND TWO-CENTER COULOMB-TYPE INTEGRALS
Geller, M., Griffith, R. W.
Technical Report No. 32-549 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, Vol. 40, No. 8, April 15, 1964)

For abstract, see Entry G03.

Hamilton, T. W.

H01 THE *RANGER VI* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING AREA
Sjogren, W. L., Curkendall, D. W., Hamilton, T. W., Kirhofer, W. E., Liu, A. S., Trask, D. W., Winneberger, R. A., Wollenhaupt, W. R.
Technical Report No. 32-605, December 15, 1964 (Unclassified)

For abstract, see Entry S13.

H02 DETERMINATION OF SOME PHYSICAL PROPERTIES OF THE ATMOSPHERE OF MARS FROM CHANGES IN THE DOPPLER SIGNAL OF A SPACECRAFT ON AN EARTH-OCCULTATION TRAJECTORY
Kliore, A., Cain, D. L., Hamilton, T. W.
Technical Report No. 32-674, October 15, 1964 (Unclassified)

For abstract, see Entry K10.

H03 EARTH–MARS TRAJECTORIES, 1964
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum No. 33-100, Vol. 1, Part B, March 15, 1964 (Unclassified)

For abstract, see Entry C10.

H04 EARTH–MARS TRAJECTORIES, 1964
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum No. 33-100, Vol. 1, Part C, April 1, 1964 (Unclassified)

For abstract, see Entry C11.

Hardy, J.

H05 POLYMER DEGRADATION III. CARBON-14 AS A TRACER FOR STUDIES OF THE THERMAL DEGRADATION OF POLYURETHANES
Simha, R., Ingham, J. D., Rapp, N. S., Hardy, J.
Technical Report No. 32-603 (Unclassified)
(Reprinted from *Polymer Letters*, Vol. 2, 1964)

For abstract, see Entry S11.

Harper, A. D.

H06 OPTIMIZATION OF SYSTEM OPERATING PARAMETERS FOR HEAT STERILIZABLE LIQUID PROPULSION SYSTEMS
Curtis, H. D., Harper, A. D.
Technical Memorandum No. 33-211, June 1, 1965

For abstract, see Entry C21.

Harris, R. A.

H07 SPACE — SINGLE PRECISION COWELL TRAJECTORY PROGRAM
White, R. J., Rosenberg, A. D., Fisher, P. S., Harris, R. A., Newhall, N. S.
Technical Memorandum 33-198, January 15, 1965 (Unclassified)

For abstract, see Entry W12.

H08 SFPRO — SINGLE PRECISION COWELL TRAJECTORY PROCESSOR
Rosenberg, A. D., White, R. J., Fisher, P. S., Harris, R. A., Newhall, N. S.
Technical Memorandum No. 33-199, January 15, 1965 (Unclassified)

For abstract, see Entry R14.

Hartop, R. W.

H09 POWER LOSS BETWEEN ARBITRARILY POLARIZED ANTENNAS
Hartop, R. W.
Technical Report No. 32-457, September 1, 1964 (Unclassified)

The general equation for loss of signal due to polarization mismatching is derived from fundamentals. Approximation formulas, as well as equations covering special cases, are presented in tabular and graphic form.

Haserot, R. L.

H10 *SYNCOM* APOGEE ROCKET MOTOR (DESCRIPTION AND PERFORMANCE CHARACTERISTICS)
Haserot, R. L.
Technical Memorandum No. 33-176, July 1, 1964 (Confidential)

This document presents a brief description of the Syncom apogee rocket motor, including motor performance, as a function of temperature, motor inert components, the ignition system, and the propellant.

Haynes, N. R.

H11 A STUDY OF THE PROBABILITY OF DEPOSITING VIABLE ORGANISMS ON MARS DURING THE *MARINER* 1964 MISSION
Haynes, N. R., Gordon, H. J.
Technical Memorandum No. 33-194, October 23, 1964
(Unclassified)

A spacecraft aimed for the close vicinity of Mars cruises through space leaving a trail of particles due to outgassing, firing of the hot motor used for midcourse maneuvers, and activation of the cold gas attitude control system. The ejected particles follow altered trajectories from their point of separation. It is shown that only the spacecraft itself and the attitude control system exhaust contribute significantly to the probability of planet contamination. The *Mariner* 1964 mission has been designed so that this probability is less than one part in ten thousand. This study considers the actual mission design, and assesses the modifications required if the desired probability were to be reduced to three parts in one hundred thousand.

Heacock, R. L.

H12 *RANGER VII* PART II. EXPERIMENTERS' ANALYSES AND INTERPRETATIONS
Heacock, R. L., Kuiper, G. P., Shoemaker, E. M., Urey, H. C., Whitaker, E. A.
Technical Report No. 32-700, February 10, 1965
(Unclassified)

On July 31, 1964, the *Ranger VII* spacecraft transmitted to Earth more than 4300 photographs of the Moon. Results are presented of the first phase of the analyses of these photographs by a team of scientists. Emphasis was placed on the qualitative interpretation of the pictures in an effort to hypothesize a surface model.

Herrera, J. G.

H13 A PNEUMATIC MODEL LAUNCHER FOR FREE-FLIGHT TESTING IN A CONVENTIONAL WIND TUNNEL
Holway, H. P., Herrera, J. G., Dayman, B., Jr.
Technical Memorandum No. 33-177, July 30, 1964
(Unclassified)

For abstract, see Entry H16.

H14 MAXIMUM MODEL-SIZE DETERMINATION AND EFFECTS OF THE STING DIAMETER ON AN ENTRY SHAPE AND SPHERE FOR LOW SUPERSONIC MACH-NUMBER TESTING
Herrera, J. G.
Technical Memorandum No. 33-191, October 30, 1964
(Unclassified)

This Report describes the experimental determination of the maximum-size entry shape that could be tested at a low supersonic Mach number in the 20-in. wind tunnel at the Jet Propulsion Laboratory. In addition, basic aerodynamic sphere data, to supplement existing data, and the effect of sting diameter on the aerodynamic characteristics are included. Tunnel blockage is discussed, and base flow data are presented.

Higa, W.

H15 TOTAL SYSTEM NOISE TEMPERATURE: 15°K
Clauss, R. C., Higa, W., Stelzried, C., Wiebe, E.
Technical Report No. 32-691 (Unclassified)
(Reprinted from *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-12, No. 6, November 1964)

For abstract, see Entry C12.

Holway, H. P.

H16 A PNEUMATIC MODEL LAUNCHER FOR FREE-FLIGHT TESTING IN A CONVENTIONAL WIND TUNNEL
Holway, H. P., Herrera, J. G., Dayman, B., Jr.
Technical Memorandum No. 33-177, July 30, 1964
(Unclassified)

The adoption of ballistic range techniques to a conventional wind tunnel is enhanced through the use of a pneumatic model launcher. The problems encountered during the development are discussed, and the subsequent solutions are presented.

An inexpensive technique for the fabrication of expendable models was developed through the use of polystyrene plastic and the injection-molding process. The precision of the free-flight, support-free aerodynamic data is dependent upon the high degree of accuracy in the measurements of both the moment of inertia and the center of gravity. These measurements were possible through development of the special instruments described.

Holzman, R.

H17 JPL TRACKING DATA EDITING PROGRAM FOR THE IBM 7094
Holzman, R., Coltharp, C.
Technical Memorandum No. 33-170, August 1, 1964
(Unclassified)

The function of the tracking data editing program is to develop formats so that new tracking data can be handled easily by the orbit determination program. Tracking data are entered on magnetic tape in a wide variety of formats and data types on punched cards, or card images. Flexible control cards allow the user to specify formats and data types, to correct wrong numbers, and to read in a large number of constants used in preliminary reduction of tracking data. These constants include weights, frequencies, smoothing criteria, angle corrections, and transmitter times. Control cards are also used to help the program maintain a master data file and to select particular sets of data from the master file for the orbit determination program.

Horn, F. M.

H18 DESIGN STUDY OF ERROR-DETECTING AND ERROR CORRECTING SHIFT REGISTER
Horn, F. M.
Technical Report No. 32-716, April 15, 1965
(Unclassified)

Details are given of the design study of an N-bit error-detecting and error-correcting (NEDEC) shift register, N being the number of stages in the device. The design criteria, NEDEC philosophy, mechanization, and development are discussed. Included are several representative peripheral circuits; advantages and disadvantages, and test data are presented.

Horowitz, S. M.

H19 *SURVEYOR* FOLLOW-ON STUDY SCIENTIFIC OBJECTIVES—PHASE 1: SIGNIFICANCE OF A SUCCESSFUL *SURVEYOR* BLOCK 1 LANDING
Clark, J. R., Dunk, A. C., Horowitz, S. M., Le Croissette, D. H., Silverstein, E. M.
Technical Memorandum No. 33-192, December 1, 1964
(Unclassified)

For abstract, see Entry C07.

Horton, T. E.

H20 THE JPL THERMOCHEMISTRY AND NORMAL SHOCK COMPUTER PROGRAM
Horton, T. E.
Technical Report No. 32-660, November 1, 1964
(Unclassified)

A computer program capable of calculating chemical equilibrium properties associated with traveling, standing, and reflected normal shocks has been developed. The initial gas mixture, temperature, and pressure can be varied with ease. The program can also be used to generate Mollier thermodynamic data and chemical composition at selected temperatures and densities. Both dissociation and ionization effects are considered in the temperature range of 2000 to 20,000°K. At the present time the program is set up to consider mixtures (containing up to 36 species) which are composed of carbon, nitrogen, oxygen, and argon.

Ingham, J. D.

I01 POLYMER DEGRADATION. II. MECHANISM OF THERMAL DEGRADATION OF POLYOXYPROPYLENE GLYCOL–TOLUENE 2,4-DIISOCYANATE POLYMER (POPG–TDI) AND A BLOCK POLYETHER GLYCOL–TDI POLYMER
Ingham, J. D., Rapp, N. S.
Technical Report No. 32-541 (Unclassified)
(Reprinted from *Journal of Polymer Science, Part A: General Papers*, Vol. 2, 1964)

Further studies on the thermal degradation of POPG–TDI polymer have been conducted. It has been shown that at temperatures of ~200°C, the predominant degradation process involves random scission of the urethane linkages to give substantial amounts of isocyanate and hydroxyl. Kinetic data suggest that the weakest links in POPG–TDI polymer are spaced at intervals of ~10,000 mol wt and may be eliminated by pretreatment of the POPG with ethylene oxide to form a block copolyether used to prepare the polyurethane. At temperatures exceeding 250°C, and with a greater conversion to volatile fragments (>10%), the kinetics of degradation of POPG–TDI are similar to results for POPG and indicate scission of the polyether bonds by a combination of intramolecular proton abstraction and free radical unzipping reactions. These results are in agreement with previous studies of POPG at much higher molecular weight.

I02 POLYMER DEGRADATION III. CARBON-14 AS A TRACER FOR STUDIES OF THE THERMAL DEGRADATION OF POLYURETHANES
Simha, R., Ingham, J. D., Rapp, N. S., Hardy, J.
Technical Report No. 32-603 (Unclassified)
(Reprinted from *Polymer Letters*, Vol. 2, 1964)

For abstract, see Entry S11.

Jacobs, A. M.

J01 A NEW APPROACH TO THE HOMOGENIZATION OF HETEROGENEOUS MEDIA FOR NEUTRON DIFFUSION CALCULATIONS
Jacobs, A. M.
Technical Report No. 32-686, April 15, 1965 (Unclassified)

The mathematical formulation of a new approach to the homogenization of certain types of heterogeneous media for the purpose of neutron diffusion calculations is developed. The new method is based on the inclusion of an angular-dependent mean free path in the theory of neutron transport.

It is found that a neutron-flux based theory and a collision-density based theory can lead to significantly different results when low-order approximations are employed in the solution of the transport equation. For the case of isotropic scattering, the normal mode technique is found applicable, and exact solutions are determined.

Jaffe, L. D.

J02 MECHANICAL AND THERMAL MEASUREMENTS ON SIMULATED LUNAR SURFACE MATERIALS
Jaffe, L. D.
Technical Report No. 32-448 (Unclassified)
(Reprinted from *The Lunar Surface Layer*, Academic Press, Inc., 1964)

Work on the mechanical and thermal properties of rock powders in vacuum and in air is described. The known behavior of terrestrial soils in air, as summarized in the field of soil mechanics, is used as a basis for comparison.

Jaivin, G. I.

J03 EFFECT OF HOLE SIZE ON PRESSURE MEASUREMENTS MADE WITH A FLAT-PLATE DYNAMIC-HEAD PROBE
Jaivin, G. I.
Technical Report No. 32-617, June 15, 1964 (Unclassified)

The dynamic-head probe, a device for evaluating the properties of free liquid jets, produced anomalous results when used to evaluate the characteristics of a laminar, uniform velocity profile jet. A comparison of the integrated pressure force on the probe with the measured thrust indicated the cause to be inaccurate pressure measurements. An investigation of the effect of the hole size used in the probe showed this factor to be significant in affecting the accuracy of the pressure measurements. A ratio of the probe-hole diameter to the jet diameter of 0.04:1 was found sufficient to eliminate probe-hole effects and to produce a good correlation of experimental and theoretical pressure data.

J04 A MOMENTUM-BALANCE METHOD FOR MEASURING THE THICKNESS OF FREE LIQUID SHEETS
Jaivin, G. I.
Technical Report No. 32-635, August 17, 1964 (Unclassified)

A method is presented for determining experimentally the momentum-averaged thickness of free liquid sheets. The technique requires the experimental determination of the reaction force produced by a sector of a liquid sheet upon a deflection plate placed in its path. This measurement, together with a weight-flow rate, is used to calculate the local thickness and average velocity of the sheet by simultaneous solution of the applicable momentum and flow continuity relations. Details of the experimental apparatus are presented, and results are given which were obtained when the apparatus was used to evaluate an axially symmetric laminar liquid sheet.

J05 THE EFFECTS OF INJECTION MASS FLUX DISTRIBUTIONS AND RESONANT COMBUSTION ON LOCAL HEAT TRANSFER IN A LIQUID-PROPELLANT ROCKET ENGINE
Rupe, J. H., Jaivin, G. I.
Technical Report No. 32-648, October 1, 1964 (Unclassified)

For abstract, see Entry R18.

Jet Propulsion Laboratory

J06 *RANGER VII* PART I. MISSION DESCRIPTION AND PERFORMANCE
Jet Propulsion Laboratory
Technical Report No. 32-700, December 15, 1964 (Unclassified)

This document series constitutes the formal report of the *Ranger VII* mission. Part I is a technical description and a performance evaluation of the systems and elements comprising the *Ranger VII* project. Some of the content was drawn from previously published reports, a general list of which is given in the Bibliography; the greater portion, however, was prepared by the cognizant engineers and other Jet Propulsion Laboratory members of the *Ranger* team. The report was compiled and edited under the direction of G. P. Kautz.

Johnson, N. E.

J07 INVESTIGATION OF FIBERGLASS SHROUD MATERIALS
Johnson, N. E.
Technical Memorandum No. 33-214, April 1, 1965 (Unclassified)

This Memorandum describes the effort performed at the Jet Propulsion Laboratory in investigating the failure of a recent spacecraft mission. The results indicate that the probable cause of the failure was the explosive delamination of the fiberglass honeycomb shroud which covered the spacecraft during the first portion of flight.

Juvinall, G. L.

J08 σ-BONDED ALKYL COMPOUNDS OF NIOBIUM AND TANTALUM. TRIMETHYLDICHLORONIOBIUM AND TRIMETHYLDICHLOROTANTALUM
Juvinall, G. L.
Technical Report No. 32-681 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, Vol. 86, 1964)

The first successful syntheses of alkyl derivatives of niobium and tantalum are reported. Trimethyldichloroniobium, $(CH_3)_3$ $NbCl_2$, and trimethyldichlorotantalum, $(CH_3)_3$–$TaCl_2$, have been prepared by the low temperature exchange of methyl groups and chlorine between dimethylzinc and the pentachlorides of niobium and tantalum, respectively. Results of these preparations are presented.

Kahn, M. E.

K01 THE EFFECT OF SOLAR SIMULATOR OPERATING CHARACTERISTICS ON SPACECRAFT THERMAL TESTS
Katter, L. B., Kahn, M. E.
Technical Memorandum No. 33-175, July 15, 1964 (Unclassified)

For abstract, see Entry K02.

Katter, L. B.

K02 THE EFFECT OF SOLAR SIMULATOR OPERATING CHARACTERISTICS ON SPACECRAFT THERMAL TESTS
Katter, L. B., Kahn, M. E.
Technical Memorandum No. 33-175, July 15, 1964 (Unclassified)

A study is made to determine the effect of the following solar-simulator operating characteristics on spacecraft ther-

mal tests: (1) decollimation, (2) spectral mismatch, and (3) axial and radial variations of energy flux density. In addition, the effect of solar simulator optics in the chamber is considered for certain special cases.

Kelly, A. J.

K03 A MICROWAVE PROBE FOR PLASMA PLUMES
Kelly, A. J.
Technical Report No. 32-625 (Unclassified)
(Reprinted from *AIAA Journal*, Vol. 3, No. 2, February 1965)

A swinging-arm microwave probe has been developed to measure the electron-density profile and effective electron-collision frequency profile transverse to a plasma-jet plume. This probe can also be used to take time-resolved data at selected positions within the plume where the observation time is small in comparison with the dwell time in the plume.

Kendall, W. B.

K04 THE PROBABILITY DENSITY FUNCTION FOR PHASE-DIFFERENCE ESTIMATES OBTAINED FROM THE ENVELOPES OF THE SUM AND DIFFERENCE OF TWO SINE WAVES
Kendall, W. B.
Technical Report No. 32-621 (Unclassified)
(Reprinted from *Proceedings of the IEEE*, Vol. 52, No. 9, September 1964)

If phase-difference measurements between low-level, equi amplitude sine waves must be made using amplifiers which are *not* phase-matched but which *are* gain-matched, then a possible estimation procedure is the use of the expression $2 \tan^{-1} (Z_-/Z_+)$ as the estimate, where Z_+ is the envelope of the sum of the two sine waves, and Z_- is the envelope of the difference between the two sine waves. In this Report, simple, exact expressions for the probability density and distribution functions of this phase difference estimate are obtained, when the two sine waves are corrupted by additive gaussian noise.

Kindt, D. H.

K05 THE DESIGN OF THE *RANGER* TELEVISION SYSTEM TO OBTAIN HIGH-RESOLUTION PHOTOGRAPHS OF THE LUNAR SURFACE
Kindt, D. H., Staniszewski, J. R.
Technical Report No. 32-717, March 1, 1965 (Unclassified)

This Report presents: (1) the design of the television system incorporated into the *Ranger* spacecraft; (2) a brief description of the mission flight sequence, along with some of the constraints and unknown factors that influenced the design of the television system; (3) the design of the ground recovery system, showing the interfaces with the Deep Space Instrumentation Facility as well as those with the flight television system; (4) and a brief analysis of the *Ranger VII* flight performance.

Kirhofer, W. E.

K06 EARTH–MOON TRAJECTORIES, 1964–69
Richard, R. J., Clarke, V. C., Jr., Roth, R. Y., Kirhofer, W. E.
Technical Report No. 32-503, May 1, 1964

For abstract, see Entry R08.

K07 THE *RANGER VI* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Sjogren, W. L., Curkendall, D. W., Hamilton, T. W., Kirhofer, W. E., Liu, A. S., Trask, D. W., Winneberger, R. A., Wollenhaupt, W. R.
Technical Report No. 32-605, December 15, 1964 (Unclassified)

For abstract, see Entry S13.

Kizner, W.

K08 A HIGH-ORDER PERTURBATION THEORY USING RECTANGULAR COORDINATES
Kizner, W.
Technical Report No. 32-470 (Unclassified)
(Reprinted from *Progress in Astronautics and Aeronautics*, Vol. 14, Academic Press Inc, 1964)

Basically, this paper presents a two-part method for approximating a system of nonlinear equations by a series of linear equations. It also shows how the differential equations for the osculating elements are derived using rectangular coordinates, and how an analytic solution to these equations may be obtained with the aid of a digital computer.

K09 A NUMERICAL METHOD FOR FINDING SOLUTIONS OF NONLINEAR EQUATIONS
Kizner, W.
Technical Report No. 32-615 (Unclassified)
(Reprinted from *Journal of the Society for Industrial and Applied Mathematics*, Vol. 12, No. 2, June 1964)

The method herein raises the order of convergence of the iterative method without calculating derivatives of higher order or requiring more accuracy than Newton's method. A point of view is presented which differs from those of existing methods in that the solution is thought of as the integration of a differential equation using a Runge-Kutta method.

Kliore, A.

K10 DETERMINATION OF SOME PHYSICAL PROPERTIES OF THE ATMOSPHERE OF MARS FROM CHANGES IN THE DOPPLER SIGNAL OF A SPACECRAFT ON AN EARTH-OCCULTATION TRAJECTORY
Kliore, A., Cain, D. L., Hamilton, T. W.
Technical Report No. 32-674, October 15, 1964 (Unclassified)

The physical properties of the atmosphere of Mars are of great interest not only to astronomers but also to the technol-

ogists who are planning to land instrumented spacecraft on the planet's surface. An improved knowledge of the density of the atmosphere of Mars both at the surface and with altitude is to be achieved by observing changes to the frequency of the spacecraft signal as the signal passes through the atmosphere of Mars prior to occultation by the planet.

The expressions describing the effects of refraction in the atmosphere are derived and used to compute expected doppler changes for several isothermal model atmospheres of Mars, using typical 1964 and 1966–1967 Earth-occulting Mars fly-by trajectories. Based on these computed results, and on the expected data accuracy, it is estimated that the scale height and surface density of the atmosphere of Mars can be determined with an accuracy of better than 10% by means of the experiment. Several limitations of the experiment are described, and their effects on the results are discussed.

Kuiper, G. P.

K11 *RANGER VII* PART II. EXPERIMENTERS' ANALYSES AND INTERPRETATIONS
Heacock, R. L., Kuiper, G. P., Shoemaker, E. M., Urey, H. C., Whitaker, E. A.
Technical Report No. 32-700, February 10, 1965 (Unclassified)

For abstract, see Entry H12.

Laufer, J.

L01 SOME STATISTICAL PROPERTIES OF THE PRESSURE FIELD RADIATED BY A TURBULENT BOUNDARY LAYER
Laufer, J.
Technical Report No. 32-528 (Unclassified)
(Reprinted from *The Physics of Fluids*, Vol. 7, No. 8, August 1964)

The radiation field generated by a supersonic turbulent boundary layer is examined, and the experimental technique for measuring the pressure fluctuations is described.

Laumann, E. A.

L02 COMPARISONS OF EXPERIMENTAL AND THEORETICAL AERODYNAMIC HEATING RESULTS IN AIR-CARBON DIOXIDE MIXTURES
Laumann, E. A.
Technical Report No. 32-715, January 15, 1965 (Unclassified)

Convective heat-transfer experiments were conducted in air-carbon dioxide mixture in a hypersonic wind tunnel. The mixtures were in chemical equilibrium, and the amounts of carbon dioxide in air were varied from 0 to 72 vol%. Using calorimetric techniques, the convective heating of three different model shapes was measured.

The results of these experiments are compared with the stagnation point heating theory of Fay and Riddell, using the Lennard-Jones potential theory to evaluate the transport properties of the gas mixtures. The heat-transfer distributions are compared to Lees' theory.

Le Croissette, D. H.

L03 *SURVEYOR* FOLLOW-ON STUDY SCIENTIFIC OBJECTIVES — PHASE 1: SIGNIFICANCE OF A SUCCESSFUL *SURVEYOR* BLOCK 1 LANDING
Clark, J. R., Dunk, A. C., Horowitz, S. M., Le Croissette, D. H., Silverstein, E. M.
Technical Memorandum No. 33-192, December 1, 1964 (Unclassified)

For abstract, see Entry C07.

Leipold, M. H.

L04 THERMAL CONDUCTIVITY AND RADIANT ENERGY TRANSPORT APPARATUS FOR NONELECTRICAL CONDUCTORS TO 2000°C
Leipold, M. H.
Technical Report No. 32-559, June 1, 1964 (Unclassified)

The apparatus described – for measuring the thermal conductivity of nonelectrical conductors to approximately 2000°C – has been in operation for over a year, and approximately 150 runs have been completed. The results are found to agree with published values for materials investigated, and an analysis is made of the nature of the high-temperature anomalous behavior. The measurement technique employed is described.

In order to evaluate a popular theory for anomalous thermal conductivity, a device is incorporated to study the radiant energy being transmitted through the specimen. The measurement of this energy is made concurrently with the thermal conductivity measurement. Radiation energy being emitted from the specimen's surface or near surface is determined over a wavelength range of 0.4 to 2.0.

L05 THERMAL EXPANSION OF YTTRIUM OXIDE AND OF MAGNESIUM OXIDE WITH YTTRIUM OXIDE
Nielsen, T. H., Leipold, M. H.
Technical Report No. 32-651 (Unclassified)
(Reprinted from *The American Ceramic Society*, Vol. 47, No. 5, May 1964)

For abstract, see Entry N11.

L06 FABRICATION OF HIGH-PURITY POLYCRYSTALLINE MgO
Leipold, M. H., Nielsen, T. H.
Technical Report No. 32-736, May 15, 1965 (Unclassified)

A technique has been developed for the chemical production of very pure magnesium oxide powder. This powder is then fabricated by specialized hot-pressing techniques into theoretically dense polycrystalline specimens. Details of the process, including starting reagents, are given. Chemical analysis of the MgO produced by this technique indicates that the material contains approximately one-tenth as much

impurity as a pure MgO from a commercial source. Initial studies of this pure MgO demonstrate grain growth approximately 100 times that found in MgO of conventionally good purity.

Lindsey, W. C.

L07 OPTIMUM AND SUBOPTIMUM FREQUENCY DEMODULATION
Lindsey, W. C.
Technical Report No. 32-637, June 15, 1964 (Unclassified)

The design and mechanization of frequency demodulators for use in telemetry communications are discussed. In general the phase-locked loop and linear-output filters described are adaptive in that their pole-zero configuration depends on the available signal power, the noise spectral density, and the modulation index. Because the filters are difficult to mechanize, two alternate and more easily implemented suboptimum frequency demodulators are analyzed.

Synthesis procedures for the optimum loop and output filters are given, and the transient behavior of the optimized system is determined. For various receiver threshold characteristics, the performance of the linear and quasi-linear demodulator models is graphically illustrated and compared for all three receiver designs.

Finally, an amplitude-modulated single-sideband or double-sideband system (which is "amplitude matched" to the same modulating spectra) is compared with that of the optimum and suboptimum linear demodulators. The results are useful for the design of optimum and near-optimum frequency demodulators.

Liu, A. S.

L08 THE *RANGER VI* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Sjogren, W. L., Curkendall, D. W., Hamilton, T. W., Kirhofer, W. E., Liu, A. S., Trask, D. W., Winneberger, R. A., Wollenhaupt, W. R.
Technical Report No. 32-605, December 15, 1964 (Unclassified)

For abstract, see Entry S13.

L09 *RANGER VII* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Wollenhaupt, W. R., Trask, D. W., Sjogren, W. L., Piaggi, E. G., Curkendall, D. W., Winneberger, R. A., Liu, A. S., Berman, A. L.
Technical Report No. 32-694, December 15, 1964 (Unclassified)

For abstract, see Entry W22.

Livingston, F. R.

L10 HYPERVELOCITY SHOCK TUBE
Collins, D. J., Livingston, F. R., Babineaux, T. L., Morgan, N. R.
Technical Report No. 32-620, June 15, 1964 (Unclassified)

For abstract, see Entry C15.

L11 EXPERIMENTALLY MEASURED EFFECTS OF THE WALL BOUNDARY LAYER ON SHOCK-TUBE PERFORMANCE
Livingston, F. R.
Technical Report No. 32-714, March 1, 1965 (Unclassified)

Shock speed and test time were measured in a 3-in. diameter shock tube. This tube was evaluated as the hot gas supply for a 43-in. diameter shock tunnel. Nitrogen was used as the test gas in the experiment, with hydrogen as the driver gas. Shock speeds compared favorably with the ideal shock-tube theory, corrected for laminar and turbulent wall boundary-layer effects. Measured test time agreed with the laminar wall boundary-layer theory of Mirels at initial nitrogen pressures below 10 mm Hg.

Locke, J. R.

L12 AN ELECTROSTATICALLY DRIVEN DYNAMIC CAPACITOR
Locke, J. R.
Technical Memorandum No. 33-178, July 15, 1964 (Unclassified)

In the measurement of very small currents, e.g., 10^{-13} amp, the vibrating-capacitor electrometer can be considered a preeminent instrument; however, due to the prohibitive weight of most vibrating capacitors, this type of electrometer has been limited primarily to laboratory applications. This Report introduces a vibrating capacitor which is ideally suited for space-flight applications since it weighs approximately an ounce and is about the size of a power transistor. Presented also are the capacitor's fundamental operating principles, its function as part of an electrometer amplifier, and the history of its development to date.

Lonborg, J. O.

L13 HIGH-IMPACT SURVIVAL
Lonborg, J. O.
Technical Report No. 32-647, September 30, 1964 (Unclassified)

The objective of the impact survival program is the development of the technology required to design and package electronic equipment capable of surviving hard impacts: e.g., in unmanned lunar and planetary landings. The experimental work includes component evaluation, component development, packaging investigations, and development of special shock-test equipment and techniques. A solid-state L-band transmitter has been developed which is capable of surviving impacts of 5000 g at a velocity of 200 ft/sec. This Report concludes that it is reasonable to attempt to design lunar and planetary landing capsule systems of moderate size and complexity for survival of impacts of the order of 1000 to 10,000 g-peak amplitude at a velocity of at least 200 ft/sec.

Lorell, J.

L14 ORBIT DETERMINATION FOR A LUNAR SATELLITE
Lorell, J.
Technical Report No. 32-483 (Unclassified)
(Reprinted from *The Journal of the Astronautical Sciences*, Vol. 11, No. 1, 1964)

The orbit determination problem for a lunar satellite is examined from the point of view of geometric determinancy of the data. Various data-type combinations are considered, including radar range, radar range-rate, and optical. Using appropriate coordinate systems, it is shown how the condition equations may be set up, and how the number of data points required for solution may be calculated. It is also shown how these considerations are related to the statistical problem of determining the orbit from noisy data.

Manatt, S. L.

M01 RELATIVE SIGNS OF THE NUCLEAR SPIN COUPLING CONSTANTS IN PROPYLENE OXIDE AND INDENE OXIDE
Elleman, D. D., Manatt, S. L., Pearce, C. D.
Technical Report No. 32-706 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, Vol. 42, No. 2, January 15, 1965)

For abstract, see Entry E05.

Marsh, H. E., Jr.

M02 STERILIZED SOLID-PROPELLANT ROCKET MOTORS FOR MARS LANDING MISSIONS
Montgomery, L. C., Marsh, H. E., Jr.
Technical Report No. 32-725, March 30, 1965 (Confidential)

For abstract, see Entry M21.

Marshall, J. H.

M03 AN AMPLIFIER FOR USE WITH SOLID STATE RADIATION DETECTORS IN SPACECRAFT APPLICATIONS
Marshall, J. H.
Technical Memorandum No. 33-190, October 30, 1964 (Unclassified)

A charge-sensitive amplifier for use with solid-state radiation detectors is described. Particular emphasis is placed on an analytic design approach so that optimal gain stability and resolution can be obtained for a minimum of weight and power. Measured results of an amplifier constructed for laboratory use are presented for comparison with the theoretical analysis. The amplifier is presently being used in the second-generation alpha scattering experiment on *Surveyor*.

Marte, J. E.

M04 THERMAL DECOMPOSITION OF FLUOROFORM IN A SINGLE-PULSE SHOCK TUBE. I
Tschuikow-Roux, E., Marte, J. E.
Technical Report No. 32-721 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, Vol. 42, No. 6, March 15, 1965)

For abstract, see Entry T11.

M05 LOW SUBSONIC DYNAMIC-STABILITY INVESTIGATION OF SEVERAL PLANETARY-ENTRY CONFIGURATIONS IN A VERTICAL WIND TUNNEL (PART I)
Marte, J. E., Weaver, R. W.
Technical Report No. 32-743, May 1, 1965 (Unclassified)

An experimental investigation of the dynamic-damping parameter $\overline{C}_{m_q}$, for a series of possible Mars-entry configurations was performed in the Langley 20-ft free-spinning tunnel at low subsonic velocities. Several of the tested configurations exhibited satisfactory dynamic characteristics including the ability to recover from angular deflections up to 80 deg. The effect of afterbody shape and maximum angle of oscillation on the dynamic stability of certain configurations was ascertained. Drag and pitching-moment data were also obtained.

M06 VISCOUS DAMPING OF ROLL DURING ENTRY OF A MARS ENTRY AND LANDING CAPSULE
Marte, J. E.
Technical Memorandum No. 33-201, April 1, 1965 (Unclassified)

An analysis has been made of the viscous damping in roll during planetary entry of two capsule configurations. The analysis extends the incompressible solution of flow over a rotating flat disk to the region behind the bow shock of both a blunt and a hemisphere-cone forebody. The results of a simplified example show the damping to be about 7%, independent of the initial roll rate. A method of integrating the results into the six-degree-of-freedom program has been developed.

M07 LOW SUBSONIC DYNAMIC-STABILITY INVESTIGATION OF SEVERAL PLANETARY-ENTRY CONFIGURATIONS IN A VERTICAL WIND TUNNEL (PART II)
Marte, J. E., Weaver, R. W.
Technical Memorandum No. 33-215, May 1, 1965 (Confidential)

This Report is a classified extension of Technical Report No. 32-743. A model design was investigated for its capability to achieve low subsonic dynamic stability during Mars atmospheric entry.

Martens, H. E.

M08 PROPERTIES OF WELDED HIGH-STRENGTH TITANIUM ALLOY SHEET
Brothers, A. J., Martens, H. E., Wood, H. L.
Technical Report No. 32-39, Revision 1 (Unclassified)
(Reprinted from *Proceedings of the American Society for Testing and Materials*, Vol. 63, 1963)

For abstract, see Entry B21.

Massier, P. F.

M09 CONVECTIVE HEAT TRANSFER IN A CONVERGENT-DIVERGENT NOZZLE
Back, L. H., Massier, P. F., Gier, H. L.
Technical Report No. 32-415 (Revision No. 1), February 15, 1965 (Unclassified)

For abstract, see Entry B02.

M10 COMPARISONS OF EXPERIMENTAL WITH PREDICTED WALL STATIC-PRESSURE DISTRIBUTIONS IN CONICAL SUPERSONIC NOZZLES
Back, L. H., Massier, P. F., Gier, H. L.
Technical Report No. 32-654, October 15, 1964 (Unclassified)

For abstract, see Entry B03.

Mathison, R. P.

M11 *MARINER* MARS 1964 TELEMETRY AND COMMAND SYSTEM
Mathison, R. P.
Technical Report No. 32-684, June 1, 1965 (Unclassified)

The *Mariner* Mars 1964 telemetry system is required to transmit video data from the vicinity of Mars in addition to transmitting other scientific and engineering data during the entire flight. The command system provides for the transmission of both direct and quantitative commands to the spacecraft.

The telemetry and command system for the *Mariner* Mars 1964 mission utilizes an extension of the techniques used for the *Mariner* Venus 1962 mission. For both the command and telemetry functions, PCM/PSK/PM modulation-demodulation in combination with pseudo-random sync codes is used.

McCaa, D. J.

M12 THE ($\nu_1 + \nu_3$) COMBINATION BAND OF OZONE
Trajmar, S., McCaa, D. J.
Technical Report No. 32-557 (Unclassified)
(Reprinted from *Journal of Molecular Spectroscopy*, Vol. 14, No. 3, November 1964)

For abstract, see Entry T07.

McClatchey, R. A.

M13 INFRARED HEAT TRANSFER BY ATMOSPHERIC WATER VAPOR
McClatchey, R. A.
Technical Report No. 32-683 (Unclassified)
(Reprinted from *Journal of Applied Meteorology*, Vol. 3, No. 5, October 1964)

Empirical data on transmission functions are used to set up a general program to calculate the infrared radiation flux in the atmosphere in the two major regions of water-vapor absorption. Employing these data as input together with atmospheric soundings, the problem is solved through the use of an electronic computer. The northern hemisphere average soundings for March are used as input to the computer program, and the results obtained are compared with cooling-rate calculations. The results for an additional sounding are displayed to demonstrate the effect of lapse-rate stability on cooling rate.

McEliece, R. J.

M14 OPTIMAL COMMUNICATIONS NETS
McEliece, R. J.
Technical Report No. 32-697, April 15, 1965 (Unclassified)

The following problem is posed: If $\bar{\lambda}$ is the average separation between vertices in a finite, connected, undirected graph and m is the total number of edges, which graph with n vertices minimizes $m\bar{\lambda}$? The unique solution is shown to be the star graph. Variance of this is done with weighted paths and probabilistic weights.

McFarland, R. K., Jr.

M15 THE DEVELOPMENT OF METAL HONEYCOMB ENERGY-ABSORBING ELEMENTS
McFarland, R. K., Jr.
Technical Report No. 32-639, July 24, 1964 (Unclassified)

The results of an experimental development program to evaluate and optimize metal honeycomb elements for use as axial energy absorbers are presented. The results indicate the potential of metal honeycomb elements for this purpose and the range of variables to be considered in the design and optimization of these elements.

McNeal, C. E.

M16 *RANGER* 5 TRACKING SYSTEMS DATA ANALYSIS FINAL REPORT
McNeal, C. E.
Technical Report No. 32-702, April 15, 1965 (Unclassified)

Presented are the results of the analysis of the tracking performance of the Deep Space Instrumentation Facility during the *Ranger* 5 mission. Tracking performance was determined by a study of tracking data, oscillographs and station reports, and preflight and postflight calibrations.

Menard, W. A.

M17 TOTAL RADIATION HEAT TRANSFER GAGE FOR HYPERVELOCITY SHOCK TUBE EXPERIMENTS
Thomas, G. M., Menard, W. A.
Technical Report No. 32-636, August 1, 1964 (Unclassified)

For abstract, see Entry T03.

Metzger, A. E.

M18 AN X-RAY SPECTOGRAPH FOR LUNAR SURFACE ANALYSIS
Metzger, A. E.
Technical Report No. 32-669, October 16, 1964 (Unclassified)

The potential of X-ray spectroscopy for the remote elemental analysis of lunar and planetary surfaces has been explored. This Report describes the performance of a proposed X-ray spectrograph for the *in situ* analysis of powdered samples of lunar material.

General considerations in the design of the X-ray spectrograph for lunar analysis are discussed. The instrument employs electron beam excitation, with dispersive crystal resolution in a fixed channel geometry. A nondispersive capability by means of pulse height analysis is also included. The processes of inter-elemental X-ray absorption and enhancement are discussed; they are illustrated by curves of response as a function of composition.

Experimental results using both synthetic and natural rock materials are presented for the dispersive and nondispersive modes. It is concluded that X-ray spectroscopy can be adapted to lunar spacecraft operation to perform a straightforward quantitative analysis for elements present in minor as well as major abundance.

Moacanin, J.

M19 KINETICS OF THE ANIONIC POLYMERIZATION OF ACENAPHTHYLENE
Moacanin, J., Rembaum, A.
Technical Report No. 32-662 (Unclassified)
(Reprinted from *Journal of Polymer Science, Part B: Polymer Letters*, Vol. 2, 1964)

From this study, four important facts emerge: (1) the overall rate follows pseudo first-order kinetics; (2) the activation energies, as compared to other anionic systems, are high; and the propagation rates are exceptionally low; (3) the highest molecular weight obtainable is about 8000; and (4) electron spin resonance measurements show the acenaphthylene radical anion initiator to be the sole radical species observable, and that its concentration remains nearly constant during the polymerization.

M20 SOME UNUSUAL PROPERTIES OF GRAFT COPOLYMERS AND POLYBLENDS OF β-VINYLNAPHTHALENE AND ETHYLENE OXIDE
Cuddihy, E., Moacanin, J., Rembaum, A.
Technical Report No. 32-708 (Unclassified)
(Reprinted from *Journal of Applied Polymer Science*, Vol. 9, No. 4, April 1965)

For abstract, see Entry C18.

Montgomery, L. C.

M21 STERILIZED SOLID-PROPELLANT ROCKET MOTORS FOR MARS LANDING MISSIONS
Montgomery, L. C., Marsh, H. E., Jr.
Technical Report No. 32-725, March 30, 1965 (Confidential)

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

Morgan, N. R.

M22 HYPERVELOCITY SHOCK TUBE
Collins, D. J., Livingston, F. R., Babineaux, T. L., Morgan, N. R.
Technical Report No. 32-620, June 15, 1964 (Unclassified)

For abstract, see Entry C15.

Nagler, R. G.

N01 COMMENTS ON RECENT STUDIES OF THE DEGRADATION OF POLYMERS AT HIGH HEAT FLUXES
Nagler, R. G.
Technical Memorandum No. 33-182, September 1, 1964 (Unclassified)

In a recently reported study of the degradation of three polymeric materials exposed to high heat fluxes, it was suggested that comparison of the results with data by other experimenters is not valid because the comparative base points were inadequate. It is evident that many of the anomalies noted in such investigations to date have resulted from variations in test equipment and techniques. This memorandum concludes that meaningful comparative data will be obtained only when correlation of experimental methods has been established.

N02 PRELIMINARY ANALYSIS OF THE IMPORTANCE OF MATERIAL PROPERTIES AND THERMAL INPUTS ON HEAT SHIELDS FOR MARS ENTRY
Nagler, R. G.
Technical Memorandum No. 33-209, June 1, 1965 (Unclassified)

The potential range of material properties available for low-ballistic-coefficient entry into Mars in 1966, 1969, or 1971 is evaluated as to the magnitude of the effect of the individual properties and the coupling between these properties. Predicted typical Mars entry heat pulses and informational variations in these pulses are used in the analyses.

Nead, M. W.

N03 SPODP — SINGLE PRECISION ORBIT DETERMINATION PROGRAM
Warner, M. R., Nead, M. W.
Technical Memorandum No. 33-204, February 15, 1965 (Unclassified)

For abstract, see Entry W03.

Neugebauer, M.

N04 SOLAR-WIND MEASUREMENTS NEAR VENUS
Neugebauer, M., Snyder, C. W.
Technical Report No. 32-733 (Unclassified)
(Reprinted from *Journal of Geophysical Research*, Vol. 70, No. 7, April 1, 1965)

The velocity, temperature, and density of the protons in the solar wind are presented for the period when *Mariner II* was near Venus. From these data it is concluded that (1) *Mariner II* never penetrated any magnetosphere associated with Venus, (2) *Mariner II* was probably also outside any shock front associated with the supersonic motion of the solar wind past Venus, (3) the solar-wind intensity was not especially great during the time of Venus encounter, (4) any shock wave surrounding Venus was probably closer than about 25,000 km to the center of the planet at the subsolar point.

Newhall, N. S.

N05 SPACE — SINGLE PRECISION COWELL TRAJECTORY PROGRAM
White, R. J., Rosenberg, A. D., Fisher, P. S., Harris, R. A., Newhall, N. S.
Technical Memorandum No. 33-198, January 15, 1965 (Unclassified)

For abstract, see Entry W12.

N06 SFPRO — SINGLE PRECISION COWELL TRAJECTORY PROCESSOR
Rosenberg, A. D., White, R. J., Fisher, P. S., Harris, R. A., Newhall, N. S.
Technical Memorandum No. 33-199, January 15, 1965 (Unclassified)

For abstract, see Entry R14.

N07 A USERS' GUIDE FOR SEARCH AND ITER
Newhall, N. S.
Technical Memorandum No. 33-203, April 15, 1965 (Unclassified)

With the creation of the Jet Propulsion Laboratory's new trajectory monitor (JPTRAJ) came a unique ability — programming options are now separate entities tied together in a JPTRAJ source deck. Two of the programs are described: (1) SEARCH, a program to calculate initial values of a trajectory whose end conditions are known, and (2) ITER, an iterative program simulating a "DO-loop" in a source deck. Both programs operate on an IBM 7094 under JPTRAJ, running under either the SFOF or FORTRAN system.

Nezhni, N.

N08 A METHOD FOR MINIMIZING STRAY MAGNETIC FIELDS IN THE ELECTROMAGNETIC VIBRATION EXCITER
Nezhni, N.
Technical Report No. 32-709, January 15, 1965 (Unclassified)

In the vibration testing of spacecraft instruments, the effect of stray magnetic fields from the vibration exciter was found to produce undesirable residual magnetism in the instrument under test. This Report presents a simple and inexpensive method for the practical elimination of such fields.

Nichols, J. O.

N09 AERODYNAMIC CHARACTERISTICS OF BLUNT BODIES
Nichols, J. O., Nierengarten, E. A.
Technical Report No. 32-677, November 19, 1964 (Unclassified)

The static aerodynamic characteristics of three related families of blunt bodies — spherically blunted cones, spherical segments, and round-shouldered circular cylinders — are presented. Data from tests of blunted cones conducted at the Marshall Space Flight Center and the Wright Air Development Center are presented together with data from tests at the Jet Propulsion Laboratory to extend the ranges of test parameters. The ranges of parameters are: cone half-angle from 10 to 60 deg; bluntness ratio (nose radius/base radius) from 0 to 1.0; and Mach number from 1.65 to 9.0, with some data at subsonic Mach numbers. The spherical segments and round-shouldered circular cylinders have not been as extensively investigated at the spherically blunted cones. This Report presents the results of the first systematic tests of these bodies.

Nicklas, J. C.

N10 THEORETICAL AND PRACTICAL ASPECTS OF SOLAR PRESSURE ATTITUDE CONTROL FOR INTERPLANETARY SPACECRAFT
Acord, J. D., Nicklas, J. C.
Technical Report No. 32-467, May 15, 1964 (Unclassified)

For abstract, see Entry A01.

Nielsen, T. H.

N11 THERMAL EXPANSION OF YTTRIUM OXIDE AND OF MAGNESIUM OXIDE WITH YTTRIUM OXIDE
Nielsen, T. H., Leipold, M. H.
Technical Report No. 32-651 (Unclassified)
(Reprinted from *The American Ceramic Society*, Vol. 47, No. 5, May 1964)

The thermal expansion of polycrystalline yttrium oxide and of magnesium oxide plus 3 wt% yttrium oxide was measured in both high-oxygen and argon-hydrogen atmospheres to above 2000°C. Expansion measurements from room temperature to 1000°C were made in an automatic recording dilatometer; above 1000°C, measurements were made in an oxide induction furnace; the change in length of the specimen was measured with telemicroscopes.

N12 FABRICATION OF HIGH-PURITY POLYCRYSTALLINE MgO
Leipold, M. H., Nielsen, T. H.
Technical Report No. 32-736, May 15, 1965 (Unclassified)

For abtract, see Entry L06.

Nierengarten, E. A.

N13 AERODYNAMIC CHARACTERISTICS OF BLUNT BODIES
Nichols, J. O., Nierengarten, E. A.
Technical Report No. 32-677, November 19, 1964 (Unclassified)

For abstract, see Entry N09.

Noble, R. M.

N14 JPL INTENSE FIELD AIR CORE MAGNET
Rust, R., Elleman, D. D., Noble, R. M.
Technical Report No. 32-652, August 31, 1964 (Unclassified)

For abstract, see Entry R20.

Norton, R. H.

N15 THE ABSOLUTE SPECTRAL-ENERGY DISTRIBUTION OF CANOPUS
Norton, R. H.
Technical Report No. 32-641, August 15, 1964 (Unclassified)

Astronomical observations of the spectral-energy distributions (SED) of twelve stars, including Canopus, are presented. Computational procedures for reducing these observations to a system of absolute units of flux outside the Earth's atmosphere are discussed, and the resulting absolute SED are given. Because of their special importance for guidance and control purposes, the SED of Canopus have been corrected for the effect of absorption lines; and the observations have been supplanted in the ultraviolet and infrared by a theoretical model atmosphere.

Null, G. W.

N16 THE EVALUATION OF CERTAIN ASTRONOMICAL CONSTANTS FROM THE RADIO TRACKING OF *MARINER II*
Anderson, J. D., Null, G. W., Thornton, C. T.
Technical Report No. 32-476 (Unclassified)
(Reprinted from *Progress in Astronautics and Aeronautics*, Vol. 14, Academic Press, Inc., 1964)

For abstract, see Entry A03.

Otoshi, T. Y.

O01 AC RATIO TRANSFORMER TECHNIQUE FOR PRECISION INSERTION LOSS MEASUREMENTS
Finnie, C. J., Schuster, D., Otoshi, T. Y.
Technical Report No. 32-690, November 30, 1964 (Unclassified)

For abstract, see Entry F02.

Pearce, C. D.

P01 RELATIVE SIGNS OF THE NUCLEAR SPIN COUPLING CONSTANTS IN PROPYLENE OXIDE AND INDENE OXIDE
Elleman, D. D., Manatt, S. L., Pearce, C. D.
Technical Report No. 32-706 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, Vol. 42, No. 2, January 15, 1965)

For abstract, see Entry E05.

Pedersen, E. S.

P02 HEAT-STERILIZABLE POWER SOURCE STUDY FOR ADVANCED *MARINER* MISSIONS
Pedersen, E. S.
Technical Memorandum No. 33-180, July 1, 1964 (Unclassified)

A limited study was performed to evaluate heat-sterilizable power sources for the *Mariner* Mars landing capsule for missions in 1969 and 1971. It was found that a radioisotope thermoelectric or thermionic generator in conjunction with a small sterilizable battery—or a dynamic system such as a hydrazine-turboalternator system—would meet the mission requirements. For a power level of 700 w and a demand time of 60 min, these systems may be built at a weight of about 20–25 lb.

Pefley, R. K.

P03 TEMPERATURE CONTROL. A CASE HISTORY OF THE *MARINER* SPACECRAFT
Pefley, R. K.
Technical Memorandum No. 33-189, November 16, 1964 (Unclassified)

The logic underlying the thermal design of the *Mariner*-Venus spacecraft is reviewed. The temperature control phi-

losophy is developed showing the influence of mission requirements, spacecraft configuration, and operational constraints on the spacecraft thermal design. Detailed engineering consideration is given to the trade-offs, alternatives, and ramifications of using louver systems, super insulation, and surface coatings. It is concluded that a reasonable thermal design has been conceived and implemented for the spacecraft.

P04 TEMPERATURE CONTROL. A CASE HISTORY OF THE *MARINER* SPACECRAFT
Pefley, R. K.
Technical Memorandum No. 33-189 (Revision No. 1), March 1, 1965 (Unclassified)

The logic underlying the thermal design of the *Mariner* is reviewed. The temperature control concept is developed showing the influence of mission requirements, spacecraft configuration, and operational constraints on the spacecraft thermal design. Detailed engineering consideration is given to the trade-offs, alternatives, and ramifications of using louver systems, super insulation, and surface coatings.

Pfeiffer, C. G.

P05 A TECHNIQUE FOR OPTIMUM FINAL VALUE CONTROL OF POWERED FLIGHT TRAJECTORIES (REVISION 1)
Pfeiffer, C. G.
Technical Report No. 32-447, May 1, 1965 (Unclassified)

A technique is described for steering a rocket vehicle to thrust termination where the objective is to minimize the sum of the squares of the variations of the standard burnout conditions. The analysis is based upon a geometrical interpretation of an optimal trajectory. It is shown that there is an envelope of reachable points in the space of boundary condition variations, and that the control to be applied can be found by dropping a perpendicular to this envelope. An example of ascent guidance into near-Earth satellite orbit is worked out in detail, and numerical results are presented. It is brought out that the control scheme is stable, and the relationship to the well known velocity-to-be-gained steering scheme is pointed out.

P06 GUIDANCE OF UNMANNED LUNAR AND INTERPLANETARY SPACECRAFT
Pfeiffer, C. G.
Technical Report No. 32-472 (Unclassified)
(Reprinted from *Progress in Astronautics and Aeronautics*, Vol. 14, Academic Press Inc., 1964)

Mathematical techniques for Earth-based guidance of unmanned lunar and interplanetary spacecraft are described. The orbit determination and guidance correction aspects of the problem are developed from linear perturbation techniques. An expression for the effect of neglected second-order terms is also established, and treatment of correlated noise on orbit determination data is discussed. Policies for determining when to perform impulsive guidance corrections to the orbit are described, and a technique for optimal guidance of powered flight trajectories is outlined.

P07 A DYNAMIC PROGRAMMING ANALYSIS OF MULTIPLE GUIDANCE CORRECTIONS OF A TRAJECTORY (REVISION NO. 1)
Pfeiffer, C. G.
Technical Report No. 32-513, August 10, 1964 (Unclassified)

The problem of deciding when to apply guidance corrections to the perturbed trajectory of a spacecraft is treated from the dynamic programming point of view. It is assumed that the objective of the guidance correction policy is to minimize the expected value of the squared error at the final time, subject to the constraint that the total-correction capability expended be less than some specified value. It is shown that a correction should be performed when a certain "switching function" passes through zero. Assuming that the orbit determination procedure has been prespecified, and that the statistics of the correction errors are known, the switching function is found to depend upon the instantaneous state of the system, which is composed of (1) the estimate of the trajectory perturbation to be corrected, (2) the variance of the error in this estimate, and (3) the correction capability of the spacecraft. Equations for computing the switching function are derived, and a numerical example is presented.

P08 EARTH–MARS TRAJECTORIES, 1964
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum No. 33-100, Vol. 1, Part B, March 15, 1964 (Unclassified)

For abstract, see Entry C10.

P09 EARTH–MARS TRAJECTORIES, 1964
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum No. 33-100, Vol. 1, Part C, April 1, 1964 (Unclassified)

For abstract, see Entry C11.

Piaggi, E. G.

P10 *RANGER VII* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Wollenhaupt, W. R., Trask, D. W., Sjogren, W. L., Piaggi, E. G., Curkendall, D. W., Winneberger, R. A., Liu, A. S., Berman, A. L.
Technical Report No. 32-694, December 15, 1964 (Unclassified)

For abstract, see Entry W22.

Posner, E. C.

P11 ROOK DOMAINS, LATIN SQUARES, AFFINE PLANES, AND ERROR-DISTRIBUTING CODES
Golomb, S. W., Posner, E. C.
Technical Report No. 32-466 (Unclassified)
(Reprinted from *IEEE Transactions on Information Theory*, Vol. IT-10, No. 3, July 1964)

For abstract, see Entry G10.

P12 THE APPLICATION OF EXTREME-VALUE THEORY TO ERROR PROBABILITY ESTIMATION IN THE *RANGER* BLOCK III COMMAND DETECTOR
Posner, E. C.
Technical Report No. 32-705, January 15, 1965 (Unclassified)

Gumbel's extreme-value theory is applied to the estimation of low-error probabilities in certain types of communications systems such as the *Ranger* Block III command detector. The systems considered all involve threshold detectors in a binary system. By taking the maxima of a large number of successive independent samples, and a large number of both the successive independent samples and of the maxima themselves, the two parameters of the Gumbel distribution are estimated using large-sample theory. The variance of the error-probability estimate is found, as well as a confidence interval. The savings obtained by the Gumbel method, as opposed to the simple monitoring of errors, is found to be large. By applying a goodness-of-fit test to the voltage data of an actual *Ranger* Block III command detector, it is shown that the Gumbel distribution does hold.

P13 APPLICATION OF THE STATISTICAL THEORY OF EXTREME VALUES TO SPACECRAFT RECEIVERS
Ashlock, J. C., Posner, E. C.
Technical Report No. 32-737, May 15, 1965 (Unclassified)

For abstract, see Entry A05.

Potter, P. D.

P14 THE DESIGN OF A VERY HIGH POWER, VERY LOW NOISE CASSEGRAIN FEED SYSTEM FOR A PLANETARY RADAR
Potter, P. D.
Technical Report No. 32-653, August 24, 1964 (Unclassified)

A modified cassegrain feed for an 85-ft-diameter antenna planetary radar system is described. The equipment and techniques involved are being developed for use in the NASA-JPL Deep Space Instrumentation Facility. The radar system operates at a frequency of 2400 Mc in a duplex mode with a transmitter power of 100 kw continuous wave and an overall receiving system noise temperature of about 28°K. The feed system utilizes a nonoptical subreflector and a suppressed sidelobe feedhorn to achieve an overall aperture efficiency of 0.65 and a zenith antenna noise temperature of 10°K, including atmospheric effects. A versatile polarizing system provides for either sense of circular polarization or for any orientation of linear polarization. Detailed design and performance information is presented.

Powell, W. B.

P15 A METHOD FOR THE DETERMINATION OF LOCAL HEAT FLUX FROM TRANSIENT TEMPERATURE MEASUREMENTS
Powell, W. B., Price, T. W.
Technical Report No. 32-578 (Unclassified)
(Reprinted from *ISA Transactions*, Vol. 3, No. 3, July 1964)

A method of determining the transient heat flux to the plane or cylindrical surface of an isotropic material is described. The method is applicable when the material is initially at a known temperature without heat transfer and then is suddenly subjected to heat transfer at one surface. Temperature measurements made on or near the heat transfer surface are used as boundary conditions for numerical solution of the transient heat conduction equation, enabling the temperature distribution within the material to be determined. The properties of the material may vary with temperature. Heat flux is computed as the product of the temperature gradient and the thermal conductivity at the surface. Experimental results from rocket motor testing indicate that the method can be used to determine local heat flux in combustion chambers and nozzles where the heat flux is known to vary in both circumferential and axial directions.

Price, T. W.

P16 A METHOD FOR THE DETERMINATION OF LOCAL HEAT FLUX FROM TRANSIENT TEMPERATURE MEASUREMENTS
Powell, W. B., Price, T. W.
Technical Report No. 32-578 (Unclassified)
(Reprinted from *ISA Transactions*, Vol. 3, No. 3, July 1964)

For abstract, see Entry P15.

Raper, O. F.

R01 DEACTIVATION OF O(^1D) IN THE ATMOSPHERE
DeMore, W. B., Raper, O. F.
Technical Report No. 32-612 (Unclassified)
(Reprinted from *The Astrophysical Journal*, Vol. 139, No. 4, May 15, 1964)

For abstract, see Entry D08.

Rapp, N. S.

R02 POLYMER DEGRADATION. II. MECHANISM OF THERMAL DEGRADATION OF POLYOXYPROPYLENE GLYCOL–TOLUENE 2,4-DIISOCYANATE POLYMER (POPG–TDI) AND A BLOCK POLYETHER GLYCOL–TDI POLYMER

Ingham, J. D., Rapp, N. S.
Technical Report No. 32-541 (Unclassified)
(Reprinted from *Journal of Polymer Science, Part A: General Papers*, Vol. 2, 1964)

For abstract, see Entry I01.

R03 POLYMER DEGRADATION. III. CARBON-14 AS A TRACER FOR STUDIES OF THE THERMAL DEGRADATION OF POLYURETHANES
Simha, R., Ingham, J. D., Rapp, N. S., Hardy, J.
Technical Report No. 32-603 (Unclassified)
(Reprinted from *Polymer Letters*, Vol. 2, 1964)

For abstract, see entry S11.

Rembaum, A.

R04 KINETICS OF THE ANIONIC POLYMERIZATION OF ACENAPHTHYLENE
Moacanin, J., Rembaum, A.
Technical Report No. 32-662 (Unclassified)
(Reprinted from *Journal of Polymer Science, Part B: Polymer Letters*, Vol. 2, 1964)

For abstract, see Entry M19.

R05 SOME UNUSUAL PROPERTIES OF GRAFT COPOLYMERS AND POLYBLENDS OF β-VINYLNAPHTHALENE AND ETHYLENE OXIDE
Cuddihy, E., Moacanin, J., Rembaum, A.
Technical Report No. 32-708 (Unclassified)
(Reprinted from *Journal of Applied Polymer Science*, Vol. 9, No. 4, April 1965)

For abstract, see Entry C18.

Renzetti, N. A.

R06 TRACKING AND DATA ACQUISITION FOR *RANGER* MISSIONS 1–5
Renzetti, N. A.
Technical Memorandum No. 33-174, July 1, 1964 (Unclassified)

The Deep Space Instrumentation Facility's support of Missions 1 through 5 of the *Ranger* project is summarized. Included are a synopsis of each mission, a comprehensive account of the tracking operations, and a performance evaluation. The tracking and data acquisition support provided by the Atlantic Missile Range (now the Air Force Eastern Test Range) sites and the Space Flight Operations Center at the Jet Propulsion Laboratory is delineated also.

Rhein, R. A.

R07 THE IGNITION OF POWDERED METALS IN NITROGEN AND IN CARBON DIOXIDE
Rhein, R. A.
Technical Report No. 32-679, September 30, 1964 (Unclassified)

The atmospheres of Mars and Venus are considered to consist essentially of carbon dioxide and nitrogen mixtures. Experimental studies have shown that a number of powdered metals will ignite in carbon dioxide as well as in nitrogen. Metals shown to ignite in both carbon dioxide and nitrogen are powdered lithium, beryllium, calcium, cerium, misch metal, titanium, zirconium, thorium, and uranium. The following will ignite in carbon dioxide only: magnesium, aluminum, chromium, and manganese. The ignition temperatures for these metals were determined in order to develop appropriate fuels for use in the planetary atmospheres.

Richard, R. J.

R08 EARTH–MOON TRAJECTORIES, 1964–69
Richard, R. J., Clarke, V. C., Jr., Roth, R. Y., Kirhofer, W. E.
Technical Report No. 32-503, May 1, 1964 (Unclassified)

This Report gives key characteristics of Earth-to-Moon trajectories for the period 1964–1969. It is intended to provide trajectory analysts with data, in quantity, 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 these purposes.

Ritchie, D. W.

R09 DEVELOPMENT OF PHOTOVOLTAIC STANDARD CELLS FOR NASA
Ritchie, D. W.
Technical Report No. 32-634, June 1, 1964 (Unclassified)

The development of space-calibrated photovoltaic standard cells provides an accurate means of extrapolation of the short-circuit current of photovoltaic systems to space conditions. Photovoltaic standard cells have been obtained using both boron- and phosphorous-diffused silicon solar cells. The solar cells are directly correlated to standard cells flown to altitudes of 80,000 ft. The use of such standard cells allows the elimination of the pyrheliometer and "sky radiation" measurements required in the evaluation of solar cell arrays. The photovoltaic standard cells can be used to obtain the space solar energy equivalent of terrestrial sunlight or to calibrate solar simulators. Such photovoltaic standard cells have been used for the power prediction of the *Ranger* and *Mariner* solar cell arrays and have provided extrapolated air-mass zero value of short-circuit currents with accuracies better than 2%.

Robillard, C. L.

R10 POSSIBLE METEOROID HAZARD TO SOLID-PROPELLANT ROCKET MOTORS
Robillard, C. L.
Technical Memorandum No. 33-186, November 1, 1964 (Unclassified)

Available data on hypervelocity penetration and on near-Earth and deep-space meteoroid environment are examined, and an attempt to determine the probable extent of meteoroid hazard to solid-propellant rocket motors is made.

The probabilities of critical penetration for both a small and a large solid-propellant spacecraft motor are estimated for a typical unmanned Mars mission. Although these values may be in error by more than an order of magnitude, they do show a basis for concern and suggest that higher chamber pressures at a small loss in performance may prove to be of significant benefit.

R11 SUMMARY OF THE MEETING OF THE PANEL ON RELIABILITY OF LARGE SOLID-PROPELLANT MOTORS
Robillard, C. L.
Technical Memorandum No. 33-219, May 10, 1965 (Unclassified)

A meeting of the NASA-sponsored Panel on Reliability of Large Solid-Propellant Rocket Motors was held at the NASA Western Operations Office, Santa Monica, California, on December 16 and 17, 1964. The December 16 session was devoted to informal presentations to the panel on design, manufacture, and quality control of large solid-propellant motors which are being built or have been built and fired. The December 17 session was a working session devoted to reliability assessment of these motors. Included in the Memorandum are the agenda, a list of the meeting attendees and a summary of the proceedings.

Rogero, S.

R12 MEASUREMENT OF THE HIGH-FREQUENCY PRESSURE PHENOMENA ASSOCIATED WITH ROCKET MOTORS
Rogero, S.
Technical Report No. 32-624, May 11, 1964 (Unclassified)

Factors which affect the fidelity of high-frequency pressure measurements of rocket motors are examined, and information gained from laboratory and operational evaluations of system components is presented. The principal areas of discussion include (1) techniques for the dynamic testing of pressure transducers, (2) results of shock tube tests on commercially available pressure transducers, (3) the effects of vibration and temperature on the output of transducers, (4) methods for shockmounting flush-diaphragm pressure transducers, (5) techniques for calculating or measuring the frequency response of transmission lines, (6) the effects of line length and/or conditioning equipment on overall system response, (7) the capabilities and limitations of record-playback equipment in use at the Jet Propulsion Laboratory Edwards Test Station, and (8) results of rocket motor tests as applicable to overall transducer system evaluation.

Rosenberg, A. D.

R13 SPACE — SINGLE PRECISION COWELL TRAJECTORY PROGRAM
White, R. J., Rosenberg, A. D., Fisher, P. S., Harris, R. A., Newhall, N. S.
Technical Memorandum No. 33-198, January 15, 1965 (Unclassified)

For abstract, see Entry W12.

R14 SFPRO — SINGLE PRECISION COWELL TRAJECTORY PROCESSOR
Rosenberg, A. D., White, R. J., Fisher, P. S., Harris, R. A., Newhall, N. S.
Technical Memorandum No. 33-199, January 15, 1965 (Unclassified)

SFPRO is a digital computer program written in the FAP language for the IBM 7094 computer and is a link under the Jet Propulsion Laboratory's IBSYS-SFOF-JPTRAJ monitor. Included are the general logic flow of SFPRO, definitions of input and output, configurations, and interfaces of the program with the systems.

Roth, R. Y.

R15 EARTH–MOON TRAJECTORIES, 1964–69
Richard, R. J., Clarke, V. C., Jr., Roth, R. Y., Kirhofer, W. E.
Technical Report No. 32-503, May 1, 1964 (Unclassified)

For abstract, see Entry R08.

R16 EARTH–MARS TRAJECTORIES, 1964
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum No. 33-100, Vol. 1, Part B, March 15, 1964 (Unclassified)

For abstract, see Entry C10.

R17 EARTH–MARS TRAJECTORIES, 1964
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum No. 33-100, Vol. 1, Part C, April 1, 1964 (Unclassified)

For abstract, see Entry C11.

Rupe, J. H.

R18 THE EFFECTS OF INJECTION MASS FLUX DISTRIBUTIONS AND RESONANT COMBUSTION ON LOCAL HEAT TRANSFER IN A LIQUID-PROPELLANT ROCKET ENGINE
Rupe, J. H., Jaivin, G. I.
Technical Report No. 32-648, October 1, 1964 (Unclassified)

Local values of the heat transfer rates in a particular liquid-propellant rocket engine–injector configuration are presented. It is shown that during stable, relatively quiescent combustion the local heat transfer rates in the chamber vary axially over a range from 0.5 to 4.0 Btu/in.^{2} sec, and circumferentially (at a station somewhat upstream from the nozzle entrance) over a range from 0.5 to 6.0 Btu/in.^{2} sec. Both heat transfer gradients can be as high as 5.0 Btu/in.^{2} sec/in., and the distribution is extremely sensitive to small changes in

injection properties (i.e., gross mixture ratio) with the consequent changes in mass and mixture ratio distribution near the wall.

Initial attempts to correlate these data with the injection scheme, as characterized by the properties of nonreactive sprays, have indicated that the boundary flow, and therefore the heat transfer rate, is dominated by the proximity of the propellant to the wall. It is therefore suggested that a quantitative correlation between these properties and local heat transfer rates in the chamber is possible and could ultimately lead to the a priori specification of a controlled, compatible boundary flow. To this end some preliminary efforts to illustrate the significance of "the propellant mass flux arriving at the wall" are presented.

The local heat flux distribution attained during resonant combustion is also presented and is compared with values for stable combustion.

Rusch, W. V. T.

R19 PHASE ERROR AND ASSOCIATED CROSS-POLARIZATION EFFECTS IN CASSEGRAINIAN-FED MICROWAVE ANTENNAS
Rusch, W. V. T.
Technical Report No. 32-610, May 30, 1965 (Unclassified)

Phase error in the aperture field of a microwave paraboloidal antenna degrades antenna gain in two ways: (1) the asynchronism of partial field contributions arriving at an axial field point reduces the magnitude of the total field there, and (2) the phase error may generate a cross-polarized component of the aperture field that further reduces the axial gain. Because of phase ripples in the field reflected from the subdish, a Cassegrainian-fed antenna may be much more susceptible to phase-error effects than conventional focal-point-fed antennas. Consequently, a two-part analysis was carried out to evaluate the importance of these phase-error effects in Cassegrainian systems.

The feed-system fields were computed, and a best-fit phase center was found. Then the axial gain was computed in terms of the feed-system fields. An expression for the phase-error loss was defined to evaluate the effects of diffractive phase ripple and feed-system misalignment. Numerical analyses were carried out for a wide range of antenna parameters. It was concluded that for a 19-wavelength subdish and a nearly symmetrical phase and amplitude feed pattern the loss in axial gain due to diffractive phase error may be only a small fraction of a decibel.

Rust, R.

R20 JPL INTENSE FIELD AIR CORE MAGNET
Rust, R., Elleman, D. D., Noble, R. M.
Technical Report No. 32-652, August 31, 1964 (Unclassified)

The Report evaluates and summarizes major system design considerations of the recently completed intense magnetic field facility at the Jet Propulsion Laboratory.

Saffren, M. M.

S01 THE ROTATING SUPERCONDUCTOR PART 1: THE FLUXOID
Saffren, M. H.
Technical Report No. 32-650 (Part I), March 15, 1965 (Unclassified)

The magnetic field present in the bore of a hollow, rotating superconducting cylinder is deduced from London's theory of superconductivity. For a cylinder whose transverse dimensions are larger than a penetration depth, the results show that quantity $\omega_L + \omega$ is a constant; where ω_L is the angular Larmor frequency of the electron, a measure of the magnetic field in the bore (in fact, proportional to this field); and ω is the angular velocity of the cylinder itself. The constant is the value of $\omega_L + \omega$ at the time the superconductor becomes superconducting. A nucleation model of the superconducting transition is used to deduce this relation. The Meissner effect in rotating superconductors is discussed; further, it is shown how the effects of an applied field on a superconductor tend to be cancelled by the superconductor's rotation.

S02 THE ROTATING SUPERCONDUCTOR PART II: THE FREE ENERGY
Saffren, M. M.
Technical Report No. 32-650 (Part II), May 14, 1965 (Unclassified)

Derived are the free energies appropriate for stationary and rotating superconductors with and without an external applied field. A general theorem is deduced that determines the fluxoids of a multiply connected superconductor in its equilibrium state. Also shown is that an isolated stationary superconductor rotates when made superconducting in an external field. This is an effect that has not been noticed previously.

While free energies are derived from the point of view of London theory, which is to treat the superelectrons as having a uniform density, it is shown that even from the point of view of the Ginzburg-Landau theory, in which this restriction is not imposed, our conclusions are essentially unaltered. In the derivation of the free energies, an expression for the magnetic enthalpy is required. This expression is obtained in a novel way through use of the concept of a "magnetic reservoir."

S03 THE ROTATING SUPERCONDUCTOR PART III: SUPERELECTRONS AS AN INCOMPRESSIBLE CHARGED FLUID
Saffren, M. M.
Technical Report No. 32-650 (Part III), May 31, 1965 (Unclassified)

This Report explores the theory of the superfluid without the London constraint. This theory is referred to as the BSH theory after its original promulgators. Its similarity to and differences from the London theory are noted. The BSH theory is examined particularly as it applies to a hollow cylinder at rest and rotating, with and without an applied field.

San Miguel, A.

S04 ON THE CONSTRUCTION AND THEORY OF A MINIATURE STRESS TRANSDUCER TO MEASURE RADIAL STRESS IN PROPELLANT GRAINS
San Miguel, A., Silver, R. H.
Technical Report No. 32-643, February 15, 1965
(Unclassified)

A miniature, directional stress transducer has been constructed and evaluated at the Jet Propulsion Laboratory. This transducer measures a directional force being experienced within a deformed material, such as a pressurized solid-propellant motor. The transducer, 0.100 in. long and 0.046 in. in diameter, has been used to measure a radial stress in a propellant grain. The active element is a piezoresistive p-type silicon splinter. A 2-mil lead wire transmits signals from the transducer to recording equipment. Nonlinearity problems are discussed both from the point of view of the circuitry and of the piezoresistance. In addition to complete information regarding construction, casting techniques for calibrating and embedding the transducer are described. Transducer response versus grain pressurization is compared with theoretical predictions of radial stress.

Schiffer, R. A.

S05 CORRELATION OF LAUNCH-VEHICLE WIND-TUNNEL AERODYNAMIC NOISE WITH SPACECRAFT FLIGHT VIBRATION DATA (REVISION NO. 1)
Schiffer, R. A.
Technical Report No. 32-619, September 15, 1964
(Unclassified)

It has been observed that the maximum vibration levels experienced by a launch vehicle occur in the region of q_{max} and transonic flight. Flight vibration data from *Rangers* 1 through 6 have been correlated with available wind-tunnel fluctuating pressure data at transonic speeds to develop a technique for vibration prediction for types of vehicles not previously flown. Statistical analysis of the wide-band vibration data suggests a linear correlation with the wind-tunnel wide-band fluctuating pressure data. Explored also is the correlation between the average vibration response spectra calculated by using the empirical method suggested by Franken and the 50-percentile log-normal acceleration confidence level obtained by spectral analysis of the flight data.

Schuster, D.

S06 AC RATIO TRANSFORMER TECHNIQUE FOR PRECISION INSERTION LOSS MEASUREMENTS
Finnie, C. J., Schuster, D., Otoshi, T. Y.
Technical Report No. 32-690, November 30, 1964
(Unclassified)

For abstract, see Entry F02.

Shapiro, J. L.

S07 THE TWO-REGION FISSION-ELECTRIC CELL REACTOR
Shapiro, J. L.
Technical Report No. 32-685, February 15, 1965
(Unclassified)

A modification of the fission-electric cell reactor is examined from the standpoint of reactor physics. This modification involves the insertion of a non-power-producing region in order to maintain nuclear criticality. The goal is to increase the overall efficiency by permitting thinner fuel layers in the electric-cell region.

A simplified, highly idealized model is utilized to make rapid calculations of a survey nature. This model uses age-diffusion theory for the neutron transport. It also assumes that the added region is vanishingly thin and is both an absorber of thermal neutrons and a source of fast neutrons. A multi-group, multi-region model is then employed to check the accuracy of the simple model and to give detailed power distribution data for one design problem.

Applied to a small (5-ft diameter) beryllium-moderated reactor, this calculational technique indicates that significant increases in overall efficiency are achievable in the two-region reactor.

Shoemaker, E. M.

S08 *RANGER VII* PART II. EXPERIMENTERS' ANALYSES AND INTERPRETATIONS
Heacock, R. L., Kuiper, G. P., Shoemaker, E. M., Urey, H. C., Whitaker, E. A.
Technical Report No. 32-700, February 10, 1965
(Unclassified)

For abstract, see Entry H12.

Silver, R. H.

S09 ON THE CONSTRUCTION AND THEORY OF A MINIATURE STRESS TRANSDUCER TO MEASURE RADIAL STRESS IN PROPELLANT GRAINS
San Miguel, A., Silver, R. H.
Technical Report No. 32-643, February 15, 1965
(Unclassified)

For abstract, see Entry S04.

Silverstein, E. M.

S10 *SURVEYOR* FOLLOW-ON STUDY SCIENTIFIC OBJECTIVES — PHASE 1: SIGNIFICANCE OF A SUCCESSFUL *SURVEYOR* BLOCK 1 LANDING
Clark, J. R., Dunk, A. C., Horowitz, S. M., Le Croissette, D. H., Silverstein, E. M.
Technical Memorandum No. 33-192, December 1, 1964
(Unclassified)

For abstract, see Entry C07.

Simha, R.

S11 POLYMER DEGRADATION III. CARBON-14 AS A TRACER FOR STUDIES IN THE THERMAL DEGRADATION OF POLYURETHANES
Simha, R., Ingham, J. D., Rapp, N. S., Hardy, J.
Technical Report No. 32-603 (Unclassified)
(Reprint from *Polymer Letters*, Vol. 2, 1964)

This paper presents some preliminary results of experiments initiated with polymers prepared from carbon-14-labled diisocyanates (1) to examine the utility of tracer applications for degradative studies, and (2) to determine further details of the degradative process for polyoxypropylene glycol-toluene diisocyanate.

Simmons, O. W.

S12 EFFECT OF GRAIN SIZE AND IMPURITIES ON TENSILE STRENGTH AND DUCTILITY OF TUNGSTEN FROM 2500 TO 5000°F IN VACUUM
Taylor, J. L., Boone, D. H., Simmons, O. W.
Technical Report No. 32-632, July 1, 1964 (Unclassified)

For abstract, see Entry T02.

Sjogren, W. L.

S13 THE *RANGER VI* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Sjogren, W. L., Curkendall, D. W., Hamilton, T. W., Kirhofer, W. E., Liu, A. S., Trask, D. W., Winneberger, R. A., Wollenhaupt, W. R.
Technical Report No. 32-605, December 15, 1964 (Unclassified)

This Report describes the current best estimate of the *Ranger VI* spacecraft flight path and the way in which it was determined. Deep Space Instrumentation Facility tracking of the spacecraft was virtually continuous from injection to lunar impact. Postflight analysis of the tracking data resulted in valuable determinations of the masses of the Earth and the Moon, tracking station locations, lunar ephemeris scale factor, and a lunar radius to the *Ranger VI* impact point, which is 3 km less than the previously accepted value. The impact location of *Ranger VI* is known to within 1.2 km on the surface of the Moon.

S14 *RANGER VII* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Wollenhaupt, W. R., Trask, D. W., Sjogren, W. L., Piaggi, E. G., Curkendall, D. W., Winneberger, R. A., Liu, A. S., Berman, A. L.
Technical Report No. 32-694, December 15, 1964 (Unclassified)

For abstract, see Entry W22.

Smith, E. J.

S15 MAGNETIC MEASUREMENTS NEAR VENUS
Smith, E. J., Davis, L., Jr., Coleman, P. J., Jr., Sonett, C. P.
Technical Report No. 32-732 (Unclassified)
(Reprinted from *Journal of Geophysical Research*, Vol. 70, No. 7, April 1, 1965)

Mariner II magnetometer data are presented with a more thorough analysis and discussion than in a previously published preliminary Report. No magnetic fields attributable to Venus were detected. An upper bound on the magnetic dipole moment of Venus, M_V, is estimated in several ways, subject to uncertainties regarding the dipole orientation and the nature of the interaction between the solar wind and the planetary field. On the basis of *Mariner's* not entering the Venus magnetosphere, the upper bound lies between ½ and ⅙ of M_E, the Earth's magnetic dipole moment. However, the absence of field fluctuations near Venus corresponding to the shell of disordered fields detected outside the Earth's magnetosphere by satellites and space probes shows that M_V is less than M_E by at least an order of magnitude and makes it probable that M_V is less than $M_E/20$. This result is consistent with qualitative predictions based on the dynamo theory of planetary fields. The energy flux of cosmic radiation above the Venus atmosphere, except perhaps for cosmic rays of the lowest energies, should everywhere approximate the intensity in the Earth's polar regions. Any radiation zone of trapped high-energy electrons is likely to be minor in comparison with the Earth's.

Snyder, C. W.

S16 SOLAR-WIND MEASUREMENTS NEAR VENUS
Neugebauer, M., Snyder, C. W.
Technical Report No. 32-733 (Unclassified)
(Reprinted from *Journal of Geophysical Research*, Vol. 70, No. 7, April 1, 1965)

For abstract, see Entry N04.

Sonett, C. P.

S17 MAGNETIC MEASUREMENTS NEAR VENUS
Smith, E. J., Davis, L., Jr., Coleman, P. J., Jr., Sonett, C. P.
Technical Report No. 32-732 (Unclassified)
(Reprinted from *Journal of Geophysical Research*, Vol. 70, No. 7, April 1, 1965)

For abstract, see Entry S15.

Soong, T. T.

S18 ON A PRIORI STATISTICS IN MINIMUM-VARIANCE ESTIMATION PROBLEMS
Soong, T. T.
Technical Report No. 32-500 (Unclassified)
(Reprinted from *Journal of Basic Engineering, Transactions of the ASME*, Series D, Vol. 87, No. 1, March 1965)

Simple general formulas are derived for investigating the effect of errors in a priori statistics on the minimum-variance estimates of linear regression parameters from observations obscured by noise. These formulas permit a direct evaluation of the covariance matrix of the errors of a posteriori estimates,

showing the sensitivity to errors in a priori weighing matrix. A simple example illustrates that the calculated a posteriori error standard deviations of the estimates can deviate substantially from the correct values.

Speed, R.

S19 QUARTZ GLASS PRESSURE VESSELS FOR HYDROTHERMAL STUDIES
Speed, R., Filice, A.
Technical Report No. 32-649 (Unclassified)
(Reprinted from *The American Mineralogist*, Vol. 49, July–August 1964)

This Report concerns hydrothermal studies with quartz glass tubes in the system plagioclase ($NaCl-Na_2CO_3-H_2O$), with emphasis on synthesis and decomposition of sodic scapolites.

Springett, J. C.

S20 TELEMETRY AND COMMAND TECHNIQUES FOR PLANETARY SPACECRAFT
Springett, J. C.
Technical Report 32-495, January 15, 1965 (Unclassified)

Communication with planetary spacecraft, where system constraints allow data rates of only a few bits per second, requires that the method used to obtain synchronization does not significantly degrade the theoretical performance of the link. A method is presented whereby bit and word synchronization can be achieved without the use of zero-crossing detectors and without the inclusion of sync words within the data format. The modulation and detection system utilizes maximal-length linear shift-register codes in conjunction with phase-lock techniques to achieve unambiguous code synchronization from which bit sync, word sync, and coherent demodulation signals can be obtained. In addition, the data bits and the sync code are combined modulo-2, thereby realizing an optimum system from the standpoint of providing all of the available transmitter sideband power to the data signal as well as the synchronization signal.

Staniszewski, J. R.

S21 THE DESIGN OF THE *RANGER* TELEVISION SYSTEM TO OBTAIN HIGH-RESOLUTION PHOTOGRAPHS OF THE LUNAR SURFACE
Kindt, D. H., Staniszewski, J. R.
Technical Report No. 32-717, March 1, 1965 (Unclassified)

For abstract, see Entry K05.

Stelzried, C.

S22 TOTAL SYSTEM NOISE TEMPERATURE: 15°K
Clauss, R. C., Higa, W., Stelzried, C., Wiebe, E.
Technical Report No. 32-691 (Unclassified)
(Reprinted from *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-12, No. 6, November 1964)

For abstract, see Entry C12.

Stephens, J. B.

S23 DESIGN FOR A SPACE MOLECULAR SINK SIMULATOR
Stephens, J. B., Wallace, D. A.
Technical Report No. 32-688, November 15, 1964 (Unclassified)

The results of a design study for a space molecular sink vacuum system facility are presented. The sharp-V-grooved, LN_2-cooled, molecular trap shrouds are a capture improvement of an order of magnitude over smooth walls and capture 99.96% of the condensable molecules emanating from the test item before they can return. A nonflaking, Dewar-fed, 20°K helium cryopump is used to remove all gases noncondensable at 77°K, except helium and hydrogen. Ion pumps operating at 77°K, in conjunction with titanium sublimation onto the molecular trap shrouds, remove the two remaining gases. A 270-cfm pump (operating in the viscous-flow regime) and a 140-liter/sec turbo-molecular impact pump are used to rough-pump the double-walled, double-doored, bottom-leading, 10 ft in diameter vacuum chamber and to sustain the guard vacuum. The chamber is decontaminated, and titanium evaporant is removed by 250°C vacuum bake-out in conjunction with glass-bead blasting. Contaminant-free loading, pumpdown, sustained ultrahigh-vacuum operation, backfill, and unloading techniques are described. Conventional ultrahigh-vacuum and cryogenic instrumentation and controls are used. Cryogenic quartz-crystal microbalances are used to measure contaminant migration.

Stephenson, R. R.

S24 THE ELECTRICALLY PROPELLED LUNAR LOGISTIC VEHICLE
Stephenson, R. R.
Technical Report No. 32-659, October 1, 1964 (Unclassified)

A parametric analysis of an electrically propelled lunar logistic system is presented. A "performance index"—the ratio of the gross payload delivered to lunar orbit during the lifetime of the nuclear-electric powerplant to the total weight placed into the initial Earth orbit during the same period of time—is evaluated. Curves are presented which describe the performance index as a function of the powerplant mass fraction (and the corresponding thrust device specific impulse) for various round trip flight times and powerplant lifetimes. For any given case there is an optimum allocation of mass to the powerplant; these optima are presented in summary curves showing the best Performance Index obtainable with a given powerplant specific weight for a specified flight time and powerplant lifetime. For first generation powerplants, which may be heavier and have a shorter lifetime than ultimately expected, one-way trips may be desirable, and applicable results are presented. An electrically propelled lunar logistic system based upon the *Saturn* 5 launch vehicle is described in detail, and the performance is found to be significantly better than that obtained with chemical or direct-heated nuclear rocket systems using the same launch vehicle.

Stevens, R.

S25 RADAR EXPLORATION OF VENUS: GOLDSTONE OBSERVATORY REPORT FOR OCTOBER–DECEMBER 1962
Goldstein, R., Stevens, R., Victor, W. K.
Technical Report No. 32-396, March 1, 1965 (Unclassified)

For abstract, see Entry G08.

Tausworthe, R. C.

T01 RANDOM NUMBERS GENERATED BY LINEAR RECURRENCE MODULO TWO
Tausworthe, R. C.
Technical Report No. 32-720 (Unclassified)
(Reprinted from *Mathematics of Computation*, Vol. 19, No. 90, April 1965)

Many situations arise in various fields of interest for which the mathematical model utilizes a random sequence of numbers, events, or both. In many of these applications it is often extremely advantageous to generate, by some deterministic means, a sequence which appears to be random, even if, upon closer and longer observation, certain regularities become evident. For example, electronic computer programs for generating random numbers to be used in Monte Carlo experiments have proved extremely useful. This article describes a random number generator of this type with several outstanding properties. The numbers are generated by modulo-2 linear recurrence techniques long used to generate binary codes for communications.

Taylor, J. L.

T02 EFFECT OF GRAIN SIZE AND IMPURITIES ON TENSILE STRENGTH AND DUCTILITY OF TUNGSTEN FROM 2500 TO 5000°F IN VACUUM
Taylor, J. L., Boone, D. H., Simmons, O. W.
Technical Report No. 32-632, July 1, 1964 (Unclassified)

The effect of grain size and impurity level on the tensile strength and ductility of powder-metallurgy tungsten was determined by comparing recrystallized coarse- and fine-grained undoped tungsten with recrystallized fine-grained doped tungsten. Tests were conducted in vacuum at a strain rate of 0.02 in./in./min from 2500 to 5000°F. Both fine-grained materials were about the same strength and stronger than the coarse-grained material. Ductility for the doped (higher impurity level) fine-grained tungsten was lower than that for the undoped in which stress-induced grain growth occurred more readily.

Thomas, G. M.

T03 TOTAL RADIATION HEAT TRANSFER GAGE FOR HYPERVELOCITY SHOCK TUBE EXPERIMENTS
Thomas, G. M., Menard, W. A.
Technical Report No. 32-636, August 1, 1964 (Unclassified)

A heat transfer gage has been developed for measuring the total radiation from shock-treated gases in the spectral region from 0.2 to 2.7μ. Essentially, the gage consists of a thin-film platinum resistance gage which is coated with a thin carbon film. The requirements for the use of the gage in shock-tube experiments are that the absorptance of the carbon film on platinum substrate be essentially constant over the spectral region of interest and that the response time of the gage be of the order of 1 μsec. The theory of operation and the technique of preparing the gages are described. Measurements of the reflectance of multilayer carbon films are presented. The methods of calibrating the gage and of relating the gage response to the radiance of the radiation source are detailed. Preliminary shock-tube measurements are made using the total radiation gage and are found to be in good agreement with both theory and experiment.

Thornton, C. T.

T04 THE EVALUATION OF CERTAIN ASTRONOMICAL CONSTANTS FROM THE RADIO TRACKING OF *MARINER II*
Anderson, J. D., Null, G. W., Thornton, C. T.
Technical Report No. 32-476 (Unclassified)
(Reprinted from *Progress in Astronautics and Aeronautics*, Vol. 14, Academic Press, Inc., 1964)

For abstract, see Entry A03.

Titsworth, R. C.

T05 EQUIVALENCE CLASSES OF PERIODIC SEQUENCES
Titsworth, R. C.
Technical Report No. 32-568 (Unclassified)
(Reprinted from *Illinois Journal of Mathematics*, Vol. 8, No. 2, June 1964)

If a and a' are called "equivalent" whenever there exist t and k, $(k,p) = 1$, such that $a_n = a'_{kn+t}$, then all sequences in an equivalence class have the same correlation values. In this paper it is shown that by applying Polya's lemma to all such transformations of the type $a_n \rightarrow a_{nk+t}$, it is possible to count the number of these equivalence classes.

T06 THE ROLE OF PSEUDORANDOM CODES IN COMMUNICATIONS
Titsworth, R. C.
Technical Memorandum No. 33-185, August 3, 1964 (Unclassified)

Pseudorandom sequences are periodic sequences with certain inherent random-like statistics. The most important randomness criterion, insofar as communications of a Gaussian channel is concerned, is the resemblance which the cyclic autocorrelation function of a sequence bears to that of a sequence of coin-tosses. The match between these two correlation functions is a function of the cycle length of the periodic code and can be measured in degrees of phase-

orthogonality. Many communications systems use this phase-orthogonality for information distinguishability in many diverse ways, depending on particular applications. This Report summarizes the kinds of pseudorandom sequences and the differing criteria under which they are studied and indicates applications wherein they have been found useful.

Trajmar, S.

T07 THE ($\nu_1+\nu_3$) COMBINATION BAND OF OZONE
Trajmar, S., McCaa, D. J.
Technical Report No. 32-557 (Unclassified)
(Reprinted from *Journal of Molecular Spectroscopy*, Vol. 14, No. 3, November 1964)

A high resolution spectrum of the ozone 4.75-μ band is analyzed, and Wilson and Badger's assignment of the ($\nu_1 + \nu_3$) combination band is confirmed.

Trask, D. W.

T08 THE *RANGER VI* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Sjogren, W. L., Curkendall, D. W., Hamilton, T. W., Kirhofer, W. E., Liu, A. S., Trask, D. W., Winnneberger, R. A., Wollenhaupt, W. R.
Technical Report No. 32-605, December 15, 1964 (Unclassified)

For abstract, see Entry S13.

T09 *RANGER VII* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Wollenhaupt, W. R., Trask, D. W., Sjogren, W. L., Piaggi, E. G., Curkendall, D. W., Winneberger, R. A., Liu, A. S., Berman, A. L.
Technical Report No. 32-694, December 15, 1964 (Unclassified)

For abstract, see Entry W22.

Trummel, M. C.

T10 ENVIRONMENTAL DYNAMIC AND ACOUSTIC DATA REPORT OF THE *RANGER 6* FLIGHT
Trummel, M. C., Wiksten, D. B.
Technical Memorandum No. 33-187, October 15, 1964 (Unclassified)

This Report presents and analyzes dynamic-environmental data measured during the launch of the *Ranger 6* spacecraft. Included are acoustic data measured internal to the spacecraft shroud, acoustic data measured on the umbilical tower, and low- and high-frequency vibration data measured near the spacecraft–*Agena* interface. Several forms of data are presented and discussed. These are oscillograph records, wide-band analyses, bandpass filter analyses, power spectral-density (PSD) analyses, and shock-spectrum analyses. The data are shown to be compatible with data from previous *Ranger* flights and with spacecraft acoustic and vibration test levels.

Tschuikow-Roux, E.

T11 THERMAL DECOMPOSITION OF FLUOROFORM IN A SINGLE-PULSE SHOCK TUBE. I
Tschuikow-Roux, E., Marte, J. E.
Technical Report No. 32-721 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, Vol. 42, No. 6, March 15, 1965)

The thermal decomposition of CF_3H has been studied between 1200 and 1600°K behind reflected shock waves in a single-pulse shock tube. The principal reaction products are found to be tetrafluoroethylene and hydrogen fluoride. This fact, coupled with thermochemical considerations, suggests that the primary process in the pyrolysis of fluoroform is $CF_3H \rightarrow CF_2 + HF$. The observed activation energy, $E_{obs} =$ 63 kcal/mole, is lower than the heat of the reaction which is 75 kcal/mole if a "reasonable" value for the heat of formation of the CF_2 biradical, ΔH_f° (CF_2) = −24 kcal/mole, is used. The reasons for this are discussed, and it is suggested that under present reaction conditions, the unimolecular decomposition may be in the falloff region.

Turk, W.

T12 *RANGER* BLOCK III ATTITUDE CONTROL SYSTEM
Turk, W.
Technical Report No. 32-663, November 15, 1964 (Unclassified)

This Report describes the attitude control system designed to orientate, stabilize, and maneuver the *Ranger* spacecraft in its mission to obtain the first detailed closeup television pictures of the Moon's surface. The system is composed of several subsystems: (1) the inertial sensors to sense the rates and positions about and along each axis; (2) the celestial sensors to provide for the Sun and Earth reference coordinates for the three-axis position stabilization; and (3) the gas-jet system to provide spacecraft torque control. Each of the modes of spacecraft attitude control operation is discussed in detail. Analyses are included of the gas system requirements, spacecraft dynamic effects, midcourse autopilot control, and maneuver errors.

Urey, H. C.

U01 *RANGER VII* PART II. EXPERIMENTERS' ANALYSES AND INTERPRETATIONS
Heacock, R. L., Kuiper, G. P., Shoemaker, E. M., Urey, H. C., Whitaker, E. A.
Technical Report No. 32-700, February 10, 1965 (Unclassified)

For abstract, see Entry H12.

Victor, W. K.

V01 RADAR EXPLORATION OF VENUS: GOLDSTONE OBSERVATORY REPORT FOR OCTOBER–DECEMBER 1962
Goldstein, R., Stevens, R., Victor, W. K.
Technical Report No. 32-396, March 1, 1965 (Unclassified)

For abstract, see Entry G08.

Volkoff, J. J.

V02 PROTECTION REQUIREMENTS FOR THE RESISTANCE OF METEOROID PENETRATION DAMAGE OF INTERPLANETARY SPACECRAFT SYSTEMS
Volkoff, J. J.
Technical Report No. 32-410, July 1, 1964 (Unclassified)

A study of spacecraft component and system protection requirements for the resistance of meteoroid penetration damage is presented for various planetary and interplanetary missions. Meteoroidal characteristics and their distribution in planetary, asteroid-belt, and interplanetary space regions are considered. A meteoroid model derived from this study is applied to typical missions for nuclear-electric spacecraft, and corresponding meteoroid flux-intensity profiles are determined.

A technique to estimate the armor requirement for any interplanetary mission is developed. This requirement is compared to that for near-Earth conventional estimates and applied to the radiator systems of a conceptual 500-kWe nuclear-electric spacecraft.

von Roos, O.

V03 INTERACTION OF VERY INTENSE RADIATION FIELDS WITH ATOMIC SYSTEMS
von Roos, O.
Technical Report No. 32-599 (Unclassified)
(Reprinted from *The Physical Review*, Vol. 135, No. 1A, July 6, 1964)

A theory is developed which permits treatment of radiation processes involving a large number of photons in first- or second-order perturbation theory. The theory is applied to the interaction of an atomic electron with a very intense linearly polarized laser beam.

Wahlquist, H. D.

W01 DYADIC ANALYSIS OF SPACE-TIME CONGRUENCES
Estabrook, F. B., Wahlquist, H. D.
Technical Report No. 32-682 (Unclassified)
(Reprinted from *Journal of Mathematical Physics*, Vol. 5, No. 11, November 1964)

For abstract, see Entry E09.

Wallace, J. B.

W02 DESIGN FOR A SPACE MOLECULAR SINK SIMULATOR
Stephens, J. B., Wallace, D. A.
Technical Report No. 32-688, November 15, 1964 (Unclassified)

For abstract, see Entry S23.

Warner, M. R.

W03 SPODP—SINGLE PRECISION ORBIT DETERMINATION PROGRAM
Warner, M. R., Nead, M. W.
Technical Memorandum No. 33-204, February 15, 1965 (Unclassified)

The SPODP was developed for operation under the data processing system of the Space Flight Operations Facility. Included are flow diagrams, load maps, the common storage map, input and output descriptions, subroutine writeups, operating instructions, and check cases. Computational methods employed by the program are described in a subroutine documentation.

Way, J. L.

W04 A MICROCIRCUIT 75-COUNTER
Way, J. L.
Technical Report No. 32-645, August 10, 1964 (Unclassified)

A synchronous 75-counter using a repetitive, truncated, binary sequence is described. The counter is designed with the Veitch diagram simplification technique and is implemented with the Fairchild microcircuit J-K flip-flop. It is free from undesirable closed loops, returns to normal sequence in a maximum of one clock-pulse time, and is capable of speeds to 8 Mc at room temperature. Minimum and maximum power-supply voltage for correct sequencing is shown as a function of temperature from -50 to $+125°C$.

Weaver, R. W.

W05 LOW SUBSONIC DYNAMIC-STABILITY INVESTIGATION OF SEVERAL PLANETARY-ENTRY CONFIGURATIONS IN A VERTICAL WIND TUNNEL (PART I)
Marte, J. E., Weaver, R. W.
Technical Report No. 32-743, May 1, 1965 (Unclassified)

For abstract, see Entry M05.

Weetall, H. H.

W06 THE SYNTHESIS AND USE OF SOME INSOLUBLE IMMUNOLOGICALLY SPECIFIC ADSORBENTS
Weliky, N., Weetall, H. H., Gilden, P. V., Campbell, D. H.
Technical Report No. 32-607 (Unclassified)
(Reprinted from *Immunochemistry*, Vol. 1, Pergamon Press, 1964)

For abstract, see Entry W09.

W07 NEW CELLULOSE DERIVATIVES FOR THE ISOLATION OF BIOLOGICALLY ACTIVE MOLECULES
Weetall, H. H., Weliky, N.
Technical Report No. 32-701 (Unclassified)
(Reprinted from *Nature*, Vol. 204, No. 4961, November 28, 1964)

Methods are investigated for isolating the maximum possible quantity of antibody, measured by the fraction precipitable with specific antigen, from a serum sample in as pure a form as possible.

Weinberg, I.

W08 PHONON-DRAG THERMOPOWER IN Cu-Al AND Cu-Si ALLOYS
Weinberg, I.
Technical Report No. 32-730, May 1, 1965 (Unclassified)

The thermoelectric power of copper-aluminum (Cu-Al) and copper-silicon (Cu-Si) alloys has been determined from 4.2 to 320°K. Assuming that the thermopower is separable into diffusion and phonon-drag components, the change in phonon-drag thermopower ΔS_g is determined for Cu + 0.77 at.% Al and Cu + 1.12 at.% Si. The change in phonon-drag thermopower is analyzed using the method developed by Huebener for lattice vacancies in gold. Scattering of phonons by impurities is assumed to follow a Rayleigh scattering law with relaxation time $\tau_i = (a\omega^4)^{-1}$. From the change in phonon-drag thermopower it is found that $a = (0.9 \pm 0.4) \times 10^{-43}$ sec^3 for 0.77 at.% Al in Cu, and that $a = (6.5 \pm 2.3) \times 10^{-43}$ sec^3 for 1.12 at.% Si in Cu. These results are compared with the scattering parameter computed from the mass-difference term in Klemens' theory for scattering of low-frequency lattice waves by point imperfections.

For Cu-Al, the results indicate that phonon scattering can be accounted for by the mass-difference term. The results for Cu-Si indicate that the mass-difference contribution to phonon scattering is of the same magnitude as the contribution from the combined effects of the elastic strain field and changes in the elastic constants of interatomic linkages.

Weliky, N.

W09 THE SYNTHESIS AND USE OF SOME INSOLUBLE IMMUNOLOGICALLY SPECIFIC ADSORBENTS
Weliky, N., Weetall, H. H., Gilden, P. V., Campbell, D. H.
Technical Report No. 32-607 (Unclassified)
(Reprinted from *Immunochemistry*, Vol. 1, Pergamon Press, 1964)

This study was undertaken to develop newer and simpler methods for coupling specific groups of biological materials to insoluble carriers for use as specific adsorbents.

W10 NEW CELLULOSE DERIVATIVES FOR THE ISOLATION OF BIOLOGICALLY ACTIVE MOLECULES
Weetall, H. H., Weliky, N.
Technical Report No. 32-701 (Unclassified)
(Reprinted from *Nature*, Vol. 204, No. 4961, November 28, 1964)

For abstract, see Entry W07.

Whitaker, E. A.

W11 *RANGER VII* PART II. EXPERIMENTERS' ANALYSES AND INTERPRETATIONS
Heacock, R. L., Kuiper, G. P., Shoemaker, E. M., Urey, H. C., Whitaker, E. A.
Technical Report No. 32-700, February 10, 1965 (Unclassified)

For abstract, see Entry H12.

White, R. J.

W12 SPACE — SINGLE PRECISION COWELL TRAJECTORY PROGRAM
White, R. J., Rosenberg, A. D., Fisher, P. S., Harris, R. A., Newhall, N. S.
Technical Memorandum No. 33-198, January 15, 1965 (Unclassified)

SPACE is a digital computer program written in the FAP language for the IBM 7094 computer and is a link under the Jet Propulsion Laboratory's IBSYS-SFOF-JPTRAJ monitor. It is an updated version of the JPL space trajectories program. Included are a short historical background, equations solved, flow charts, descriptions of input and output parameters, configurations, and interfaces between the program and the monitor.

W13 SFPRO — SINGLE PRECISION COWELL TRAJECTORY PROCESSOR
Rosenberg, A. D., White, R. J., Fisher, P. S., Harris, R. A., Newhall, N. S.
Technical Memorandum No. 33-199, January 15, 1965 (Unclassified)

For abstract, see Entry R14.

Wiebe, E.

W14 TOTAL SYSTEM NOISE TEMPERATURE: 15°K
Clauss, R. C., Higa, W., Stelzried, C., Wiebe, E.
Technical Report No. 32-691 (Unclassified)
(Reprinted from *IEEE Transactions on Microwave Theory and Techniques*, Vol. MTT-12, No. 6, November 1964)

For abstract, see Entry C12.

Wiksten, D. B.

W15 ENVIRONMENTAL DYNAMIC AND ACOUSTIC DATA REPORT OF THE *RANGER 6* FLIGHT
Trummel, W. C., Wiksten, D. B.
Technical Memorandum 33-187, October 15, 1964 (Unclassified)

For abstract, see Entry T10.

Williams, R. D.

W16 DESCRIPTION AND FLIGHT ANALYSIS OF THE *RANGER VII* TV SUBSYSTEM
Benson, M. A., Williams, R. D.
Technical Report No. 32-680, February 15, 1965
(Unclassified)

For abstract, see Entry B13.

Willingham, D.

W17 THE LUNAR REFLECTIVITY MODEL FOR *RANGER* BLOCK III ANALYSIS
Willingham, D.
Technical Report No. 32-664, November 2, 1964
(Unclassified)

The methods employed in deriving a revised lunar reflectivity model are detailed, with plots illustrating the data scatter encountered. The need for revision of the photometric function developed in 1963 is discussed, and the "old" and "new" functions are compared.

Winneberger, R. A.

W18 THE *RANGER VI* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Sjogren, W. L., Curkendall, D. W., Hamilton, T. W., Kirhofer, W. E., Liu, A. S., Trask, D. W., Winneberger, R. A., Wollenhaupt, W. R.
Technical Report No. 32-605, December 15, 1964
(Unclassified)

For abstract, see Entry S13.

W19 *RANGER VII* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Wollenhaupt, W. R., Trask, D. W., Sjogren, W. L., Piaggi, E. G., Curkendall, D. W., Winneberger, R. A., Liu, A. S., Berman, A. L.
Technical Report No. 32-694, December 15, 1964
(Unclassified)

For abstract, see Entry W22.

Witte, A. B.

W20 ANALYSIS OF ONE-DIMENSIONAL ISENTROPIC FLOW WITH TABLES FOR PARTIALLY IONIZED ARGON
Witte, A. B.
Technical Report No. 32-661, September 30, 1964
(Unclassified)

The purpose of this investigation is to calculate flow variables for an isentropic expansion of partially ionized argon for stagnation conditions ranging in temperature from 6000 to 14,000°K, and in pressure from 0.1 to 3 atm. Equilibrium properties for argon calculated for this process include the sound speed, entropy, enthalpy, electron concentration, ionization fraction, electrical conductivity, and static-to-stagnation ratios of temperature, pressure, and density. Local values of velocity, mass flux, area ratio, and Reynolds number per centimeter are also calculated.

Wollenhaupt, W. R.

W21 THE *RANGER VI* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Sjogren, W. L., Curkendall, D. W., Hamilton, T. W., Kirhofer, W. E., Liu, A. S., Trask, D. W., Winneberger, R. A., Wollenhaupt, W. R.
Technical Report No. 32-605, December 15, 1964
(Unclassified)

For abstract, see Entry S13.

W22 *RANGER VII* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Wollenhaupt, W. R., Trask, D. W., Sjogren, W. L., Piaggi, E. G., Curkendall, D. W., Winneberger, R. A., Liu, A. S., Berman, A. L.
Technical Report No. 32-694, December 15, 1964
(Unclassified)

This Report describes the current best estimate of the *Ranger VII* spacecraft flight path and the way in which it was determined. Deep Space Instrumentation Facility tracking of the spacecraft was virtually continuous from injection to lunar impact. Dramatic TV photos of the lunar surface were received at the Goldstone tracking station during the last 17 min before impacting the Moon, in what was later to be named the lunar "Mare Cognitum." This event marked the first time that man has succeeded in obtaining closeup photographs of the front side of the Moon. Postflight analysis of the tracking data resulted in valuable determinations of the masses of the Earth and the Moon, tracking station locations, lunar ephemeris scale factor, and lunar radius to the *Ranger VII* impact point to within 0.4 km.

Wong, R. Y.

W23 A FIBER OPTICAL SYSTEM FOR SPACE APPLICATION
Wong, R. Y.
Technical Report No. 32-646, August 31, 1964 (Unclassified)

Theoretical analyses were made of light transmission through a fiber optic and the various factors affecting its performance. As a result, various data were computed and, to a certain extent, verified by means of experiments. The results served as design data for the fiber optics system.

Wood, H. L.

W24 PROPERTIES OF WELDED HIGH-STRENGTH TITANIUM ALLOY SHEET
Brothers, A. J., Martens, H. E., Wood, H. L.
Technical Report No. 32-39, Revision 1 (Unclassified)
(Reprinted from *Proceedings of the American Society for Testing and Materials*, Vol. 63, 1963)

For abstract, see Entry B21.

Wu, C.-S.

W25 A SIMPLE PROOF OF THE IDENTITY OF LANDAU'S AND VAN KAMPEN'S SOLUTIONS OF THE LINEARIZED VLASOV EQUATION
Wu, C.-S.
Technical Report No. 32-627, April 15, 1964 (Unclassified)

Earlier, Case in a generalized analysis showed that the electrostatic potentials obtained in Landau's and van Kampen's solutions to the collisionless Boltzmann equation are equivalent. The purpose of this Report is to furnish a simple explicit proof of the complete identity of Landau's and van Kampen's solutions; the present analysis, however, follows a course different from that of Case.

W26 USEFUL OPERATOR IN PLASMA KINETIC THEORY
Wu, C.-S.
Technical Report No. 32-692 (Unclassified)
(Reprinted from *Journal of Mathematical Physics*, Vol. 5, No. 12, December 1964)

An operator to facilitate derivation of the plasma kinetic equation is introduced which determines the first integral of the pair correlation function, requiring no knowledge of the function itself. The present operator method is found to be far superior to the singular integral equation technique. The mathematical simplification which can be gained by this operator is demonstrated.

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. 37-28, (May 1 to June 30, 1964), July 31, 1964
No. 37-29, (July 1 to August 31, 1964), September 30, 1964
No. 37-30, (September 1 to October 31, 1964), November 30, 1964
No. 37-31, (November 1 to December 31, 1964), January 31, 1965
No. 37-32, (January 1 to February 28, 1965), March 31, 1965
No. 37-33, (March 1 to April 30, 1965), May 31, 1965

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. 37-28, (May 1 to June 30, 1964), July 31, 1964
No. 37-29, (July 1 to August 31, 1964), September 30, 1964
No. 37-30, (September 1 to October 31, 1964), November 30, 1964
No. 37-31, (November 1 to December 31, 1964), January 31, 1965
No. 37-32, (January 1 to February 28, 1965), March 31, 1965
No. 37-33, (March 1 to April 30, 1965), May 31, 1965

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. 37-28, (May 1 to June 30, 1964), July 31, 1964
No. 37-29, (July 1 to August 31, 1964), September 30, 1964
No. 37-30, (September 1 to October 31, 1964), November 30, 1964
No. 37-31, (November 1 to December 31, 1964), January 31, 1965
No. 37-32, (January 1 to February 28, 1965), March 31, 1965
No. 37-33, (March 1 to April 30, 1965), May 31, 1965

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. 37-27, (April 1 to May 31, 1964), June 30, 1964
No. 37-28, (June 1 to July 31, 1964), August 31, 1964
No. 37-29, (August 1 to September 30, 1964), October 31, 1964
No. 37-30, (October 1 to November 30, 1964), December 31, 1964
No. 37-31, (December 1, 1964 to January 31, 1965), February 28, 1965
No. 37-32, (February 1 to March 31, 1965), April 30, 1965

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 ex-

ploration 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. 37-28, (June 1 to July 31, 1964), August 31, 1964
No. 37-29, (August 1 to September 30, 1964), October 31, 1964
No. 37-30, (October 1 to November 30, 1964), December 31, 1964
No. 37-31, (December 1, 1964 to January 31, 1965), February 28, 1965
No. 37-32, (February 1 to March 31, 1965), April 30, 1965
No. 37-33, (April 1 to May 31, 1965), June 30, 1965

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. 37-28, (May 1 to June 30, 1964), July 31, 1964
No. 37-29, (July 1 to August 31, 1964), September 30, 1964
No. 37-30, (September 1 to October 31, 1964), November 30, 1964
No. 37-31, (November 1 to December 31, 1964), January 31, 1965
No. 37-32, (January 1 to February 28, 1965), March 31, 1965
No. 37-33, (March 1 to April 30, 1965), May 31, 1965

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 SEARCHES

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 ORGANIC SEMICONDUCTORS, II: PROPERTIES, SYNTHESIS, AND APPLICATION

Sweitzer, D. I., Compiler

Literature Search No. 482, 1964 (Unclassified)

This Literature Search updates and supplements Astronautics Information Literature Search No. 341, "Organic Semiconductors: Properties and Applications." Most of the entries refer to material published or papers presented during July 1961 through September 1963.

The references herein are categorized under the following subject areas: Conductivity and Semiconductivity, Photoconductivity, Excited States, and Dielectric Effects. Entries in each of the four areas are further grouped to comprise general references, theory, experiment, synthesis, and application. Several subjects which were only sampled in Literature Search No. 341, such as organic liquids, biological molecules, and electron spin resonance, are more fully covered here. Ion, exciton, and electron conduction processes are considered for both extrinsic and intrinsic semiconductors.

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."

Anderson, E. C.

AD01 DETECTION OF AN INTERSTELLAR FLUX OF GAMMA-RAYS
Metzger, A. E., Anderson, E. C., Van Dilla, M. A., Arnold, J. R.
Nature, Vol. 204, No. 4960, pp. 766–767, November 21, 1964

For abstract, see Entry AD22.

Anderson, H. R.

AD02 ENERGETIC PARTICLES MEASURED NEAR VENUS *MARINER 2*
Anderson, H. R.
Journal of Geophysical Research, Vol. 69, No. 13, pp. 2651–2657, July 1, 1964

The energetic particle experiment on *Mariner 2* was designed to measure the intensity of ionizing radiation as a function of time and position in interplanetary space and to observe energetic trapped particles, if any, near Venus. This paper briefly describes the instrumentation employed and presents the results obtained near Venus. The maximum fluxes of various types of particles consistent with these data are stated and compared with the fluxes in the Earth's outer radiation belt.

Arnold, J. R.

AD03 DETECTION OF AN INTERSTELLAR FLUX OF GAMMA-RAYS
Metzger, A. E., Anderson, E. C., Van Dilla, M. A., Arnold, J. R.
Nature, Vol. 204, No. 4960, pp. 766–767, November 21, 1964

For abstract, see Entry AD22.

Baumert, L. D.

AD04 A NEW CONSTRUCTION FOR HADAMARD MATRICES
Baumert, L. D., Hall, M., Jr.
Bulletin of the American Mathematical Society, Vol. 71, No. 1, pp. 169–170, January 1965

A new construction is given which yields, among others, the previously unknown value $n=156$, leaving only two undecided values of $n=4$ $t\leq 200$ (these are 116 and 188).

Beaudet, R. A.

AD05 THE STABLE CONFORMATION OF 1,1,4,4-TETRAFLUOROBUTADIENE
Beaudet, R. A.
Journal of the American Chemical Society, Vol. 87, No. 6, p. 1390, March 20, 1965

The NMR spectra of I, II, and *cis* and *trans*-III reveal that the long-range fluorine-fluorine spin-spin coupling constant J_{FF}, has a large value when the fluorine atoms are spatially close to each other. The large magnitude of J_{FF}, has been attributed to a "through space" spin-spin interaction. Based on the large value of J_{FF}, and on the assumption of a "through space" contribution to the spin-spin coupling, it would seem that $CF_2=CH-CH=CF_2$ exists in a cisoid form. Studies of the rotational spectrum of isoprene and of fluoroprene have, however, detected only the spectrum of the *trans* isomer. There is no conclusive spectroscopic evidence for the existence of a *cis* isomer of any butadiene. These results render doubtful the "through space" explanation for the large J_{FF}, long-range coupling constant in other molecules.

Carpenter, R. L.

AD06 STUDY OF VENUS BY CW RADAR — RESULTS OF THE 1964 CONJUNCTION
Carpenter, R. L.
The *Astronomical Journal*, Vol. 70, No. 2, p. 134, March 1965

This article is an abstract of a paper presented at the 117th meeting of the American Astronomical Society, December 28–31, 1964, at Montreal, Canada.

Carr, R. E.

AD07 FREE OSCILLATIONS OF THE MOON AND OBSERVATIONS BY A LONG-PERIOD SEISMOGRAPH SYSTEM
Kovach, R. L., Carr, R. E.
Proceedings of the 13th International Astronautical Congress, Varna, Bulgaria, September 1962, pp. 1–10, Springer-Verlag, 1964

For abstract, see Entry AD18.

Collins, D. J.

AD08 EXPERIMENTAL CONVECTIVE HEAT-TRANSFER MEASUREMENTS
Collins, D. J., Horton, T.
AIAA Journal, Vol. 2, No. 11, pp. 2046–2047, November 1964

An extensive series of stagnation-point heat-transfer experiments completed at the Jet Propulsion Laboratory disclosed that (1) carbon dioxide and nitrogen atmospheres have convective heat-transfer rates similar to that of air, and (2) the presence of argon in the atmosphere increases the convective heat transfer by about a factor of two for the model atmosphere investigated.

Davey, J. R.

AD09 SYNCHRONIZATION
Golomb, S. W., Davey, J. R., Reed, I. S., Van Trees, H. L., Stiffler, J. J.
IEEE Transactions on Communications Systems, Vol. CS-11, No. 4, pp. 481–491, December 1963

For abstract, see Entry AD12.

Fischbach, D. B.

AD10 COMMENTS ON "DIAMAGNETIC" GAUSSMETER
Fischbach, D. B.
The Review of Scientific Instruments, Vol. 36, No. 2, pp. 241–243, February 1965

This paper examines certain aspects of the diamagnetic properties of pyrolytic carbon and cites their relationship to the performance capabilities of a torque gaussmeter.

Franzgrote, E.

AD11 CHEMICAL ANALYSIS OF SURFACES USING ALPHA PARTICLES
Patterson, J. H., Turkevich, A. L., Franzgrote, E.
Journal of Geophysical Research, Vol. 70, No. 6, pp. 1311–1327, March 15, 1965

For abstract, see Entry AD26.

Golomb, S. W.

AD12 SYNCHRONIZATION
Golomb, S. W., Davey, J. R., Reed, I. S., Van Trees, H. L., Stiffler, J. J.
IEEE Transactions on Communications Systems, Vol. CS-11, No. 4, pp. 481–491, December 1963

This paper presents the proceedings of a panel discussion held on January 31, 1963 at the IEEE Winter General Meeting, New York. Topics discussed included: synchronization in data communication, synchronization in communication theory, synchronization and bit timing, and word synchronization over noisy channels.

Hall, M., Jr.

AD13 A NEW CONSTRUCTION FOR HADAMARD MATRICES
Baumert, L. D., Hall, M., Jr.
Bulletin of the American Mathematical Society, Vol. 71, No. 1, pp. 169–170, January 1965

For abstract, see Entry AD04.

Horton, T.

AD14 EFFECT OF ARGON ADDITION ON SHOCK-LAYER RADIANCE OF CO_2–N_2 GAS MIXTURES
Wolf, F., Horton, T.
AIAA Journal, Vol. 2, No. 8, pp. 1472–1474, August 1964

For abstract, see Entry AD41.

AD15 EXPERIMENTAL CONVECTIVE HEAT-TRANSFER MEASUREMENTS
Collins, D. J., Horton, T.
AIAA Journal, Vol. 2, No. 11, pp. 2046–2047, November 1964

For abstract, see Entry AD08.

Jaffe, L. D.

AD16 PROBLEMS IN STERILIZATION OF UNMANNED SPACE VEHICLES
Jaffe, L. D.
Life Sciences and Space Research II: Proceedings of the 4th International Space Science Symposium, Warsaw, June 3–12, 1963, pp. 406–432, North-Holland Publishing Co., 1964

There is general agreement (at least among biologists) that, to avoid interference with exobiological observations, terrestrial organisms should not be freely released on other planets. Sterilization and other techniques for avoiding biological contamination of the planets may, therefore, be prerequisite for exobiological research. Considerable controversy has evolved regarding the need for sterilization of planetary and lunar spacecraft, the degree of assurance required against contamination, and the methods to be used for sterilization. In this paper, an engineering examination of the problem is made. Specifically, unmanned exploration and contamination of another planet with Earth organisms are considered. (Sterilization of manned spacecraft, and the contamination of Earth with organisms from other planets—when samples or spacecraft are brought back to Earth—are not discussed.)

Kotlensky, W. V.

AD17 DEFORMATION IN PYROLYTIC GRAPHITE
Kotlensky, W. V.
Transactions of the Metallurgical Society of AIME, Vol. 233, pp. 830–832, April 1965

Pyrolytic graphite may be represented by a stack of over-

lapping, wrinkled sheets with the graphite basal planes approximately parallel to the deposition surface. Previous work has described two stages in the deformation above 2600°C, produced by applying a stress parallel to the deposition surface.

The first stage occurs at deformation less than 15% and involves dewrinkling accompanied by basal-plane slip and basal-plane reorientation. The second stage occurs at deformation above 15% and is not too well understood.

This article presents some additional evidence for two distinct stages in the deformation of pyrolytic graphite as well as some recent considerations regarding the second stage mechanism.

Kovach, R. L.

AD18 FREE OSCILLATIONS OF THE MOON AND OBSERVATIONS BY A LONG-PERIOD SEISMOGRAPH SYSTEM
Kovach, R. L., Carr, R. E.
Proceedings of the 13th International Astronautical Congress, Varna, Bulgaria, September 1962, pp. 1–10, Springer-Verlag, 1964

If excited, the free oscillations of the Moon can be recorded by a long-period seismograph, gravimeter, or tiltmeter placed on the lunar surface; the gross aspects of the Moon's internal structure can then be deduced by comparing observed frequencies of vibration with those predicted theoretically for various assumed lunar models. Low order oscillations involve the body as a whole, and the higher order oscillations depend principally on the physical properties of the body at successively shallower depths. Numerical calculations for the spheroidal and torsional oscillations are discussed for several assumed lunar models and demonstrate the sensitivity of the periods of vibration to variations in assumed internal structure.

Leipold, M. H.

AD19 THERMAL EXPANSION OF NICKEL OXIDE
Nielsen, T. H., Leipold, M. H.
Journal of the American Ceramic Society, Vol. 48, No. 3, p. 164, March 1965

For abstract, see Entry AD25.

Lindsey, W. C.

AD20 INFINITE INTEGRALS CONTAINING BESSEL FUNCTION PRODUCTS
Lindsey, W. C.
Journal of the Society for Industrial and Applied Mathematics, Vol. 12, No. 2, pp. 458–464, June 1964

The major purpose of this paper is to provide explicit and exact formulas for making numerical computations. In particular, an integral (heretofore seemingly unsolved) is evaluated which has arisen in connection with a multiple-sample detection theory problem.

Lyttleton, R. A.

AD21 ON THE INTERNAL STRUCTURE OF THE PLANET MARS
Lyttleton, R. A.
Monthly Notices of the Royal Astronomical Society, Vol. 129, No. 1, pp. 21–39, 1965

The hypothesis that Mars is of similar constitution to the Earth is investigated. Numerical values are found for Mars pressure- and density-distributions, its overall radius, its moment of inertia, and its gravitational energy. The linear law is also applied to determining the structure of the Moon.

Metzger, A. E.

AD22 DETECTION OF AN INTERSTELLAR FLUX OF GAMMA-RAYS
Metzger, A. E., Anderson, E. C., Van Dilla, M. A., Arnold, J. R.
Nature, Vol. 204, No. 4960, pp. 766–767, November 21, 1964

Gamma-ray measurements are reported at distances of 7×10^4 to 4×10^5 km from the Earth, for enough to make contributions from the Earth negligible. The experiment described here involved operation of a spectrometer on two *Ranger* flights with the primary purpose of monitoring lunar surface radiation.

Münch, G.

AD23 WAVELENGTH DEPENDENCE OF THE BAND STRUCTURES OF JUPITER AND OF SATURN
Younkin, R. L., Münch, G.
The Astronomical Journal, Vol. 69, No. 8, p. 565, October 1964

For abstract, see Entry AD44.

Newburn, R. L., Jr.

AD24 A LOW-DISPERSION SPECTROSCOPIC SEARCH FOR WATER VAPOR IN COOL STARS
Spinrad, H., Newburn, R. L., Jr.
The Astrophysical Journal, Vol. 141, No. 3, pp. 965–975, April 1, 1965

For abstract, see Entry AD33.

Nielsen, T. H.

AD25 THERMAL EXPANSION OF NICKEL OXIDE
Nielsen, T. H., Leipold, M. H.
Journal of the American Ceramic Society, Vol. 48, No. 3, p. 164, March 1965

The thermal expansion of polycrystalline nickel oxide was determined in an atmosphere of 95% O_2-5% N_2 to a maximum temperature of 1930°C. Expansion measurements below 1000°C were made in an automatic recording dilatometer; above 1000°C measurements were made optically in an oxide induction furnace.

Patterson, J. H.

AD26 CHEMICAL ANALYSIS OF SURFACES USING ALPHA PARTICLES
Patterson, J. H., Turkevich, A. L., Franzgrote, E.
Journal of Geophysical Research, Vol. 70, No. 6, pp. 1311–1327, March 15, 1965

The chemical analysis of surfaces using α-particle interactions has been investigated. Simple instruments incorporating Cm α sources and semiconductor silicon detectors are described. The characteristic energy spectrums of α-particles scattered at large angles from thick targets of different elements have been determined. The relative intensities of scattering by different elements have been established. They show large enhancement due to nuclear effects over Rutherford scattering for elements lighter than sodium. The production of protons from (α, p) reactions in certain elements increases the sensitivity of the method for these elements. The theoretical basis for the quantitative interpretation of scattering spectrums from complex materials is developed. The technique appears to be suitable for instrumented space missions.

Reed, I. S.

AD27 SYNCHRONIZATION
Golomb, S. W., Davey, J. R., Reed, I. S., Van Trees, H. L., Stiffler, J. J.
IEEE Transactions on Communications Systems, Vol. CS-11, No. 4, pp. 481–491, December 1963

For abstract, see Entry AD12.

Runcorn, S. K.

AD28 SATELLITE GRAVITY MEASUREMENTS AND A LAMINAR VISCOUS FLOW MODEL OF THE EARTH'S MANTLE
Runcorn, S. K.
Journal of Geophysical Research, Vol. 69, No. 20, pp. 4389–4394, October 15, 1964

This paper develops an intuitive approach into an analytical method of determining the nature of the flow patterns in the Earth's mantle.

Sciama, D. W.

AD29 ON THE FORMATION OF GALAXIES AND THEIR MAGNETIC FIELDS IN A STEADY STATE UNIVERSE
Sciama, D. W.
Quarterly Journal of the Royal Astronomical Society, Vol. 5, pp. 196–213, September 1964

The author's previous work on galaxy formation in a steady state universe is extended by including thermal and magnetic forces along with the gravitational forces considered earlier.

Sehgal, R.

AD30 THRUST VECTOR CONTROL BY LIQUID INJECTION INTO ROCKET NOZZLES
Sehgal, R., Wu, J.-M.
Journal of Spacecraft and Rockets, Vol. 1, No. 5, pp. 545–551, September–October 1964

An analytical model is constructed to represent the interaction between the injected liquid and the supersonic stream by considering the mechanism of atomization, the rate of evaporation, and the motion of droplets, based on the injectant and gas properties. The body shape, because of the generated vapor, is calculated from basic drag equations; the flow interference pattern, including the shock waves owing to turbulent boundary-layer separation, is then investigated. The total side force is computed by summing the reaction force due to the liquid jet, the force due to the excess pressure on the nozzle wall downstream of the shock pattern, and the contribution due to the separated region. Numerical examples are presented for two cases, results of which compare favorably with available test data.

Shumate, M. S.

AD31 INTERFEROMETRIC DETERMINATION OF THE PRINCIPAL REFRACTIVE INDICES OF BARIUM TITANATE SINGLE CRYSTALS
Shumate, M. S.
Applied Physics Letters, Vol. 5, No. 9, pp. 178–179, November 1, 1964

A measurement is reported of the principal indices of refraction of single crystals of barium titanate at several wavelengths in the visible portion of the spectrum. The method of determination—similar to techniques described more than 50 years ago—uses an interferometer to measure the optical path length through the sample, which is in the form of a plane parallel plate.

Solomon, G.

AD32 ALGEBRAICALLY PUNCTURED CYCLIC CODES
Solomon, G., Stiffler, J. J.
Information and Control, Vol. 8, No. 2, pp. 170–179, April 1965

This paper presents a new class of optimal (n, k) group codes over the general finite field $GF(q)$, q, a prime power, which are obtained by systematically deleting or puncturing certain coordinates of the maximal length shift register $(q^k - 1, k)$ code. The algorithm for puncturing is algebraic. The specific algebraic nature of this puncturing procedure for any particular k yields codes of length n greater than q^{k-1}. Optimality is proven by generalizing the Griesmer bound on group codes. Encoding and decoding procedures are presented for this class of codes.

Spinrad, H.

AD33 A LOW-DISPERSION SPECTROSCOPIC SEARCH FOR WATER VAPOR IN COOL STARS
Spinrad, H., Newburn, R. L., Jr.
The Astrophysical Journal, Vol. 141, No. 3, pp. 965–975, April 1, 1965

The presence of water-vapor absorption lines in the spectra of late-type M giants has been established with low-dispersion spectra at the (201) rotation-vibration band near λ9400. The high-excitation stellar H_2O lines form a noticeable head at λ9278, and the medium- and low-excitation lines blend with the telluric absorptions to increase markedly the total observed band strength.

The water band is strongest in the coolest stars, especially long-period Mira variables near minimum light. The detection of nearby TiO and ZrO bands has been utilized in a tabular description of the near-infrared stellar spectra.

An approximate abundance of 2 gm/cm² is derived for the water vapor in the visible atmosphere of Mira near minimum light. This amount of stellar H_2O falls far below the amount of water theoretically predicted above $\tau \approx 0.1$ in Mira.

Stiffler, J. J.

AD34 SYNCHRONIZATION

Golomb, S. W., Davey, J. R., Reed, I. S., Van Trees, H. L., Stiffler, J. J.
IEEE Transactions on Communications Systems, Vol. CS-11, No. 4, pp. 481–491, December 1963

For abstract, see Entry AD12.

AD35 COMMA-FREE ERROR-CORRECTING CODES
Stiffler, J. J.
IEEE Transactions on Information Theory, Vol. IT-11, No. 1, pp. 107–112, January 1965

A method is shown by which it is possible to establish the existence or nonexistence of the comma-free properties of any group code from a simple observation of its null-space. Using this technique, it is then demonstrated that all (n, k) *cyclic* group error-correcting code dictionaries can be made comma-free (without adding further redundancy or altering their error-correcting properties) if $k \leq (n-1)/2$. If k is larger than $(n-1)/2$, it is still possible to detect bit gains or losses of up to $n-k-1$ code bits.

AD36 ALGEBRAICALLY PUNCTURED CYCLIC CODES
Solomon, G., Stiffler, J. J.
Information and Control, Vol. 8, No. 2, pp. 170–179, April 1965

For abstract, see Entry AD32.

Turkevich, A. L.

AD37 CHEMICAL ANALYSIS OF SURFACES USING ALPHA PARTICLES
Patterson, J. H., Turkevich, A. L., Franzgrote, E.
Journal of Geophysical Research, Vol. 70, No. 6, pp. 1311–1327, March 15, 1965

For abstract, see Entry AD26.

Van Dilla, M. A.

AD38 DETECTION OF AN INTERSTELLAR FLUX OF GAMMA-RAYS
Metzger, A. E., Anderson, E. C., Van Dilla, M. A., Arnold, J. R.
Nature, Vol. 204, No. 4960, pp. 766–767, November 21, 1964

For abstract, see Entry AD22.

Van Trees, H. L.

AD39 SYNCHRONIZATION
Golomb, S. W., Davey, J. R., Reed, I. S., Van Trees, H. L., Stiffler, J. J.
IEEE Transactions on Communications Systems, Vol. CS-11, No. 4, pp. 481–491, December 1963

For abstract, see Entry AD12.

Wilson, T. A.

AD40 MINIMUM ENTROPY PRODUCTION AS A DESIGN CRITERION FOR BREATHING
Wilson, T. A.
Experientia, Vol. 20, No. 6, pp. 333–334, 1964

In an attempt to analyze biological processes in terms of entropy production and entropy flux, a model for a particular mechanism — the respiratory system in man — is examined, using ventilation as one of the model's parameters.

Wolf, F.

AD41 EFFECT OF ARGON ADDITION ON SHOCK-LAYER RADIANCE OF CO_2–N_2 GAS MIXTURES
Wolf, F., Horton, T.
AIAA Journal, Vol. 2, No. 8, pp. 1472–1474, August 1964

A Jet Propulsion Laboratory thermochemistry and real-gas normal shock computer program, used previously to give solutions to the equilibrium gas radiance of a CO_2-N_2 mixture, has been extended to cases of high argon content. This program used thermochemistry input data obtained from the General

Electric Company Missile and Space Vehicle Department; the radiance was computed with existing emissivity data.

Wu, C.-S.

AD42 HIGH-FREQUENCY CONDUCTIVITY OF A PLASMA IN QUASIEQUILIBRIUM: I. FORMULATION OF THE GENERAL THEORY
Wu, C.-S.
The Physical Review, Vol. 138, No. 1A, pp. A51–A57
April 5, 1965

A general expression for the high-frequency conductivity is derived from the Bogolyubov-Born-Green-Kirkwood-Yvon hierarchy for a fully ionized plasma whose unperturbed state is stable. The result includes all the effects due to the high-frequency field and the collective interactions up to first order in the plasma parameter.

Wu, J.-M.

AD43 THRUST VECTOR CONTROL BY LIQUID INJECTION INTO ROCKET NOZZLES
Sehgal, R., Wu, J.-M.
Journal of Spacecraft and Rockets, Vol. 1, No. 5, pp. 545–551, September–October 1964

For abstract, see Entry AD30.

Younkin, R. L.

AD44 WAVELENGTH DEPENDENCE OF THE BAND STRUCTURES OF JUPITER AND OF SATURN
Younkin, R. L., Münch, G.
The Astronomical Journal, Vol. 69, No. 8, p. 565, October 1964

Instrumentation used and results obtained during the 1963 photoelectric measurements of the band structures of the two planets are discussed.

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