Bibliography No. 39-5

Publications of the Jet Propulsion Laboratory July 1963 through June 1964

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PREFACE

JPL Bibliography No. 39-5 is a compilation of official reports of the Jet Propulsion Laboratory released July 1, 1963 through June 30, 1964. Current security classifications of all documents are indicated; however, their titles and abstracts given herein are unclassified.

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.

This Bibliography is divided into the following sections:

Technical Reports and Memorandums. Comprising the main portion of the Bibliography, this section is alphabetically arranged, and cross referenced by author.

Summary Publications. This section lists issues of the Quarterly Summary Report and Space Programs Summary.

Astronautics Information. Publications herein consist of Literature Searches, Abstracts—Reports and Open Literature, and Translations.

Numerical Index. All entries of the above three sections are indexed according to report number.

Subject Index. All entries of the Technical Reports and Memorandums and the Summary Publications sections, as well as Literature Searches and Translations, are indexed according to subject.

For previous entries, see Bibliography Nos. 39-1, 39-2, 39-3, and 39-4.

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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.

Allen, J. D.

A01 A MICROELECTRONIC ANALOG-TO-DIGITAL CONVERTER AND SYNC GENERATOR
Allen, J. D.
Technical Report 32-569, February 6, 1964 (Unclassified)

The application of thin-film passive components and planar transistor technology to the fabrication of an analog-to-digital converter and sync generator for use in spacecraft television is described. The analog-to-digital converter selected is also described, and compared with other types that were considered. Fabrication technology, and material selection criteria are discussed. It is concluded that the combination of semiconductor and thin film techniques offers considerable advantages in this and other microelectronic applications.

Anderson, F. A.

A02 LOW PRESSURE ROCKET EXTINCTION
Anderson, F. A., Strehlow, R. A., Strand, L. D.
Technical Report 32-509 (Unclassified)
(Reprinted from the *AIAA Journal*, v. 1, no. 11, pp. 2669–2671, November 1963)

Two primary requirements of a solid rocket design for low pressure operation are (1) that there be no loss of combustion efficiency, and (2) that the rocket ignites and burns in a completely reliable manner. Low pressure operation has always encountered difficulties, however, and this preliminary work does not answer all the questions concerning low pressure extinction, but it does indicate that a few experimental vacuum firings using regressive grains can be used to determine the low pressure limit for any particular propellant formulation. Results of some grain firings with regressive cylindrical rounds are reported.

A03 AN EXPERIMENTAL INVESTIGATION OF THE LOW-PRESSURE COMBUSTION LIMITS OF SOME SOLID PROPELLANTS
Anderson, F. A., Strand, L. D., Strehlow, R. A.
Technical Memorandum 33-134, June 3, 1963
(Confidential)

Studies of combustion at the Jet Propulsion Laboratory have shown that solid propellants, including aluminized systems, can be burned at relatively low chamber pressures—100 psia and below – without exhibiting an appreciable loss in combustion efficiency. It has been recognized for some time, however, that certain propellants exhibit lower limits of combustion, but the correlation of this phenomenon with motor geometry as well as chamber pressure is relatively new. This minimum pressure limit, or extinction pressure, has been found to be independent of the propellant grain geometry but strongly dependent on L^* (the ratio of the free-chamber volume to the nozzle-throat area) and on the propellant ballistic properties. The chamber extinction pressure (Pc_e) for a given L^* was also found to be independent of the back pressure as long as the critical-pressure ratio was maintained such that sonic flow in the nozzle throat was also maintained, i.e.,

$$\left(\frac{Pa}{Pc}\right) \leq r_c = \left(\frac{2}{\gamma+1}\right)^{\gamma/\gamma-1}$$

The L^* instability associated with the minimum pressure limit does not appear to be related to the higher pressure combustion instability normally characterized by high-frequency pressure oscillations.

Anderson, J. D.

A04 APPLICATION OF THE METHOD OF AVERAGES TO CELESTIAL MECHANICS
Lorell, J., Anderson, J. D., Lass, H.
Technical Report 32-482, March 16, 1964 (Unclassified)

For abstract, see Entry L19.

A05 THEORY OF ORBIT DETERMINATION—PART I CLASSICAL METHODS
Anderson, J. D.
Technical Report 32-497, October 1, 1963 (Unclassified)

A cursory review of the classical methods of orbit determination is given to acquaint the reader with the nature of the classical orbit determination problem. The Gaussian and Laplacian methods of obtaining a first approximation to the orbit are outlined, but no attempt is made to describe the computational procedures in detail. Instead, a list of references is included that provides exhaustive treatment of the classical orbit determination topics.

A06 THEORY OF ORBIT DETERMINATION—PART II ESTIMATION FORMULAS
Anderson, J. D.
Technical Report 32-498, October 1, 1963 (Unclassified)

Parameter estimation formulas are described which are currently in use for the orbit determination of space vehicles. The weighted least-squares-estimator with the inclusion of *a priori* parameter information is defined, and its relation to the maximum-likelihood-estimator is discussed. The Schmidt-Kalman estimator is described also and compared with the least-squares procedure, showing conditions under which the two formulas are mathematically equivalent.

Anderson, R. G.

A07 THE *SYNCOM 1* JPL APOGEE ROCKET MOTOR
Anderson, R. G., Gin, W., Kohorst, D. P.
Technical Memorandum 33-143 (Revision 1), September 16, 1963 (Confidential)

On July 26, 1963, the first successful *Syncom* satellite of the Group I R&D series was injected into a nearly circular, synchronous orbit by the firing of the first flight motor (P-46), the design of which is described in this memorandum. The altitude of firing was approximately 22,500 mi.

Ashkenas, H.

A08 LOW-DENSITY SPHERE DRAG WITH EQUILIBRIUM AND NONEQUILIBRIUM WALL TEMPERATURE
Ashkenas, H.
Technical Report 32-442 (Unclassified)
(Presented at the 3rd International Rarefied Gas Dynamics Symposium, Paris, France, June 26–30, 1962. Reprinted from "3rd International Rarefied Gas Dynamics Symposium, Volume II," pp. 278–290, Academic Press, Inc., New York, N.Y., 1963)

The drag of a sphere in a supersonic low-density flow has been measured under both equilibrium and nonequilibrium surface temperature conditions. A simple deflection technique described earlier has been exploited to yield drag data for free stream Mach numbers between 1.8 and 4.4, free stream Reynolds numbers between 3 and 125, and free stream Knudsen numbers between 1 and 0.05. Radiation heating of the sphere models has produced wall temperatures as high as 1860°R (= 1033°K), resulting in wall-to-free-stream temperature ratios up to 15; the drag increase due to heating has been measured at up to 25% of the equilibrium wall-temperature value.

Avizienis, A.

A09 A SET OF ALGORITHMS FOR A DIAGNOSABLE ARITHMETIC UNIT
Avizienis, A.
Technical Report 32-546, March 1, 1964 (Unclassified)

The design of a diagnosable arithmetic unit for a digital computer is discussed, arithmetical errors are classified, and the effects of circuit failure on an arithmetical result are considered. The methods of hardware (wired-in) checking of arithmetic are reviewed, and the cost of checking is proposed as a merit criterion. A low-cost checking algorithm for product-coded numbers is presented and its effectiveness evaluated with respect to various types of errors. A complete set of arithmetical algorithms for product-coded numbers is also given. The algorithms are especially economical when the product code is chosen for the proposed low-cost checking algorithm.

Babineaux, T. L.

B01 THE INFLUENCE OF SHAPE ON AERODYNAMIC DAMPING OF OSCILLATORY MOTION DURING MARS ATMOSPHERE ENTRY AND MEASUREMENT OF PITCH DAMPING AT LARGE OSCILLATION AMPLITUDES
Dayman, B., Jr., Brayshaw, J. M., Jr., Nelson, D. A., Jaffe, P., Babineaux, T. L.
Technical Report 32-380, February 28, 1963 (Unclassified)

For abstract, see Entry D04.

Back, L. H.

B02 CONVECTIVE HEAT TRANSFER IN A CONVERGENT–DIVERGENT NOZZLE
Back, L. H., Massier, P. F., Gier, H. L.
Technical Report 32-415, November 15, 1963 (Unclassified)

Results are presented of an experimental investigation of 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 thicknesses 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 made by using thermocouples embedded in the nozzle wall. The most significant unexpected trend in the results is the reduction in the heat-transfer coefficient (below the variation with stagnation pressure anticipated for a turbulent boundary layer) at stagnation pressures less than about 75 psia.

Heat-transfer predictions with which the data were compared either incorporate a prediction of the boundary-layer characteristics or are related to pipe flow. At the higher stagnation pressures, predicted values from a modification of Bartz' turbulent boundary-layer analysis are in fair agreement with the data. As a possible explanation of the low heat-transfer rates at the lower stagnation pressures, a parameter was found which is a measure of the importance of flow acceleration in reducing the turbulent transport below that typical of a fully turbulent boundary layer.

Barth, C. A.

B03 ULTRAVIOLET SPECTROSCOPY OF PLANETARY ATMOSPHERES
Barth, C. A.
Technical Report 32-516 (Unclassified)
(Reprinted from "Dynamics of Manned Lifting Planetary Entry," pp. 82–94, John Wiley & Sons, Inc., New York, N.Y., 1963)

The ultraviolet spectrum of a planetary atmosphere is produced by charged-particle bombardment and solar radiation. The ultraviolet aurora and dayglow may be observed from a rocket within the atmosphere, from a satellite above the atmosphere, and from a space probe flying by the planet. The spectrum of the ultraviolet dayglow is the result of molecular scattering, absorption, resonance re-radiation, and fluorescence of the incident solar radiation. The composition of the upper atmosphere may be determined from a quantitative analysis of the dayglow spectra. The spectrum of the ultraviolet aurora identifies many of the atoms and molecules present in the atmosphere. The geographic distribution of the aurora is believed to be the result of the interaction of the solar plasma with the planet's magnetosphere. The details of the spectrum will provide information on the energy and nature of the bombarding particles.

B04 THREE-BODY REACTIONS
Barth, C. A.
Technical Report 32-593 (Unclassified)
(Reprinted from *Annales de Géophysique*, v. 20, no. 2, pp. 182–196, April–June 1964)

This paper discusses (1) the laboratory experimental technique most useful in studying upper atmosphere three-body reactions, (2) the laboratory results on overall reaction rates, (3) the three-body reactions that lead to the emission of light, and (4) the laboratory results as applied to the Earth's upper atmosphere and the night airglow.

Baumert, L. D.

B05 TABLE OF PERIOD GENERATORS
Baumert, L. D.
Technical Report 32-564, November 1, 1962 (Unclassified)

A table of logics for digital countdown circuits of periods 4 through 2047 is given. In addition, a complete exposition of the underlying theoretical results and a brief discussion of applications are presented.

Beaudet, R. A.

B06 THE STRUCTURE OF $C_2B_5H_7$
Beaudet, R. A., Poynter, R. L.
Technical Report 32-609 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, v. 86, pp. 1258–1259, March 20, 1964)

Information pertinent to the structure of one of the recently synthesized carboranes, 2,4-dicarbaheptaborane, is reported.

Bernett, E. C.

B07 THE BEARING CAPACITY OF SIMULATED LUNAR SURFACES IN VACUUM
Bernett, E. C., Scott, R. F., Jaffe, L. D., Frink, E. P., Martens, H. E.
Technical Report 32-326, August 15, 1963 (Unclassified)

The static-bearing capacity of a granular material consisting of dry, crushed olivine basalt was determined in both air and a 10^{-6} mm Hg vacuum by means of cylindrical probes with a range of diameters. Samples with various particle size distributions (all below 35 mesh) were used for these tests. The packing density of these granular materials was found to have the greatest effect on the bearing capacity. The minimum bearing capacity of a loosely packed sample with a density of 1.25 g/cm^3 was about 0.1 kg/cm^2. The maximum bearing capacity of a densely packed sample with density of 2.1 g/cm^3 was about 7 kg/cm^2. The effects of vacuum were insignificant as compared with the effect of packing density. Direct shear tests indicated the cohesion in a few densely packed samples to be 1 to 2×10^4 dynes/cm^2. For the small probes used, the cohesion was estimated to contribute 85 to 95% of the observed bearing capacity for the densely packed samples, but much less for those loosely packed.

B08 METALLURGICAL EXAMINATION OF DEVELOPMENT-TYPE THERMIONIC POWER CONVERTERS
Bernett, E. C.
Technical Report 32-548, December 15, 1963 (Unclassified)

A number of thermionic power converters (diodes) were examined, after they had been tested to failure, to determine causes of failure, and check for substandard material or workmanship.

Some components of the early model diodes showed very poor machine finishes; however, there was a noticeable improvement in the later models. The braze joints (particularly the metal–ceramic seal) continued to show a marked variation in structure from model to model, indicating a lack of process control in this area. Heavy foreign deposits were observed on the collectors of two diodes, and there was an intergranular cesium attack on two emitter sleeves. The exact nature of these two effects could not be established, but the evidence indicated an association with impurities in the cesium and with poor control of the test atmosphere.

Block, N.

B09 PLANETARY POSITION-VELOCITY EPHEMERIDES OBTAINED BY SPECIAL PERTURBATIONS
Peabody, P. R., Block, N.
Technical Report 32-545 (Unclassified)
(Reprinted from *AIAA Journal*, v. 1, no. 12, pp. 2812–2815, December 1963)

For abstract, see Entry P01.

Bollman, W. E.

B10 EARTH–VENUS TRAJECTORIES, 1967
Clarke, V. C., Jr., Roth, R. Y., Bollman,W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 3, Part A, June 15, 1963 (Unclassified)

For abstract, see Entry C11.

B11 EARTH–VENUS TRAJECTORIES, 1967
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 3, Part B, July 1, 1963 (Unclassified)

For abstract, see Entry C11.

B12 EARTH–VENUS TRAJECTORIES, 1967
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 3, Part C, July 15, 1963 (Unclassified)

For abstract, see Entry C11.

B13 EARTH–VENUS TRAJECTORIES, 1968–1969
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 4, Part A, August 1, 1963 (Unclassified)

For abstract, see Entry C11.

B14 EARTH–VENUS TRAJECTORIES, 1968–1969
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 4, Part B, August 15, 1963 (Unclassified)

For abstract, see Entry C11.

B15 EARTH–VENUS TRAJECTORIES, 1968–1969
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 4, Part C, September 3, 1963 (Unclassified)

For abstract, see Entry C11.

B16 EARTH–VENUS TRAJECTORIES, 1970
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 5, Part A, September 16, 1963 (Unclassified)

For abstract, see Entry C11.

B17 EARTH–VENUS TRAJECTORIES, 1970
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 5, Part B, October 1, 1963 (Unclassified)

For abstract, see Entry C11.

B18 EARTH–VENUS TRAJECTORIES, 1970
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 5, Part C, October 15, 1963 (Unclassified)

For abstract, see Entry C11.

B19 EARTH–MARS TRAJECTORIES, 1964
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-100, Volume 1, Part A, March 1, 1964 (Unclassified)

For abstract, see Entry C12.

Boone, D. H.

B20 TENSILE PROPERTIES OF PYROLYTIC TUNGSTEN FROM 1370° TO 2980°C IN VACUUM
Taylor, J. L., Boone, D. H.
Technical Report 32-463 (Unclassified)
(Reprinted from *Journal of the Less-Common Metals*, v. 6, pp. 157–164, 1964)

For abstract, see Entry T09.

Brayshaw, J. M., Jr.

B21 THE INFLUENCE OF SHAPE ON AERODYNAMIC DAMPING OF OSCILLATORY MOTION DURING MARS ATMOSPHERE ENTRY AND MEASUREMENT OF PITCH DAMPING AT LARGE OSCILLATION AMPLITUDES
Dayman, B., Jr., Brayshaw, J. M., Jr., Nelson, D. A., Jaffe, P., Babineaux, T. L.
Technical Report 32-380, February 28, 1963 (Unclassified)

For abstract, see Entry D04.

B22 MARS ATMOSPHERE ENTRY PARAMETRIC STUDY
Brayshaw, J. M., Jr.
Technical Report 32-458, September 15, 1963 (Unclassified)

In anticipation of the many technical disciplines involved in a Mars planetary entry program requiring such information for design studies and preliminary design decisions, a fairly complete parametric study of the Mars atmospheric entry was performed. The expected extreme model atmospheres, as well as the anticipated extremes of initial entry velocity, entry angle, and ballistic coefficient were included. As functions of these variables, the following parameters are plotted in graphic form: (1) flight-path acceleration vs. altitude, (2) Mach numbers vs. altitude, (3) dynamic pressure vs. altitude, (4) heating rate vs. altitude, (5) flight-path angle vs. altitude, (6) atmospheric velocity vs. altitude, (7) altitude vs. time, and (8) altitude vs. planet-centered angle.

In addition, summary plots of peak heating rate, peak acceleration, unretarded impact velocity, and altitude for parachute deployment are shown as a function of entry angle for the extremes of ballistic coefficient and model atmosphere.

B23 MARS ATMOSPHERE ENTRY PARAMETRIC STUDY
Brayshaw, J. M., Jr.
Technical Report 32-458 (Revision 1), October 31, 1963 (Unclassified)

For abstract, see Entry B22.

Briggs, M. H.

B24 ORGANIC CONSTITUENTS OF THE CARBONACEOUS CHONDRITES
Briggs, M. H., Mamikunian, G.
Technical Report 32-436 (Unclassified)
(Reprinted from *Space Science Reviews*, v. 1, pp. 647–682, June 1962–May 1963)

From a brief discussion of forms of meteorite carbon, it is concluded that almost all the carbon in the carbonaceous chondrites is present as organic matter. Attempts to extract and identify this organic matter are reviewed; it is shown that only 25% has been extracted and, of that, only about 5% chemically characterized. Of this 5%, the majority is a complex mixture of hydroxylated aromatic acids together with various hydrocarbons of the paraffin, naphthene, and aromatic series. Small amounts of amino acids, sugars, and fatty acids, are also present. It is suggested that the chemical nature of the major fraction may be a mixture of high molecular weight aromatic and hydrocarbon polymers.

Possible sources of contamination of the meteorites are described, and evidence indicating a general lack of organic contaminants is presented. Most of the organic constituents are found to be indigenous to the meteorites and are extraterrestrial in origin. Synthetic processes for the compounds are mentioned, and it is concluded that the organic material is probably of abiogenetic origin.

Studies of "organized elements" contained within the meteorites are briefly reviewed. Difficulties of identification are discussed, and photographs of some micro-structures of several carbonaceous chondrites are presented. No final conclusion about the nature of these elements is possible, but some appear to be various indigenous organic and mineral structures, while others are terrestrial contaminants.

Burt, P. B.

B25 DAMPING OF QUANTIZED LONGITUDINAL PLASMA OSCILLATIONS
Klevans, E. H., Burt, P. B., Wu, C.-S.
Technical Report 32-553, April 15, 1964 (Unclassified)

For abstract, see Entry K10.

Butler, E. A.

B26 DISCHARGE BEHAVIOR OF THE AgO–Ag ELECTRODE
Butler, E. A.
Technical Report 32-535, December 22, 1963 (Unclassified)

The production of gas by AgO electrodes and by AgO powder and pellets in 40% KOH at 25°C was investigated. Little gas was evolved by any form of AgO during chemical or electrochemical reaction, provided that the temperature of the material remained in the vicinity of 25°C. Electrodes treated at 100°C released gas which was probably occluded oxygen produced by the chemical decomposition of AgO. There was no evidence that gassing was affected by the electrode potential. Examination of partially discharged plates indicated that the electrochemical reaction occurred preferentially at physical discontinuities.

Cain, D. L.

C01 DETERMINATION OF TRACKING STATION LOCATIONS BY DOPPLER AND RANGE MEASUREMENTS TO AN EARTH SATELLITE
Cain, D. L., Hamilton, T. W.
Technical Report 32-534, February 1, 1964 (Unclassified)

The accumulation of accurate tracking data on an Earth satellite that is relatively free from unknown or unpredictable accelerations offers opportunity to obtain estimates of

tracking-station locations, data systematic errors, and the Earth's potential field, as well as a precise ephemeris of the satellite. This report is an examination of a simplified version of the case stated, with attention to the determination of station coordinates.

Under the assumption that the satellite's orbit is perfectly known, an examination is made to ascertain the accuracy to which the station coordinates may be obtained from the tracking of single and multiple passes by means of range or doppler (range-rate) measurements alone. The results indicate that dramatic improvement is attained when data from two different passes are statistically combined. A method is introduced whereby this improvement may be easily understood. The middle semi-axis of the three-dimensional error ellipsoid associated with a single pass is introduced as the most valuable measure of accuracy. The variation of accuracy with satellite altitude, station latitude, data type, and the geometry of the pass is extensively examined.

It is found that the ranging accuracy equivalent to a 0.03-m/sec range-rate accuracy varies from 1.8 m at a satellite altitude of 100 nm to 15.5 m at 1000 nm; such data accuracies should permit determination of all three station coordinates to about 5 m when the data from two or more passes are utilized.

C02 THE *RANGER* 5 FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Sjogren, W. L., Kirhofer, W. E., Cain, D. L., Wollenhaupt, W. R., Hamilton, T. W.
Technical Report 32-562, December 6, 1963 (Unclassified)

For abstract, see Entry S13.

Chahine, M. T.

C03 THE STRUCTURE OF STRONG SHOCK WAVES IN THE KROOK COLLISION MODEL
Chahine, M. T.
Technical Report 32-327 (Unclassified)
(Presented at the 3rd International Rarefied Gas Dynamics Symposium, June 26–30, 1962, Paris, France. Reprinted from "3rd International Rarefied Gas Dynamics Symposium, Volume 11," pp. 260–273, Academic Press, Inc., New York, N. Y., 1963)

Shock profiles are computed using Krook's collision model in an iteration scheme starting from the Navier-Stokes solution.

C04 EVALUATION OF THE INTEGRAL $\int_0^\infty v^n \exp\left[-(v-u)^2 - \frac{x}{v}\right] dv$
Chahine, M. T., Narasimha, R.
Technical Report 32-459, August 5, 1963 (Unclassified)

The function defined by the integral

$$g_n(x, u) = \int_0^\infty v^n \exp\left[-(v-u)^2 - \frac{x}{v}\right] dv$$

is tabulated to six decimals in the ranges $0 \leq x \leq 20$ and $-2.5 \leq u \leq 10$ for $n = 0, 1, 2$, and asymptotic expressions for the function are given for limiting values of x and u.

Chamberlain, R. G.

C05 PARTIAL MATHEMATICAL SOLUTION OF THE THREE-DIMENSIONAL FOUR-BAR LINKAGE
Chamberlain, R. G.
Technical Report 32-386, September 16, 1963 (Unclassified)

This paper considers a four-bar linkage in which two adjacent hinges have skew axes and are fixed in the coordinate system, while the remaining two joints are universal. Analytical relations are found between the rotations, angular velocities, angular accelerations, and torques about the fixed joints.

Chase, S. C.

C06 THE *MARINER* 2 INFRARED RADIOMETER EXPERIMENT
Chase, S. C., Kaplan, L. D., Neugebauer, G.
Technical Report 32-484 (Unclassified)
(Reprinted from the *Journal of Geophysical Research*, v. 68, no. 22, pp. 6157–6169, November 1963)

Measurements of the 8.4- and 10.4-μ radiation temperature of small regions of Venus were made by using an infrared radiometer on *Mariner 2*. The radiation temperatures agree with broad-band (8- to 13-μ) Earth-based measurements, the light- and dark-side temperatures are equal, and there is definite limb darkening. The data are consistent with equal radiation temperatures at 8.4 and 10.4 μ, which is interpreted as indicating that the emission is from a cloud structure. No breaks in the clouds were observed. A description of the radiometer instrumentation and operation is given.

Chen, C. J.

C07 TEMPERATURE EFFECT ON LANGMUIR PROBE MEASUREMENT
Chen, C. J.
Technical Memorandum 33-157, October 30, 1963 (Unclassified)

When a moderately heated tungsten Langmuir probe is immersed in an argon plasma in a discharge tube, a substantial lowering of its work function is observed. The mechanism is thought to be similar to the Schottky effect. The influence of this phenomenon on the accuracy of the probe measurements is discussed.

Childress, S.

C08 ASYMPTOTIC EXPANSIONS OF NAVIER–STOKES SOLUTIONS IN THREE DIMENSIONS FOR LARGE DISTANCES
Childress, S.
Technical Report 32-480, January 15, 1964 (Unclassified)

This report studies the stationary flow field at large distances from a finite obstacle moving uniformly in a viscous, incompressible fluid. The principal results consist of asymptotic expansions, uniformly valid for large distances, of the velocity and pressure of the flow field.

The calculated results include the following: for the case of axially symmetric flow, a uniformly valid expansion of the velocity to order r^{-2} inclusive, and of the pressure to order r^{-3} inclusive, r being the distance from the obstacle; for the general case, an expansion of the velocity to order $r^{-3/2}$ inclusive and of the pressure to order r^{-2} inclusive.

Clarke, V. C., Jr.

C09 EARTH RADIUS/KILOMETER CONVERSION FACTOR FOR THE LUNAR EPHEMERIS
Clarke, V. C., Jr.
Technical Report 32-489 (Unclassified)
(Reprinted from *AIAA Journal*, v. 2, no. 2, pp. 363–364, 1964)

This paper develops a relationship that is a function of the Moon's mean motion and the gravitational constants of both Earth and Moon, and gives a value for the Earth radius/kilometer conversion factor for the lunar ephemeris.

C10 CONSTANTS AND RELATED DATA FOR USE IN TRAJECTORY CALCULATIONS. As adopted by the Ad Hoc NASA Standard Constants Committee
Clarke, V. C., Jr.
Technical Report 32-604, March 6, 1964 (Unclassified)

The establishment of a standard set of constants and ephemerides data for trajectory and orbit determination computations is essential to ensure accuracy and consistency between the various NASA agencies and contractors participating in the space program. One of the conditions for correct comparison and use of numerical results is that the same set of constants and ephemerides data be used. Further, in the selection of numerical values for the constants, recent measurements should be considered so that the values are near optimum, i.e., the best available. Periodic review of the values is necessary to incorporate significant improvements; however, too frequent changes are undesirable.

The establishment, selection, and review of a NASA Standard Set of Constants for use in trajectory and orbit calculations were the concern of several NASA engineers. In late 1960, plans were made to form an ad hoc group to adopt such a set of constants; as a result of this activity, a set was adopted in 1961, and was reviewed, with minor changes, in 1963; a periodic review on about a two-year basis is planned.

This report presents the adopted values of key constants for use in trajectory calculations, information regarding the procurement of the best available ephemerides data, and other work of the ad hoc group.

C11 EARTH–VENUS TRAJECTORIES
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99 (Unclassified)

This memorandum is a five-volume series of publications, each volume consisting of three parts, giving key characteristics of Earth-to-Venus trajectories during the period 1964–1970. The period is divided into five 120-day launch intervals about 19.2 months apart. During each interval, trajectory characteristics are given for flight times of from 70 to 220 days in 2-day steps. Thus, each of the volumes contains 9,120 trajectories. It is intended that these publications 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 the above purposes.

Volume 3, Part A (1967), June 15, 1963
Volume 3, Part B (1967), July 1, 1963
Volume 3, Part C (1967), July 15, 1963
Volume 4, Part A (1968–1969), August 1, 1963
Volume 4, Part B (1968–1969), August 15, 1963
Volume 4, Part C (1968–1969), September 3, 1963
Volume 5, Part A (1970), September 16, 1963
Volume 5, Part B (1970), October 1, 1963
Volume 5, Part C (1970), October 15, 1963

For Volumes 1 and 2, see Bibliography 39-4, Entry C15.

C12 EARTH–MARS TRAJECTORIES, 1964
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-100, Volume 1, Part A, March 1, 1964 (Unclassified)

This is the first 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.

C13 DUAL-CAVITY MASER USED IN MARS RADAR EXPERIMENT
Higa, W. H., Clauss, R. C.
Technical Report 32-432 (Unclassified)
(Reprinted from the *Proceedings of the IEEE*, v. 51, no. 6, pp. 948–949, June 1963)

For abstract, see Entry H23.

Cotter, F. W.

C14 HARDENABILITY OF TITANIUM ALLOYS
Jaffe, L. D., Gordon, E., Cotter, F. W.
Technical Report 32-589 (Unclassified)
(Reprinted from *Transactions of the Metallurgical Society of AIME*, v. 230, pp. 541–550, April 1964)

For abstract, see Entry J02.

Cuddihy, E. F.

C15 JPL X600 PROPELLANT, A UREA-CONTAINING POLYURETHANE PROPELLANT
Havlik, A. J., Moacanin, J., Cuddihy, E. F.
Technical Report 32-438, June 1, 1963 (Confidential)

For abstract, see Entry H15.

C16 GRAFT AND BLOCK COPOLYMERS OF SOME VINYL AROMATIC HYDROCARBONS
Rembaum, A., Moacanin, J., Cuddihy, E. F.
Technical Report 32-474 (Unclassified)
(Reprinted from *Journal of Polymer Science, Part C: Polymer Symposia*, no. 4, pp. 529–549, 1964)

For abstract, see Entry R08.

C17 REPRODUCIBILITY OF PROPERTIES OF COMPOSITE POLYURETHANE PROPELLANTS
Cuddihy, E. F., Havlik, A. J., Moacanin, J.
Technical Report 32-481, February 1, 1964 (Confidential)

Batch-to-batch and within-batch property differences can result from variations in the processing, handling, and testing procedures employed for composite polyurethane propellants. The magnitude of the effect of each of these parameters was investigated and their relative importance established. Particular emphasis was given to the influence of the mixing, casting, curing, and test specimen preparation techniques.

Dallas, S. S.

D01 MOON-TO-EARTH TRAJECTORIES
Dallas, S. S.
Technical Report 32-412, June 1, 1963 (Unclassified)

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 computing techniques for 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, J. P.

D02 LITHIUM-BOILING POTASSIUM REFRACTORY METAL LOOP FACILITY
Davis, J. P., Kikin, G. M., Phillips, W. M., Wolfson, L. S.
Technical Report 32-508, August 31, 1963 (Unclassified)

A 30-kw lithium-boiling potassium two-loop facility is presently under construction at the Jet Propulsion Laboratory and is expected to be in operation during 1964. The loop is constructed totally of columbium-1% zirconium alloy and will operate at temperatures up to 2100°F.

The primary purposes of this facility are as follows: (1) to investigate overall transient and steady-state characteristics of a two-loop system which approximately simulates velocities, temperatures, pressures, transit times, and heat fluxes in the range of actual system interest (A detailed study of regimes of boiling stability under various operating conditions, heat fluxes, exit vapor quality, inlet subcooling, etc., will be made.); (2) to obtain steady-state local-boiling heat-transfer coefficients and two-phase pressure drop data for a variety of operating parameters; (3) to evaluate components such as throttling valves, centrifugal pumps, hot traps, and experimental turbine-alternators for potential application to operational systems.

Dayman, B., Jr.

D03 COMPARISON OF CALCULATED WITH MEASURED BOUNDARY-LAYER THICKNESS ON THE CURVED WALLS OF THE JPL 20-IN. SUPERSONIC WIND TUNNEL TWO-DIMENSIONAL NOZZLE
Dayman, B., Jr.
Technical Report 32-349, March 18, 1963 (Unclassified)

Experimentally determined values of the local skin-friction coefficients of adiabatic flat-plate, turbulent, compressible boundary layers were approximated by an analytical expression which, in turn, was used in conjunction with the boundary-layer integral-momentum equation to calculate test-section boundary-layer thicknesses in the Jet Propulsion Laboratory 20-in. supersonic wind tunnel. These calculations were compared with measured boundary-layer thicknesses for the Mach number range of 1.4 to 5. The comparisons were fair, but varied with the Reynolds number. The use of a simpler analytical boundary-layer skin-friction equation gave better comparisons and was not as dependent upon Reynolds number as the more complicated analytical expression. A shortcut method (in contrast to the step-by-step integration from the throat to the test section) for estimating the test-section boundary-layer momentum and displacement thicknesses is shown, and several examples are given.

D04 THE INFLUENCE OF SHAPE ON AERODYNAMIC DAMPING OF OSCILLATORY MOTION DURING MARS ATMOSPHERE ENTRY AND MEASUREMENT OF PITCH DAMPING AT LARGE OSCILLATION AMPLITUDES
Dayman, B., Jr., Brayshaw, J. M., Jr., Nelson, D. A., Jaffe, P., Babineaux, T. L.
Technical Report 32-380, February 28, 1963 (Unclassified)

Preliminary mission requirements for first-generation vehicles proposed for entry into the atmosphere of Mars indicate the use of a high-drag body of revolution with length about equal to the maximum diameter. Even for the case of initial rearward entry, it is desirable that forward orientation with low amplitudes of oscillation of such vehicles be attained passively during the heating period (and beyond), i.e., without the need of any active control devices. Six-degree-of-freedom atmosphere-entry studies indicate the significant effects of both vehicle shape and pitch damping upon the envelope of the angle-of-attack oscillation at the time of practicable parachute deployment. One purpose of this report is to demonstrate the importance of the vehicle shape upon the requirements (accuracy and angle-of-attack amplitude) for measuring pitch damping; the other purpose is to discuss the two wind-tunnel methods being developed to accurately measure small amounts of pitch damping at high amplitudes of oscillation.

DeMore, W. B.

D05 HARTLEY BAND EXTINCTION COEFFICIENTS OF OZONE IN THE GAS PHASE AND IN LIQUID NITROGEN, CARBON MONOXIDE, AND ARGON
DeMore, W. B., Raper, O. F.
Technical Report 32-567 (Unclassified)
(Reprinted from *Journal of Physical Chemistry*, v. 68, pp. 412–414, 1964)

The gas-phase extinction coefficients are measured throughout the 2000- to 3100-Å region, and the results are found to be in close agreement with those obtained previously by E. C. Y. Inn and T. Tanaka.

D06 REACTION OF O(^{1}D) WITH CO
Raper, O. F., DeMore, W. B.
Technical Report 32-571 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 40, no. 4, pp. 1053–1057, February 15, 1964)

For abstract, see Entry R04.

D07 REACTION OF ELECTRONICALLY EXCITED O_2 WITH CO
Raper, O. F., DeMore, W. B.
Technical Report 32-572 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 40, no. 4, pp. 1047–1052, February 15, 1964)

For abstract, see Entry R05.

Dowdy, M. W.

D08 INVESTIGATION OF LIQUID AND GASEOUS SECONDARY INJECTION PHENOMENA ON A FLAT PLATE WITH $M = 2.01$ TO $M = 4.54$
Dowdy, M. W., Newton, J. F., Jr.
Technical Report 32-542, December 23, 1963 (Unclassified)

An experimental program has been conducted in the 20-in. Supersonic Wind Tunnel at the Jet Propulsion Laboratory to study the interaction effects produced when liquid or gaseous nitrogen is injected in a direction perpendicular to a supersonic stream on a flat plate. The tests provided useful information about the effects of free-stream Mach number, free-stream Reynolds number, injection pressure on the shock structure, and pressure distribution induced on the plate by the injection process. Pressure distributions in the injector region, schlierens, spark shadowgraphs, and motion pictures provided details about the flow interaction, which should assist in the development of more meaningful analytical models of secondary injection.

Dumas, L. N.

D09 FINAL REPORT ON *MARINER 2* TEMPERATURE CONTROL
Lewis, D. W., Gram, M. B., Spehalski, R. J., Dumas, L. N.
Technical Memorandum 33-140, July 1, 1963 (Unclassified)

For abstract, see Entry L12.

Duran, E. N.

D10 SOME EXPERIMENTAL AND THEORETICAL SIGNIFICANCES ASSOCIATED WITH IRRADIATED PROPELLANT
San Miguel, A., Duran, E. N.
Technical Report 32-518, November 1, 1963 (Unclassified)

For abstract, see Entry S01.

D11 SOME LOW-MODULUS BIREFRINGENT RESINS
San Miguel, A., Duran, E. N.
Technical Report 32-556 (Unclassified)
(Reprinted from *Experimental Mechanics*, March 1964)

For abstract, see Entry S02.

Ebersole, S. J.

E01 GEMINAL PROTON–PROTON COUPLING CONSTANTS IN $CH_2{=}N{-}$SYSTEMS
Shapiro, B. L., Ebersole, S. J., Karabatsos, G. J., Vane, F. M., Manatt, S. L.
Technical Report 32-538 (Unclassified)
(Reprinted from *The Journal of the American Chemical Society*, v. 85, pp. 4041–4042, October 18, 1963)

For abstract, see Entry S11.

Eisenberg, E.

E02 THE OCCURRENCE OF CHAIN TRANSFER IN THE ANIONIC POLYMERIZATION OF 9-VINYLANTHRACENE
Eisenberg, E., Rembaum, A.
Technical Report 32-576 (Unclassified)
(Reprinted from *Journal of Polymer Science, Part B: Polymer Letters*, v. 2, pp. 157–162, 1964)

On the basis of experimental results outlined, it is concluded that (1) chain termination by impurities cannot occur to any significant extent; (2) the maximum degree of polymerization obtainable by an anionic mechanism is limited by a chain transfer reaction, most probably to monomer; and (3) the ratio of the chain transfer rate constant to the propagation rate constant is essentially independent of concentrations, nature of the solvent, counterion, and temperature.

Eisenberger, I.

E03 SYSTEMATIC STATISTICS USED FOR DATA COMPRESSION IN SPACE TELEMETRY
Eisenberger, I., Posner, E. C.
Technical Report 32-510, October 1, 1963 (Unclassified)

As a consequence of the need for data compression, consideration was given the use of sample quantiles in estimating population parameters and obtaining goodness-of-fit tests for large samples. In this report, optimal unbiased estimators of the mean and standard deviation are given using up to twenty quantiles when the population is normal. Moreover, the estimators are relatively insensitive to deviations from normality. A distribution-free goodness-of-fit test is presented, based on the sum of the squares of four quantiles after an orthogonal transformation to independent normal deviates. If a frequency function is of the form $f(x;p) = pf_1(x) + (1 - p)f_2(x)$, $0 < p < 1$, where f_1 and f_2 are normal frequency functions, the distribution is likely to be bimodal. Another goodness-of-fit test is obtained using four quantiles, which is likely to have considerable power with a null hypothesis of normality and the alternative hypothesis of bimodality. The "data compression ratios" obtained with the use of a quantile system can be approximately 100 to 1.

Elleman, D. D.

E04 NMR DOUBLE RESONANCE TECHNIQUES FOR THE DETERMINATION OF RELATIVE SIGNS OF SPIN SPIN COUPLING CONSTANTS
Elleman, D. D., Manatt, S. L.
Technical Report 32-266 (Unclassified)
(Reprinted from "Magnetic and Electric Resonance and Relaxation: Proceedings of the XIth Colloque Ampère," July 2–7, 1962, Eindhoven, The Netherlands, pp. 594–598, Interscience Publishers, John Wiley & Sons, Inc., New York, N.Y., 1963)

Double irradiation of high resolution NMR (nuclear magnetic resonance) spectra makes it possible to determine the relative signs of some or all of the spin–spin coupling constants. The technique has been used to determine the relative signs of not only proton–proton coupling constants but also fluorine–proton and fluorine–fluorine coupling constants.

Ewing, G. E.

E05 INFRARED ABSORPTION OF THE ν_3 FUNDAMENTAL OF LIQUID AND SOLID CH_4 AND CD_4
Ewing, G. E.
Technical Report 32-551 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 40, no. 1, pp. 179–183, January 1, 1964)

This work was undertaken to (1) remove the apparent contradiction between the infrared and Raman results, and (2) establish a better understanding of rotational motion in the condensed phases of methane. The infrared absorption of ν_3 of liquid and solid CH_4, CD_4, and a solution of CD_4 in CH_4 are described.

Fischbach, D. B.

F01 KINETICS OF HIGH-TEMPERATURE STRUCTURAL TRANSFORMATION IN PYROLYTIC CARBONS
Fischbach, D. B.
Technical Report 32-532 (Unclassified)
(Reprinted from *Applied Physics Letters*, v. 3, no. 9, pp. 168–170, November 1, 1963)

The kinetics of high-temperature structural transformation in pyrolytic carbons is reported, with particular attention to the graphitization process.

F02 KINETICS OF GRAPHITIZATION OF A PETROLEUM COKE
Fischbach, D. B.
Technical Report 32-570 (Unclassified)
(Reprinted from *Nature*, v. 200, no. 4913, pp. 1281–1283, December 28, 1963)

In order to obtain further information on the kinetic behavior of conventional carbons, petroleum coke which had been baked approximately 15 min at 2,000°C was examined; an effective activation energy was found which was in excellent agreement with the value observed for pyrolytic carbons—indicating that in the two types of carbon the graphitization process was the same and the activation energy constant, at least over the range of 2,300°–3,000°C. The different kinetic behavior of different carbons was attributed to a broad range of pre-exponential factors which is probably related to the detailed microstructure of the material.

Ford, H. W.

F03 PHOTOLYSIS OF NITROGEN DIOXIDE AT 3660 AND 4047 A AT 25°C
Ford, H. W., Jaffe, S.
Technical Report 32-401 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 38, no. 12, pp. 2935–2942, June 1963)

Nitrogen dioxide was irradiated at 3660 and 4047 A at various pressures of NO_2, with and without CO_2, NO, and N_2 as added gases. The data indicate a primary dissociation at 3660 A and shorter wavelengths corresponding to energies greater than the ON–O bond energy. At 4047 A, the data are explained by an excited-molecule mechanism. Isotopic oxygen scrambling experiments at 4047 A indicate the probability of reactions to produce oxygen atoms at that wavelength, but photolysis of NO_2 at trace concentrations and high inert-gas pressures indicates that these atoms are not derived from the unimolecular decomposition of the photoactivated molecule. The inhibition of the quantum yield by NO addition was pressure-dependent, lending further support to the premise that oxygen atoms are important in the mechanism at 4047 A. It is postulated that the reaction $NO_2^* + NO_2 \rightarrow N_2O_3 + O$ is the source of atomic oxygen.

F04 REACTION BETWEEN NITRIC OXIDE AND OZONE IN A SUPERSONIC NOZZLE
Marte, J. E., Tschuikow-Roux, E., Ford, H. W.
Technical Report 32-494 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 39, no. 12, pp. 3277–3285, December 15, 1963)

For abstract, see Entry M07.

Frink, E. P.

F05 THE BEARING CAPACITY OF SIMULATED LUNAR SURFACES IN VACUUM
Bernett, E. C., Scott, R. F., Jaffe, L. D., Frink, E. P., Martens, H. E.
Technical Report 32-326, August 15, 1963 (Unclassified)

For abstract, see Entry B07.

Gates, C. R.

G01 A DESCRIPTION OF A MARS SPACECRAFT WITH A LANDING CAPSULE
Gates, C. R.
Technical Report 32-93 (Unclassified)
(Presented at the National IAS/ARS Joint Meeting, Los Angeles, Calif., June 13–16, 1961)

As depicted in this paper, the spacecraft will pass by Mars, while the capsule will enter the atmosphere of the planet and land upon its surface. The subsystems of the spacecraft, and the operational sequence are also described.

G02 A SIMPLIFIED MODEL OF MIDCOURSE MANEUVER EXECUTION ERRORS
Gates, C. R.
Technical Report 32-504, October 15, 1963 (Unclassified)

Midcourse maneuvers are commonly employed in ballistic lunar and interplanetary space flight, and errors committed in executing these maneuvers contribute to target dispersion. A simplified model, developed at the Jet Propulsion Laboratory, of such execution errors is presented, along with an expression for its second moment.

Geller, M.

G03 TWO-ELECTRON, ONE- AND TWO-CENTER INTEGRALS
Geller, M.
Technical Report 32-408 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 39, no. 3, p. 853, August 1, 1963)

In a recent note, other authors mentioned the use of the Fourier convolution theorem method for the evaluation of one-electron, two-center integrals. In another paper (see Entry G04), the present author applied this method to one-electron integrals involving non-integral Slater orbitals and to one-electron integrals involving solid spherical harmonic operators.

The current note is concerned with the application of this method to the evaluation of two-electron, two-center integrals.

G04 TWO-CENTER INTEGRALS OVER SOLID SPHERICAL HARMONICS
Geller, M.
Technical Report 32-409 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 39, no. 1, pp. 84–89, July 1963)

One-electron, two-center integrals (and the corresponding one-center case) are evaluated for integrals of the type

$$\int [N, L, M]_a \frac{r_b^{N'} P_{L'}[M'](\cos\theta_b)}{r_b^{L'}+1} \begin{Bmatrix} \cos[M']\phi_b \\ \sin[M']\phi_b \end{Bmatrix} d\tau$$

arising in electromagnetic interactions. The Fourier convolution theorem method is employed, and specific results are obtained for $N' = 0$ and $N' = 2$ in terms of an F function and recursion formulas. All cases up to $L' = 3$ are evaluated in terms of both the F and elementary functions.

G05 A TABLE OF INTEGRALS INVOLVING POWERS, EXPONENTIALS, LOGARITHMS, AND THE EXPONENTIAL INTEGRAL
Geller, M.
Technical Report 32-469, August 1, 1963 (Unclassified)

The general integrals $\int_\beta^\alpha x^p e^{-\alpha x} (\ln x)^n \, dx$ and $\int_\alpha^\beta x^p e^{-\alpha x} (\ln x)^n [-E_1(-\beta x)] dx$ are investigated, where n is an integer, α and β are real positive numbers, and p is a number greater than -1. Many special cases are obtained, and the results are tabulated in a logical order. Where possible the integrals are expressed in closed form, and several cases are expressed in series expansions.

G06 SPIN PROPERTIES OF PAIR-CORRELATED ATOMIC AND MOLECULAR SINGLET WAVEFUNCTIONS
Levine, H. B., Geller, M., Taylor, H. S.
Technical Report 32-565 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 40, no. 2, pp. 595–602, January 15, 1964)

For abstract, see Entry L11.

Gier, H. L.

G07 CONVECTIVE HEAT TRANSFER IN A CONVERGENT–DIVERGENT NOZZLE
Back, L. H., Massier, P. F., Gier, H. L.
Technical Report 32-415, November 15, 1963 (Unclassified)

For abstract, see Entry B02.

Gin, W.

G08 THE *SYNCOM 1* JPL APOGEE ROCKET MOTOR
Anderson, R. G., Gin, W., Kohorst, D. P.
Technical Memorandum 33-143 (Revision 1), September 16, 1963 (Confidential)

For abstract, see Entry A07.

Gordon, E.

G09 HARDENABILITY OF TITANIUM ALLOYS
Jaffe, L. D., Gordon, E., Cotter, F. W.
Technical Report 32-589 (Unclassified)
(Reprinted from *Transactions of the Metallurgical Society of AIME*, v. 230, pp. 541–550, April 1964)

For abstract, see Entry J02.

Gram, M. B.

G10 FINAL REPORT ON *MARINER* 2 TEMPERATURE CONTROL
Lewis, D. W., Gram, M. B., Spehalski, R. J., Dumas, L. N.
Technical Memorandum 33-140, July 1, 1963 (Unclassified)

For abstract, see Entry L12.

Gronroos, H. G.

G11 CRITICALITY CALCULATIONS FOR FAST LIQUID-METAL COOLED REACTOR—PHASE I
Gronroos, H. G.
Technical Report 32-512, November 15, 1963 (Unclassified)

Multigroup diffusion theory calculations are employed to evaluate some static reactor physical properties for a conceptual, fast liquid-metal-cooled reactor, and the influence of the constructional components on reactivity is investigated. It is concluded that the reactor concept holds promise in fulfilling the requirements of 20,000 hr of operation at 10-Mw thermal power with reflector control, provided 45,000-Mw day/ton burnup can be achieved with a uranium refractory and lithium fuel slurry at 2700°F peak fuel temperature.

Hall, W. M.

H01 THE APPLICATION OF TEMPERATURE RATE MEASUREMENTS TO THE DETERMINATION OF THERMAL EMITTANCE
Hall, W. M.
Technical Report 32-596, April 15, 1964 (Unclassified)

Two calorimetric techniques are evolved to facilitate accurate measurement at room temperature of the hemispherical emittance of spacecraft temperature-control surfaces. Emittance is determined in a reasonably short period of time without use of high-precision temperature-control apparatus. The first technique, the rate-equation method, employs both a heating and a cooling curve to obtain emittance without the use of the heat-capacity value for the test surface. The second technique, the iteration method, uses data from several arbitrarily induced heating and cooling curves in an iteration procedure where the data converge, within a 3-hr observation period, to a set of steady-state power-temperature values. Results of applying the preceding techniques to surfaces of both low and moderate emittance are presented, together with data on the accuracy and dispersion of the measurements. Some values of emittance obtained from long-term temperature-equilibrium tests are given for comparison.

Measurements are made on a heated 6- by 6-in. flat sample placed adjacent and parallel to a liquid-nitrogen-cooled flat receiver plate which views the sample hemispherically. The test apparatus is described.

Hamburg, R.

H02 UNIFIED GUIDANCE ANALYSIS IN DESIGN OF SPACE TRAJECTORIES
Soong, T. T., Pfeiffer, C. G., Hamburg, R.
Technical Report 32-577, January 31, 1964 (Unclassified)

For abstract, see Entry S17.

Hamilton, T. W.

H03 DETERMINATION OF TRACKING STATION LOCATIONS BY DOPPLER AND RANGE MEASUREMENTS TO AN EARTH SATELLITE
Cain, D. L., Hamilton, T. W.
Technical Report 32-534, February 1, 1964 (Unclassified)

For abstract, see Entry C01.

H04 THE *RANGER* 5 FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Sjogren, W. L., Kirhofer, W. E., Cain, D. L., Wollenhaupt, W. R., Hamilton, T. W.
Technical Report 32-562, December 6, 1963 (Unclassified)

For abstract, see Entry S13.

H05 EARTH–VENUS TRAJECTORIES, 1967
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 3, Part A, June 15, 1963 (Unclassified)

For abstract, see Entry C11.

H06 EARTH–VENUS TRAJECTORIES, 1967
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 3, Part B, July 1, 1963 (Unclassified)

For abstract, see Entry C11.

H07 EARTH–VENUS TRAJECTORIES, 1967
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 3, Part C, July 15, 1963 (Unclassified)

For abstract, see Entry C11.

H08 EARTH–VENUS TRAJECTORIES, 1968–1969
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 4, Part A, August 1, 1963 (Unclassified)

For abstract, see Entry C11.

H09 EARTH–VENUS TRAJECTORIES, 1968–1969
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 4, Part B, August 15, 1963 (Unclassified)

For abstract, see Entry C11.

H10 EARTH–VENUS TRAJECTORIES, 1968–1969
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 4, Part C, September 3, 1963 (Unclassified)

For abstract, see Entry C11.

H11 EARTH–VENUS TRAJECTORIES, 1970
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 5, Part A, September 16, 1963 (Unclassified)

For abstract, see Entry C11.

H12 EARTH–VENUS TRAJECTORIES, 1970
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 5, Part B, October 1, 1963 (Unclassified)

For abstract, see Entry C11.

H13 EARTH–VENUS TRAJECTORIES, 1970
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 5, Part C, October 15, 1963 (Unclassified)

For abstract, see Entry C11.

H14 EARTH–MARS TRAJECTORIES, 1964
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-100, Volume 1, Part A, March 1, 1964 (Unclassified)

For abstract, see Entry C12.

Havlik, A. J.

H15 JPL X600 PROPELLANT, A UREA-CONTAINING POLYURETHANE PROPELLANT
Havlik, A. J., Moacanin, J., Cuddihy, E. F.
Technical Report 32-438, June 1, 1963 (Confidential)

A new polyurethane composite propellant—JPL X600—has been developed which differs from the JPL X500 propellant family by the presence of substituted urea groups. The techniques and materials employed in the development of this new propellant are reported.

H16 REPRODUCIBILITY OF PROPERTIES OF COMPOSITE POLYURETHANE PROPELLANTS
Cuddihy, E. F., Havlik, A. J., Moacanin, J.
Technical Report 32-481, February 1, 1964 (Confidential)

For abstract, see Entry C17.

H17 FORTRAN SOURCE PROGRAM FOR RETENTION OF GAS–LIQUID CHROMATOGRAPHY MEASUREMENTS
Lawson, D. D., Havlik, A. J.
Technical Memorandum 33-128, March 26, 1963 (Unclassified)

For abstract, see Entry L06.

H18 VOLTAGE-TO-FREQUENCY INTEGRATORS IN GAS CHROMATOGRAPHY
Johnson, R. D., Lawson, D. D., Havlik, A. J.
Technical Memorandum 33-158, February 15, 1964 (Unclassified)

For abstract, see Entry J14.

H19 ANALYSES FOR CHAIN AND STEREO ISOMERS IN DIPROPYLENE GLYCOL BY GAS–LIQUID PARTITION CHROMATOGRAPHY
Havlik, A. J., Udlock, D. E., Lawson, D. D.
Technical Memorandum 33-161, April 15, 1964
(Unclassified)

A study was made of the separation of dipropylene glycol (DPG) into its chain and stereo isomers by gas–liquid partition chromatography, using DPG from seven different commercial sources. These materials were further characterized by adjunct analyses for hydroxyl, unsaturation, water, and propylene glycol contents, and by index of refraction, infrared spectrum, and bulk viscosity. For the qualitative analysis, packed columns (prepared with liquid phases of Carbowax 20M, Polyox WSR 35, or Reoplex 400) and capillary columns (prepared with Carbowax 1540) were used. For quantitative analyses, packed columns prepared with Carbowax 20M were used. The quantities of the three chain isomers of DPG and the two diastereomers of one of the chain isomers present in each of the seven commercial samples were determined by the method of an internal standard. Significant differences in the isomer contents were observed among the commercial DPG's.

Haymes, R. C.

H20 FAST NEUTRONS IN THE EARTH'S ATMOSPHERE 1. VARIATION WITH DEPTH
Haymes, R. C.
Technical Report 32-539 (Unclassified)
(Reprinted from *Journal of Geophysical Research*, v. 69, no. 5, March 1, 1964)

Measurements of cosmic-ray neutrons in the 1- to 14-Mev range of energies are discussed. These measurements were conducted from the Earth surface to the ceiling altitudes of the balloons employed, or to about 128,000 ft. This corresponds to a residual atmospheric pressure of 3.5 mb. The variation of the flux with atmospheric depth, and the differential neutron energy spectrum were also measured.

H21 FAST NEUTRONS IN THE EARTH'S ATMOSPHERE 2. TIME VARIATIONS AT HIGH ALTITUDES
Haymes, R. C.
Technical Report 32-540 (Unclassified)
(Reprinted from *Journal of Geophysical Research*, v. 69, no. 5, March 1, 1964)

This paper, the second of two concerning balloon experiments, discusses measurements of flux variations of cosmic-ray neutrons in the 1- to 14-Mev range of energies. These measurements were conducted during a series of balloon flights at altitudes of about 125,000 ft for periods of up to 24.5 hr.

Heacock, R. L.

H22 SCIENTIFIC INSTRUMENTS IN SPACE EXPLORATION
Heacock, R. L.
Technical Report 32-525 (Unclassified)
(Reprinted from *Science*, v. 142, no. 3589, pp. 188–195, October 1963)

The background and design concepts of instruments for space exploration are reviewed generally. Mechanical integration, power, communication and data handling, temperature control, and sterilization problems are considered as constraints on a spacecraft system. The environmental constraints of temperature and vacuum are studied. Quality assurance and control, systems testing and field operations, and mission operations complete the discussion of problems posed by the increase in mission capability.

Higa, W. H.

H23 DUAL-CAVITY MASER USED IN MARS RADAR EXPERIMENT
Higa, W. H., Clauss, R. C.
Technical Report 32-432 (Unclassified)
(Reprinted from the *Proceedings of the IEEE*, v. 51, no. 6, pp. 948–949, June 1963)

The principal advantage of the multiple cavity maser is stated, and a relation is readily derived as the ratio of fractional gain variation ($\delta G/G$) for a n-stage maser as compared with a single-stage cavity maser operating with the same total gain G_0. A cross-sectional view of one of the two identical stages employed and a performance summary for the maser system are given.

H24 NOISE PERFORMANCE OF TRAVELING-WAVE MASERS
Higa, W. H.
Technical Report 32-506 (Unclassified)
(Reprinted from *IEEE Transactions on Microwave Theory and Techniques*, v. MTT-12, no. 1, January 1964)

A review of the noise performance of traveling-wave masers is given. In particular, it is shown that when the gain per unit length of structure is low, the equivalent noise temperature of the traveling-wave masers can become appreciable.

Hovis, W. A., Jr.

H25 INFRARED EMISSION SPECTRA OF ORGANIC SOLIDS FROM 5 TO 6.6 MICRONS
Hovis, W. A., Jr.
Technical Report 32-547 (Unclassified)
(Reprinted from *Science*, v. 143, no. 3606, pp. 587–588, February 7, 1964)

The emission spectra of thin layers of a number of organic solids were studied from 5 to 6.6 μ in the infrared region to determine if there are specific emission characteristics that would allow identification of such solids as organic. This was the case only for very thin films with strong absorption bands.

Hudson, R. H.

H26 THE ORBIT DETERMINATION PROGRAM OF THE JET PROPULSION LABORATORY
Warner, M. R., Nead, M. W., Hudson, R. H.
Technical Memorandum 33-168, March 18, 1964 (Unclassified)

For abstract, see Entry W01.

Hurty, W. C.

H27 DYNAMIC ANALYSIS OF STRUCTURAL SYSTEMS BY COMPONENT MODE SYNTHESIS
Hurty, W. C.
Technical Report 32-530, January 15, 1964 (Unclassified)

A method of analysis is developed for treating structural systems by a synthesis of the properties of the system components. Primarily, the method deals with dynamic loads and responses, but it is also suitable for the static case. Internal forces in the connections between the components may be found, so that each component may be isolated from the system and analyzed in detail.

A distinctive feature of the method is the use of specified sets of generalized displacement functions or modes for each component to define the deflected configuration. Hence, it falls in the general category of stiffness or displacement methods. Lagrange equations are used to generate the equations of motion which are expressed and manipulated in matrix form. In this report, the method is restricted to systems with linear force-deflection and force-velocity properties.

A set of steps by which the analysis may be carried out is listed and clarified in a summary, with further clarification attempted through presentation of a flow chart or block diagram. Finally, a discussion is included to indicate some of the engineering considerations that motivated the study.

Ingham, J. D.

I01 POLYMER DEGRADATION. I. COLUMN ELUTION FRACTIONATION AND THERMAL DEGRADATION OF POLYOXYPROPYLENE GLYCOL-TOLUENE DIISOCYANATE (PPG–TDI) POLYMERS
Rapp, N. S., Ingham, J. D.
Technical Report 32-433 (Unclassified)
(Reprinted from *Journal of Polymer Science, Part A: General Papers*, v. 2, pp. 689–704, 1964)

For abstract, see Entry R06.

Jaffe, L. D.

J01 THE BEARING CAPACITY OF SIMULATED LUNAR SURFACES IN VACUUM
Bernett, E. C., Scott, R. F., Jaffe, L. D., Frink, E. P., Martens, H. E.
Technical Report 32-326, August 15, 1963 (Unclassified)

For abstract, see Entry B07.

J02 HARDENABILITY OF TITANIUM ALLOYS
Jaffe, L. D., Gordon, E., Cotter, F. W.
Technical Report 32-589 (Unclassified)
(Reprinted from *Transactions of the Metallurgical Society of AIME*, v. 230, pp. 541–550, April 1964)

A method of estimating hardenability of titanium alloys from their composition was suggested previously by one of the authors, on a preliminary basis, utilizing scattered data found in the literature. This suggestion is the basis for a systematic experimental study of the effect of composition upon hardenability. From this study, an equation is derived for estimating the hardenability of titanium-base alloys. In addition, checks against data in the literature show that values calculated by this equation agree with measured values within the standard deviation of the equation. It is also noted that this equation will give a low-side estimate for material quenched from the α-β range if the gross composition of the alloy is used. Further, it is concluded that a more accurate estimate of hardenability will be obtained if the composition of the β can be estimated and inserted in the equation.

Jaffe, P.

J03 THE INFLUENCE OF SHAPE ON AERODYNAMIC DAMPING OF OSCILLATORY MOTION DURING MARS ATMOSPHERE ENTRY AND MEASUREMENT OF PITCH DAMPING AT LARGE OSCILLATION AMPLITUDES
Dayman, B., Jr., Brayshaw, J. M., Jr., Nelson, D. A., Jaffe, P., Babineaux, T. L.
Technical Report 32-380, February 28, 1963 (Unclassified)

For abstract, see Entry D04.

J04 HYPERSONIC BALLISTIC RANGE RESULTS OF TWO PLANETARY ENTRY CONFIGURATIONS IN AIR AND CARBON DIOXIDE/NITROGEN MIXTURES
Jaffe, P.
Technical Report 32-543, January 31, 1964 (Unclassified)

Tests were performed at velocities of 15,500 ft/sec in the Ballistic Range of the Naval Ordnance Laboratory in order to determine the effects of carbon dioxide on aerodynamic characteristics. Two configurations were tested—both spherically blunted cones with flat bases. The resultant aerodynamic data indicated no appreciable effect on drag and stability due to carbon dioxide. They correlated well with existing information obtained at lower Mach numbers and showed a slight decrease in stability with increasing Mach number.

J05 OBTAINING FREE-FLIGHT DYNAMIC DAMPING OF AN AXIALLY SYMMETRIC BODY (AT ALL ANGLES-OF-ATTACK) IN A CONVENTIONAL WIND TUNNEL
Jaffe, P.
Technical Report 32-544, January 15, 1964 (Unclassified)

Two methods are presented for calculating the dynamic damping parameter, $Cm_q + Cm_{\dot{\alpha}}$, from a novel wind tunnel

free-flight technique being developed at the Jet Propulsion Laboratory. These methods, applicable to nonlinear, high angle-of-attack motion, are (1) a computer method for nonplanar, nonsymmetrical motion requiring iterations, and (2) a noncomputer solution applicable when the model exhibits planar motion. Both methods assume that the static aerodynamic coefficients are known. The basic hypothesis of the planar solution is that the second-order effects can be determined by assuming that the instantaneous oscillatory frequency is a function of a nonlinear pitching moment of the form $M \sin (k\alpha)$. Both methods are applied to representative problems and solutions using the planar method are compared with results from the computer program.

Jaffe, S.

J06 PHOTOLYSIS OF NITROGEN DIOXIDE AT 3660 AND 4047 A AT 25°C
Ford, H. W., Jaffe, S.
Technical Report 32-401 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 38, no. 12, pp. 2935–2942, June 1963)

For abstract, see Entry F03.

Jaivin, G. I.

J07 EFFECT OF HOLE SIZE ON PRESSURE MEASUREMENTS MADE WITH A FLAT-PLATE DYNAMIC-HEAD PROBE
Jaivin, G. I.
Technical Report 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 was found sufficient to eliminate probe-hole effects and to produce a good correlation of experimental and theoretical pressure data.

Jet Propulsion Laboratory

J08 THE MISSION OF *MARINER II*: PRELIMINARY OBSERVATIONS
Jet Propulsion Laboratory
Technical Report 32-383 (Unclassified)
(Reprinted from *Science*, v. 138, no. 3545, December 7, 1962; ibid., v. 139, no. 3549, January 4, 1963)

The interplanetary spacecraft *Mariner II* was launched from Cape Canaveral on August 27, 1962. In addition to two radiometers for making close-up measurements of the electromagnetic radiation from Venus in both the microwave and infrared spectral regions, the spacecraft carried scientific instruments for observing various features of the interplanetary environment. The preliminary results of some of these experiments are reported in the following papers: "Solar Plasma Experiment," by M. Neugebauer and C. W. Snyder; "The Iowa Radiation Experiment," by J. A. Van Allen and L. A. Frank; "Cosmic Dust," by W. M. Alexander; "Interplanetary Magnetic Fields," by P. J. Coleman, Jr., L. Davis, Jr., E. J. Smith, and C. P. Sonett; and "Mariner II: High-Energy-Radiation Experiment," by H. R. Anderson.

J09 THE *MARINER R* PROJECT: PROGRESS REPORT SEPTEMBER 1, 1962–JANUARY 3, 1963 VOLUME I. *MARINER 2* FLIGHT REPORT
Jet Propulsion Laboratory
Technical Report 32-422, Volume I, July 1, 1963 (Confidential)

Operational events and mission results in the *Mariner R* Project are reviewed for the period September 1962 to January 1963. Standard and nonstandard occurrences in the space flight of the *Mariner* are summarized, and the flight performances of the spacecraft and its component subsystems are examined. Other results reported in detail for the *Mariner 2* mission include: methods of orbit and trajectory determination, computation and execution of the midcourse maneuver, flight reliability, processes of the data-recovery system, findings of the scientific experiments, and the current design status of the *Mariner R* spacecraft. It should be noted, however, that some of these results are based on a preliminary examination of recovered data.

J10 THE *MARINER R* PROJECT: PROGRESS REPORT SEPTEMBER 1, 1962–JANUARY 3, 1963 VOLUME II. SUPPLEMENTARY DOCUMENTATION
Jet Propulsion Laboratory
Technical Report 32-422, Volume II, July 1, 1963 (Unclassified)

This material supplements documentation on the *Mariner R* Project, and provides a unified reference source.

J11 SYMPOSIUM ON RADAR AND RADIOMETRIC OBSERVATIONS OF VENUS DURING THE 1962 CONJUNCTION
Jet Propulsion Laboratory
Technical Report 32-533 (Unclassified)
(Reprinted from the *Astronomical Journal*, v. 69, no. 1, February 1964)

The following papers are presented which report the results of various studies and observations of Venus during the 1962 conjunction:

"Further Venus Radar Depolarization Experiments," by G. S. Levy and D. Schuster

"Faraday Rotation of Venus Radar Echoes," by D. Schuster and G. S. Levy

"Radar Scattering from Venus and the Moon," by D. O. Muhleman

"Study of Venus by CW Radar," by R. L. Carpenter

"Venus Characteristics by Earth-Based Radar," by R. M. Goldstein

"Some Decimeter Observations of Venus During the 1962 Conjunction," by B. G. Clark and C. L. Spencer

"Radio Emission from Venus at 8.35 mm," by D. D. Thornton and W. J. Welch

"Observations of Venus, the Sun, Moon, and Tau A at 1.18-cm Wavelength," by D. H. Staelin, A. H. Barrett, and B. R. Kusse

"Observations of Venus at 2.07 cm," by T. P. McCullough and J. W. Boland

"Observations of Venus, the Region of Taurus A, and the Moon at 8.5-Millimeter Wavelength," by V. L. Lynn, M. L. Meeks, and M. D. Sohigian

"Radar Observations of Venus at 38 Mc/sec," by J. C. James and R. P. Ingalls

"Radar Echoes from Venus at 50 Mc/sec," by W. K. Klemperer, G. R. Ochs, and K. L. Bowles

"Microwave Observations of Venus, 1962–1963," by F. D. Drake

"Mariner 2 Microwave Radiometer Experiment and Results," by F. T. Barath, A. H. Barrett, J. Copeland, D. E. Jones, and A. E. Lilley

J12 SYSTEM CAPABILITIES AND DEVELOPMENT SCHEDULE OF THE DEEP SPACE INSTRUMENTATION FACILITY, 1964–68
Jet Propulsion Laboratory
Technical Memorandum 33-83 (Revision 1), April 24, 1964 (Unclassified)

The Deep Space Instrumentation Facility (DSIF) is a precision tracking and communications system capable of providing command, control, and tracking of, and data acquisition from, spacecraft designed for deep space exploration. This memorandum discusses the capability of the DSIF for the 1964–1968 period in terms of station geometry and coverage, system capabilities, and Space Flight Operations Facility. The relationship of the DSIF to foreign governments and operating agencies is also considered.

Jodele, J.

J13 *MARINER* SPACECRAFT PACKAGING
Jodele, J.
Technical Report 32-451, July 1, 1963 (Unclassified)

This report presents the packaging techniques employed on *Mariner 2*. The following goals were established: (1) a high degree of standardization, (2) flexibility in the location of subsystems, and (3) integration of electronic assemblies into the prime structure.

The subassembly packaging technique (conventional components on printed wiring boards) was found to be reliable, relatively easy to design, fabricate, and modify.

Johnson, R. D.

J14 VOLTAGE-TO-FREQUENCY INTEGRATORS IN GAS CHROMATOGRAPHY
Johnson, R. D., Lawson, D. D., Havlik, A. J.
Technical Memorandum 33-158, February 15, 1964 (Unclassified)

Two voltage-to-frequency conversion integrators, available commercially for use in gas chromatography, were evaluated for (1) reproducibility of integration over a range of mixture composition, and (2) linear dynamic range of integration. The mixtures used consisted of acrylonitrile, *n*-propanol, and dioxane. The advantages and limitations of the two integrators, as revealed by this study, are discussed.

Jordan, J. F.

J15 THE APPLICATION OF LAMBERT'S THEOREM TO THE SOLUTION OF INTERPLANETARY TRANSFER PROBLEMS
Jordan, J. F.
Technical Report 32-521, February 1, 1964 (Unclassified)

Lambert's equations are stated and discussed for elliptical, hyperbolic, and parabolic trajectories. Numerical results are obtained for Earth-to-Venus and Earth-to-Mars free-flight transfers, with the assumptions of the two-body (Sun-spacecraft) approximation and constant planetary radii. Straightforward methods to determine which forms of Lambert's equations are valid for a few specific problems are presented.

Josias, C.

J16 AN INSTRUMENT FOR THE MEASUREMENT OF INTERPLANETARY SOLAR PLASMA
Josias, C., Lawrence, J., Jr.
Technical Report 32-492, May 1, 1964 (Unclassified)

An important scientific result of the interplanetary flight of *Mariner 2* to Venus was the collection of extensive detailed data indicating the presence of a constantly flowing "solar wind." This report describes the *Mariner 2* solar-plasma instrument and its predecessor, which flew on *Rangers 1* and 2. Special emphasis is given the discussion of a wide-range electrometer system stabilized by a dynamic capacitor.

The instrument described measures charged-particle energy spectra with a sensor consisting of a pair of concentric curved electrostatic deflection plates terminated by an isolated faraday collector cup. The collection rate of charged particles is mea-

sured with an electrometer whose wide dynamic current range is provided by a logarithmic compressor composed of one or two subminiature thermionic diodes operated in the retarded field region. The electrostatic field is controlled by a programmed high-voltage sweep amplifier that provides the deflection plates with voltages of equal magnitude but opposite polarity.

This report includes a history of preflight testing and calibration of the *Mariner* 2 flight instruments, in addition to some details of the spacecraft's flight performance.

Kaplan, L. D.

K01 THE DETECTION OF WATER VAPOR ON MARS
Spinrad, H., Münch, G., Kaplan, L. D.
Technical Report 32-454 (Unclassified)
(Reprinted from *The Astrophysical Journal*, v. 137, no. 4, pp. 1319–1321, May 1963)

For abstract, see Entry S21.

K02 THE *MARINER* 2 INFRARED RADIOMETER EXPERIMENT
Chase, S. C., Kaplan, L. D., Neugebauer, G.
Technical Report 32-484 (Unclassified)
(Reprinted from the *Journal of Geophysical Research*, v. 68, no. 22, pp. 6157–6169, November 1963)

For abstract, see Entry C06.

K03 AN ANALYSIS OF THE SPECTRUM OF MARS
Kaplan, L. D., Münch, G., Spinrad, H.
Technical Report 32-554 (Unclassified)
(Reprinted from *The Astrophysical Journal*, v. 139, no. 1, January 1, 1964)

Rotational lines of H_2O near $\lambda 8300$ and CO_2 near $\lambda 8700$ have been detected on a high-dispersion spectrogram of Mars taken at Mount Wilson. Recent laboratory measurements of line strengths have been used to determine the amount of H_2O and CO_2 in the atmosphere of Mars, i.e., $14 \pm 7\,\mu$ precipitable water and 55 ± 20 m atm CO_2. From the absence of O_2 in the Martian spectra, an upper limit of 70 cm atm is set for the O_2 content.

By suitably combining the CO_2 amount with observations (by others) of the strongly saturated bands in the 2-μ region, a surface pressure of 25 ± 15 mb has been derived. The implications of the results on the composition of the Martian atmosphere are discussed.

Karabatsos, G. J.

K04 GEMINAL PROTON–PROTON COUPLING CONSTANTS IN $CH_2{=}N-$SYSTEMS
Shapiro, B. L., Ebersole, S. J., Karabatsos, G. J., Vane, F. M., Manatt, S. L.
Technical Report 32-538 (Unclassified)
(Reprinted from *The Journal of the American Chemical Society*, v. 85, pp. 4041–4042, October 18, 1963)

For abstract, see Entry S11.

Kelly, H. P.

K05 SECOND-ORDER PERTURBATION THEORY IN ATOMIC AND MOLECULAR QUANTUM MECHANICS (APPLICATION TO THE ELECTRIC DIPOLE AND QUADRUPOLE POLARIZABILITIES AND SHIELDING FACTORS OF THE BERYLLIUM ATOM)
Kelly, H. P., Taylor, H. S.
Technical Report 32-587 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 40, no. 6, pp. 1478–1485, March 15, 1964)

A new method, previously used in calculating atomic correlation energies, is shown to be applicable to a wide variety of atomic and molecular problems. Use is made of the fact that it is possible in many problems to calculate exactly the first-order perturbation correction to uncoupled Hartree–Fock wavefunctions and also second-order energy expressions. Particular application is made to the numerical calculation of dipole and quadrupole polarizabilities and shielding factors for the beryllium atom.

Kikin, G. M.

K06 LITHIUM-BOILING POTASSIUM REFRACTORY METAL LOOP FACILITY
Davis, J. P., Kikin, G. M., Phillips, W. M., Wolfson, L. S.
Technical Report 32-508, August 31, 1963 (Unclassified)

For abstract, see Entry D02.

Kirhofer, W. E.

K07 THE *RANGER* 5 FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Sjogren, W. L., Kirhofer, W. E., Cain, D. L., Wollenhaupt, W. R., Hamilton, T. W.
Technical Report 32-562, December 6, 1963 (Unclassified)

For abstract, see Entry S13.

Kistler, A. L.

K08 FLUCTUATING WALL PRESSURE UNDER A SEPARATED SUPERSONIC FLOW
Kistler, A. L.
Technical Report 32-505 (Unclassified)
(Reprinted from *The Journal of the Acoustical Society of America*, v. 36, no. 3, pp. 543–550, March 1964)

Measurements are presented of the pressure fluctuations under the turbulent, separated region ahead of a forward-facing step at M 3.01 and 4.54. These pressures are signifi-

cantly larger than those produced by an attached boundary layer. The data can be interpreted as showing that the pressure fluctuations originate from two distinct causes: changes in the geometry of the separated region, and the turbulent, free shear layer. The levels to be expected from each cause can be estimated from a simple model.

Klejnot, O. J.

K09 ALKOXYCHLOROSILANES AND ALKOXYSILANES CONTAINING SILANE HYDROGEN
Klejnot, O. J.
Technical Report 32-220 (Unclassified)
(Reprinted from *Inorganic Chemistry*, v. 2, no. 4, pp. 825–828, August 1963)

Syntheses and new compounds are reported for silanes $SiHCl_{3-x}(OR)_x$ and $SiH_{4-x}(OR)_x$ with $x = 1 - 3$, $R = CH_3$, C_2H_5. New silanes $CH_3SiHClOR$ and CH_3SiH_2OR are reported. Ligand exchanges of such silanes are described. Properties of some alkoxides of carbon and silicon are compared on the basis of new data.

Klevans, E. H.

K10 DAMPING OF QUANTIZED LONGITUDINAL PLASMA OSCILLATIONS
Klevans, E. H., Burt, P. B., Wu, C.-S.
Technical Report 32-553, April 15, 1964 (Unclassified)

Although the damping of longitudinal plasma oscillations has received considerable study for both classical plasmas and degenerate electron gases, expressions for damping in the degenerate systems at arbitrary temperatures have not been obtained. In this report, the damping in the degenerate electron gas at arbitrary temperatures is evaluated within the random phase approximation in the long-wavelength limit. In addition, exchange damping for a plasma slightly above the degeneracy temperature is evaluated and shown to be comparable to the random phase approximation damping for a wide range of parameters.

Kliore, A.

K11 THE UTILITY OF LIBRATION POINT SATELLITES
Kliore, A.
Technical Memorandum 33-154, August 31, 1963 (Unclassified)

Much interest has been expressed in the possibility of placing a satellite at one of the stable (equilateral) libration points of the Earth–Moon system. In this memorandum, libration point satellites are discussed and their value in achieving certain scientific and technological objectives is compared to that of certain alternate missions. Among the objectives that form the basis of comparison are (1) communications relay, (2) solar-flare observatory, (3) determination of the mass of the Moon, (4) optical and radio astronomical observatories, (5) bistatic radar astronomy, (6) investigation of "dust-cloud" observations, and (7) navigation beacon.

The libration point satellites were found superior only in the investigation of "dust clouds" in the space surrounding the libration points, and as relays to communicate with stations on the surface of the Moon. In all other applications, other missions appear to be superior.

Five appendixes are included to provide background material pertinent to the discussion.

Kohorst, D. P.

K12 THE *SYNCOM 1* JPL APOGEE ROCKET MOTOR
Anderson, R. G., Gin, W., Kohorst, D. P.
Technical Memorandum 33-143 (Revision 1), September 16, 1963 (Confidential)

For abstract, see Entry A07.

Kotlensky, W. V.

K13 STRUCTURAL AND HIGH-TEMPERATURE TENSILE PROPERTIES OF BORON PYROLYTIC GRAPHITE
Kotlensky, W. V., Martens, H. E.
Technical Report 32-299, December 16, 1963 (Unclassified)

Several producers of boron pyrolytic graphite have reported it to have improved mechanical properties over pyrolytic graphite. The tensile properties in the basal plane direction and the structural changes accompanying heating and straining over the range from room temperature to 2200°C were found to be similar to pyrolytic graphite. At 2480 and 2760°C, pyrolytic graphite with approximately 1% boron exhibits greater ductility than pyrolytic graphite. In comparing the structural transformation of these two materials, the presence of boron appears to enhance the strain-induced transformation at 2480 and 2760°C, and to inhibit the thermally induced transformation due to heating alone at all temperatures up to 3000°C.

Landel, R. F.

L01 RUPTURE BEHAVIOR OF ELASTOMERS: EFFECT OF STATISTICAL VARIABILITY AND CROSSLINK DENSITY
Landel, R. F., Fedors, R. F.
Technical Report 32-468 (Unclassified)
(Reprinted from *The Journal of Polymer Science, Part B, Polymer Letters*, v. 1, pp. 539–544, October 1963)

It has been proposed that rupture data for elastomers be examined in terms of a failure envelope—a plot of the tensile strength (based on the original cross-sectional area) times the usual temperature reduction factor versus the rupture strain. For materials which obey time-temperature superposition, the shape of the failure envelope is independent of the test rate or temperature, although changes in these variables shift the location of response along the envelope.

An investigation is reported of (1) the effects of statistical distribution of break properties on the resolution of the envelope, and (2) the effects of changing the crosslink density on its shape and location in the plot of tensile strength versus the rupture strain plane. The tensile failure properties of dicumyl peroxide-cured commercial SBR (Philprene 1500) were determined by measurements of ring samples at four strain rates and at eight temperatures. These data were used to construct a failure envelope and to check the statistical distribution of breaks.

Lass, H.

L02 APPLICATION OF THE METHOD OF AVERAGES TO CELESTIAL MECHANICS
Lorell, J., Anderson, J. D., Lass, H.
Technical Report 32-482, March 16, 1964 (Unclassified)

For abstract, see Entry L19.

Lawrence, J., Jr.

L03 AN INSTRUMENT FOR THE MEASUREMENT OF INTERPLANETARY SOLAR PLASMA
Josias, C., Lawrence, J., Jr.
Technical Report 32-492, May 1, 1964 (Unclassified)

For abstract, see Entry J16.

Lawson, C. L.

L04 SEGMENTED RATIONAL MINMAX APPROXIMATION, CHARACTERISTIC PROPERTIES AND COMPUTATIONAL METHODS
Lawson, C. L.
Technical Report 32-579, December 19, 1963 (Unclassified)

Characterization theorems, solution procedures, and results of numerical examples are reported regarding the problem of partitioning an interval so that the largest error incurred in approximating a continuous function by separate polynomial or rational forms on each subinterval is minimized.

L05 STUDY OF THE ACCURACY OF THE DOUBLE-PRECISION ARITHMETIC OPERATIONS ON THE IBM 7094 COMPUTER
Lawson, C. L.
Technical Memorandum 33-142, July 15, 1963 (Unclassified)

The IBM 7094 operations DFMP, DFDP, DFAD, and DFSB, and the FORTRAN II library subroutines (DFMP), (DFDP), (DFAD), (DFSB) were tested by applying each to 32,000 pairs of random arguments uniformly distributed between 0.5 and 1.0.

The operations DFAD and DFSB performed true 54-bit floating-point arithmetic. The operation DFMP gave a correctly rounded 54-bit result in only 3.6% of the cases, and the error ranged from -6.00 to 0.00 in units of the last bit position of the product. The relative error ranged from $-0.750 * 2^{-50}$ ($= -0.666 * 10^{-15}$) to 0.

The corresponding figures for DFDP were 47.2 percent, -3.48 to 2.72, and $-0.45 * 2^{-51}$ ($= -0.20 * 10^{-15}$) to $0.62 * 2^{-51}$ ($= 0.28 * 10^{-15}$).

The subroutines were less accurate on the average than the corresponding hardware operations; however, there were cases such as multiplication by 1.0 (or by any other exact power of 2) in which the reverse was true.

Lawson, D. D.

L06 FORTRAN SOURCE PROGRAM FOR RETENTION OF GAS–LIQUID CHROMATOGRAPHY MEASUREMENTS
Lawson, D. D., Havlik, A. J.
Technical Memorandum 33-128, March 26, 1963 (Unclassified)

Modern high-speed computers are capable of assisting in the reduction and storage of data obtained from gas–liquid partition chromatography (GLPC) measurements. In the past, in order that a computer could be used, it was necessary to prepare machine language programs. This difficulty can now be largely avoided by the application of FORTRAN programming in which the computer is used in the preparation of the program. To illustrate this approach, a typical set of experimental GLPC data for a homologous series of alcohols is reduced.

The program is designed to give values for the specific retention volumes, the partition coefficients, and the number of theoretical plates for each peak appearing on a chromatogram. In the course of the data reduction, other parameters of importance to the interpretation of results from GLPC measurements are also obtained.

L07 VOLTAGE-TO-FREQUENCY INTEGRATORS IN GAS CHROMATOGRAPHY
Johnson, R. D., Lawson, D. D., Havlik, A. J.
Technical Memorandum 33-158, February 15, 1964 (Unclassified)

For abstract, see Entry J14.

L08 ANALYSES FOR CHAIN AND STEREO ISOMERS IN DIPROPYLENE GLYCOL BY GAS–LIQUID PARTITION CHROMATOGRAPHY
Havlik, A. J., Udlock, D. E., Lawson, D. D.
Technical Memorandum 33-161, April 15, 1964 (Unclassified)

For abstract, see Entry H19.

Leipold, M. H.

L09 MECHANICAL AND THERMAL PROPERTIES OF HOT-PRESSED ZIRCONIUM CARBIDE TESTED TO 2600°C
Leipold, M. H., Nielsen, T. H.
Technical Report 32-452, September 14, 1963 (Unclassified)

Tensile, creep, thermal expansion, and modulus of elasticity data were determined for hot-pressed zirconium carbide. The material was relatively impure, containing 1 to 2% nitrogen and 1 to 2% free carbon. Tensile and creep properties, measured to 2600°C, indicated that above 2100°C the strength is 2,000 psi or lower and the elongation is 40% or greater, thus signifying little structural usefulness. It is suggested that results were influenced by the presence of impurity at the grain boundaries. The mean coefficient of thermal expansion of this zirconium carbide varied from 5.6×10^{-6}°C^{-1} (for 25 to 400°C) to 7.6×10^{-6}°C^{-1} (for 25 to 2300°C). Room-temperature modulus-of-elasticity values averaging 51.6×10^{6} psi were obtained by dynamic methods.

L10 THERMAL EXPANSION OF YTTRIA-STABILIZED ZIRCONIA
Nielsen, T. H., Leipold, M. H.
Technical Report 32-600 (Unclassified)
(Reprinted from the *Journal of the American Ceramic Society*, v. 47, no. 3, March 1964)

For abstract, see Entry N11.

Levine, H. B.

L11 SPIN PROPERTIES OF PAIR-CORRELATED ATOMIC AND MOLECULAR SINGLET WAVEFUNCTIONS
Levine, H. B., Geller, M., Taylor, H. S.
Technical Report 32-565 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 40, no. 2, pp. 595–602, January 15, 1964)

The recent work of Sinanoğlu upon pair-correlated wavefunctions is examined. The conditions required for Sinanoğlu's wavefunction are derived to be a spin singlet, and then related to his theory. In particular, these conditions are shown to be satisfied to an approximation consistent with those conditions used by Sinanoğlu in deriving his "exact pair" theory. An error in the original integral breakdown is also pointed out and shown to have little effect on the results of the theory.

Lewis, D. W.

L12 FINAL REPORT ON *MARINER* 2 TEMPERATURE CONTROL
Lewis, D. W., Gram, M. B., Spehalski, R. J., Dumas, L. N.
Technical Memorandum 33-140, July 1, 1963 (Unclassified)

The basic principles and specific techniques of temperature control employed on the *Mariner R* spacecraft are presented. A thermal history of the *Mariner* 2 flights is given, including telemetry data for monitored components. The significance of the data in terms of improving temperature-control techniques is discussed.

Liaugminas, R.

L13 PLANETARY ENTRY SIMULATION BY MEANS OF COMBUSTION
Wood, R. D., Liaugminas, R.
Technical Report 32-614 (Unclassified)
(Reprinted from *American Institute of Aeronautics and Astronautics*, v. CP7, Aerodynamic Texting, March 1964)

For abstract, see Entry W08.

Lindsey, W. C.

L14 ERROR PROBABILITIES FOR RICIAN FADING MULTICHANNEL RECEPTION OF BINARY AND *N*-ARY SIGNALS
Lindsey, W. C.
Technical Report 32-450, June 3, 1963 (Unclassified)

Performance characteristics are derived for two different forms of multireceivers (the coherent and noncoherent) which are used with binary and *N*-ary signaling through the Rician fading multichannel. This multichannel model is sufficiently general to include four types of practical multichannels: the Rician, Rayleigh, fixed- and/or mixed-mode multichannels.

Error probabilities are illustrated graphically and compared for various multichannel models. The results show that multichannel reception, as compared with single-channel reception, increases the reliability of communication. It is found that the effectiveness of multichannel reception is highly dependent on the strength of the specular channel component and the mean squared value of the random channel component. In particular, multichannel reception is more effective when applied to the completely random multichannel.

Finally, asymptotic expansions for system performance are derived for various multichannel conditions. The results indicate the rapidity with which system performance increases or decreases as the multichannel characteristics change. For special cases the error-rate expressions, as well as the asymptotic expressions, reduce to well-known results.

L15 COMPARISON OF NONLINEAR AND LINEAR MULTIRECEIVER DETECTION SYSTEMS
Lindsey, W. C.
Technical Report 32-597 (Unclassified)
(Reprinted from the *IEEE Transactions on Space Electronics and Telemetry*, v. SET-10, no. 1, pp. 10–14, March 1964)

Detection of a binary transmission by both optimum and suboptimum nonlinear and linear multireceivers is considered by comparing their asymptotic performance characteristics. The multichannel model is presumed to be of the Rician type. Specifically, Turin's nonlinear specular-coherent multireceiver and the nonlinear noncoherent Pierce-Stein multireceiver are

considered. These two termination error-rate characteristics are graphically compared for low and high output signal-to-noise ratios. The performance characteristics of two other coherent linear multireceivers—one optimum and one more easily implemented suboptimum—are derived and compared with the above-mentioned nonlinear multireceivers. The numerical results indicate system design trends and provide information on the degradation or improvement afforded by employing nonlinear detection systems as compared with linear detection systems.

Linnenkamp, C. J.

L16 SCIENTIFIC DATA TRANSLATOR OPERATION AND MAINTENANCE MANUAL
Morecroft, J. H., Linnenkamp, C. J.
Technical Memorandum 33-90, August 30, 1962 (Unclassified)

For abstract, see Entry M19.

Livingston, F. R.

L17 OBLIQUE SHOCK WAVE ANGLE CHARTS FOR A PERFECT GAS (γ = 1.20, 1.26, 1.40, AND 1.67)
Livingston, F. R.
Technical Memorandum 33-162, March 15, 1964 (Unclassified)

When operating in the perfect gas regime of planetary atmospheric gases in conventional wind tunnels, and when solving two-dimensional flow problems, the aerodynamicist requires charts illustrating the variation of oblique shock-wave angle with turning angle. For this purpose, the oblique shock-wave angle as a function of turning angle has been computed for Mach numbers to 10 in accordance with the shock theory. Specific heat ratios of 1.20, 1.26, 1.40, and 1.67 were used.

Employing the proper trigonometric relations, these charts may be used in conjunction with normal shock tables to obtain the thermodynamic characteristics of a perfect gas behind an oblique shock wave.

Loomis, A. A.

L18 INTERPRETATION OF RESULTS FROM *SURVEYOR* ALPHA-SCATTERING EXPERIMENT
Loomis, A. A.
Technical Report 32-606, April 30, 1964 (Unclassified)

A major step in the petrologic exploration of the Moon is to determine the mechanical and chemical conditions under which the sample formed in order to identify lunar processes and evaluate their relative effects in the evolution of the Moon. This report investigates the interpretation of the data to be provided by the alpha-scattering experiment on the *Surveyor 1* spacecraft. The compositions of igneous rocks and meteorites are used as the simplified models because these chemical groups have the greatest chance of being the main components in the composition of an unknown lunar rock. Volcanic names are applied to rock compositions wherever possible instead of their plutonic equivalents. All analyses and concentrations are given in atomic percent, calculated hydrogen-free.

Lorell, J.

L19 APPLICATION OF THE METHOD OF AVERAGES TO CELESTIAL MECHANICS
Lorell, J., Anderson, J. D., Lass, H.
Technical Report 32-482, March 16, 1964 (Unclassified)

Formulas are derived giving the second-order secular and long period effects on the orbit of the satellite of an oblate planet. The presentation is in terms of the standard osculating elements and their averages. The derivation involves the second-order method of averages for solving nonlinear differential equations. In the application to the present problem, this second-order theory can be very cumbersome. However, by introducing an auxiliary function, ψ, it is possible to simplify the equation to a manageable form.

Lyttleton, R. A.

L20 ON THE INTERNAL CONSTITUTION OF THE TERRESTRIAL PLANETS
Lyttleton, R. A.
Technical Report 32-522, September 21, 1963 (Unclassified)

Assuming an integral relation between pressure and density in each zone within the Earth, a theoretical history of the internal constitution of the planet is presented. The effect of internal phase change (due to radioactive heating) on compressibility and the character of the outer layers is examined; known mountain building is accommodated by this theory. Venus, Mars, and the Moon are similarly examined, and their properties are found to be consistent with the general hypothesis.

Malling, L. R.

M01 SPACE AGE ASTRONOMY AND THE SLOW-SCAN VIDICON
Malling, L. R.
Technical Report 32-531 (Unclassified)
(Reprinted from the *Journal of the Society of Motion Picture and Television Engineers*, v. 72, pp. 872–875, November 1963)

Space astronomy is defined, and the requirements for visual exploration of the Moon and Mars are outlined. The slow-scan vidicon is shown to be particularly useful as an astrophotographic instrument for space astronomy. The special instrumentation requirements for a slow-scan vidicon system are described for a Mars mission. Some of the techniques are illustrated with photos taken with a slow-scan vidicon system, using the Mt. Wilson 60-inch telescope as an optical objective.

Mamikunian, G.

M02 ORGANIC CONSTITUENTS OF THE CARBONACEOUS CHONDRITES
Briggs, M. H., Mamikunian, G.
Technical Report 32-436 (Unclassified)
(Reprinted from *Space Science Reviews*, v. 1, pp. 647–682, June 1962–May 1963)

For abstract, see Entry B24.

Manatt, S. L.

M03 NMR DOUBLE RESONANCE TECHNIQUES FOR THE DETERMINATION OF RELATIVE SIGNS OF SPIN SPIN COUPLING CONSTANTS
Elleman, D. D., Manatt, S. L.
Technical Report 32-266 (Unclassified)
(Reprinted from "Magnetic and Electric Resonance and Relaxation: Proceedings of the XIth Colloque Ampère," July 2–7, 1962, Eindhoven, The Netherlands, pp. 594–598, Interscience Publishers, John Wiley & Sons, Inc., New York, N. Y., 1963)

For abstract, see Entry E04.

M04 THE RELATIVE SIGNS OF PHOSPHORUS–PROTON NUCLEAR MAGNETIC RESONANCE COUPLING CONSTANTS
Manatt, S. L., Juvinall, G. L., Elleman, D. D.
Technical Report 32-485 (Unclassified)
(Reprinted from *The Journal of the American Chemical Society*, v. 85, pp. 2664–2665, September 1963)

Karplus suggested that an "absolute" sign determination could be made from a measurement of the sign of a non-bonded proton-X coupling constant relative to the coupling constant between a proton and a directly bonded atom X. Approximate theoretical calculations for B–H, C^{13}–H, and N–H suggest that these couplings are positive and large. The proposal by Karplus has been the basis for two "absolute" sign determinations relating the C^{13}–H coupling (which is large and taken as positive) to certain other proton–proton couplings. It is suggested here that his proposal can be extended to the P^{31}–H coupling, and on this basis present a correlation of the signs of the coupling constants in some phosphorus compounds containing protons. A table summarizes results of high-resolution analyses of diphosphine, triethylphosphine, methylphosphine, dimethylphosphine, the recent H^1–[H^1] double resonance studies on trivinylphosphine, and H^1–[H^1] and H^1–[P^{31}] double resonance studies on dimethylphosphine.

M05 GEMINAL PROTON–PROTON COUPLING CONSTANTS IN CH_2=N–SYSTEMS
Shapiro, B. L., Ebersole, S. J., Karabatsos, G. J., Vane, F. M., Manatt, S. L.
Technical Report 32-538 (Unclassified)
(Reprinted from *The Journal of the American Chemical Society*, v. 85, pp. 4041–4042, October 18, 1963)

For abstract, see Entry S11.

Marsden, B.

M06 THE MASSES OF THE FOUR INNER PLANETS
Marsden, B.
Technical Memorandum 33-165, October 1, 1963 (Unclassified)

Four direct methods have been applied to the problem of determining the ratios of the Sun's mass to the masses of the planets. The more recent results for the inner planets are summarized. A discussion of mass determinations for the satellites of these planets is also included. The most likely values of the mass ratios, as derived by the four methods presented, are stated as follows: Mercury, 6200 000 ± 200 000; Venus, 408 540 ± 40; Mars, 3080 000 ± 15 000; Earth and Moon together, 328 906 ± 10; Earth alone, 332 952 ± 11. The value given for the Earth–Moon mass ratio is 81.30 ± 0.01.

Marte, J. E.

M07 REACTION BETWEEN NITRIC OXIDE AND OZONE IN A SUPERSONIC NOZZLE
Marte, J. E., Tschuikow-Roux, E., Ford, H. W.
Technical Report 32-494 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 39, no. 12, pp. 3277–3285, December 15, 1963)

The rate of reaction between nitric oxide and ozone in a supersonic nozzle was measured in the temperature range 245°–345°K by following the absorption of ultraviolet radiation by ozone at 2537°K. The specific rate constant was found to be $k = 1.19 \times 10^{12} \exp(-2500/RT)$ $cm^3 mole^{-1} sec$. The result is in good agreement with previous studies and confirms the bimolecular nature of the reaction. The experimental pre-exponential factor is in satisfactory agreement with one calculated from transition-state theory.

Martens, H. E.

M08 THE BEARING CAPACITY OF SIMULATED LUNAR SURFACES IN VACUUM
Bernett, E. C., Scott, R. F., Jaffe, L. D., Frink, E. P., Martens, H. E.
Technical Report 32-326, August 15, 1963 (Unclassified)

For abstract, see Entry B07.

Maserjian, J.

M09 SINGLE-CRYSTAL GERMANIUM FILMS BY MICROZONE MELTING
Maserjian, J.
Technical Report 32-418 (Unclassified)
(Reprinted from *Solid-State Electronics*, v. 6, no. 5, pp. 477–484, September–October 1963)

A technique has been developed for growing single-crystal germanium films *in situ* on a dielectric substrate. An electron beam is used to melt a small zone of a polycrystalline ger-

manium film. Single-crystal growth is induced by electrically scanning the beam in a preferred manner over a selected region of the film. An additional heat source maintains the surrounding film at elevated temperatures in order to avoid excessive temperature differentials. The scanning pattern employed permits a randomly nucleated crystallite to seed the surrounding growth. In this manner, a single-crystal approximately a millimeter in diameter can be grown in a chosen location. Larger crystals should be possible with larger beam deflections.

This work has been largely confined to film thicknesses of 3–10μ and to substrates of sapphire. Sapphire was used because its coefficient of thermal expansion closely matches that of germanium and because of other desirable properties. All films were deposited by vacuum evaporation.

The technique is logically extendable to other materials that can be grown in vacuum. It is anticipated that the technique will find applications in both microelectronics and the fabrication of special device structures.

Massier, P. F.

M10 CONVECTIVE HEAT TRANSFER IN A CONVERGENT–DIVERGENT NOZZLE
Back, L. H., Massier, P. F., Gier, H. L.
Technical Report 32-415, November 15, 1963 (Unclassified)

For abstract, see Entry B02.

Meghreblian, R. V.

M11 FUEL-CONTAINMENT REQUIREMENTS FOR GASEOUS-FUEL NUCLEAR ROCKETS
Meghreblian, R. V.
Technical Report 32-441, September 2, 1963 (Unclassified)

Fuel-containment requirements for open-cycle gaseous-fuel nuclear rockets are examined for systems in which there is physical contact between propellant and fuel. Such systems necessarily allow some loss of nuclear material. Analysis shows that the total fuel lost during the propulsion period is the prime constraint in determining containment requirements. A parameter—the containment factor—is introduced to provide a measure of fuel-containment efficiency. Application to representative high-thrust (booster) and low-thrust (interplanetary) vehicles is considered. The analysis indicates that containment factors fifty times as large as those presently demonstrated experimentally are required in order to limit nuclear fuel loss during propulsion to the order of 1000 kg.

Melbourne, W. G.

M12 OPTIMUM EARTH-TO-MARS ROUNDTRIP TRAJECTORIES UTILIZING A LOW-THRUST POWER-LIMITED PROPULSION SYSTEM
Sauer, C. G., Jr., Melbourne, W. G.
Technical Report 32-376, March 29, 1963 (Unclassified)

For abstract, see Entry S06.

Menard, W. A.

M13 THEORETICAL NOBLE-GAS PERFORMANCES IN AN IDEAL CONSTANT-AREA SHOCK TUBE
Menard, W. A.
Technical Memorandum 33-163, March 1, 1964 (Unclassified)

The analytical procedures described were developed to support an experimental investigation of the thermal conductivity of noble gases in a constant-area shock tube. To provide a more efficient means of choosing initial pressures for the driver and for driven gases in the tube, the gas dynamic equations were solved by an iterative method, and curves were plotted for ten combinations of helium or argon driving helium, neon, argon, krypton, or xenon. From these curves, the initial shock-tube pressures may be easily determined for any given set of stagnation conditions.

Minovitch, M. A.

M14 THE DETERMINATION AND CHARACTERISTICS OF BALLISTIC INTERPLANETARY TRAJECTORIES UNDER THE INFLUENCE OF MULTIPLE PLANETARY ATTRACTIONS
Minovitch, M. A.
Technical Report 32-464, October 31, 1963 (Unclassified)

When an interplanetary vehicle approaches a planet on a free-fall trajectory, the gravitational influence of the planet can radically change the vehicle's trajectory about the Sun. The vehicle can take advantage of this influence if it passes the planet on a precisely calculated trajectory that will place it on an intercept trajectory with another planet.

This report contains the results of a study of such conic trajectories performed at the Jet Propulsion Laboratory during the summer of 1961. It also includes results of a numerical study performed at the computing facility of the University of California at Los Angeles and the computing complex at the Jet Propulsion Laboratory. These calculations show that, by utilizing multiple planetary trajectories, many interplanetary missions requiring very large launch vehicles can be carried out with much smaller vehicles by simply changing their mission profiles. The numerical study is confined to the decade beginning with 1965.

Moacanin, J.

M15 JPL X600 PROPELLANT, A UREA-CONTAINING POLYURETHANE PROPELLANT
Havlik, A. J., Moacanin, J., Cuddihy, E. F.
Technical Report 32-438, June 1, 1963 (Confidential)

For abstract, see Entry H15.

M16 GRAFT AND BLOCK COPOLYMERS OF SOME VINYL AROMATIC HYDROCARBONS
Rembaum, A., Moacanin, J., Cuddihy, E. F.
Technical Report 32-474 (Unclassified)
(Reprinted from *Journal of Polymer Science, Part C: Polymer Symposia*, no. 4, pp. 529–549, 1964)

For abstract, see Entry R08.

M17 REPRODUCIBILITY OF PROPERTIES OF COMPOSITE POLYURETHANE PROPELLANTS
Cuddihy, E. F., Havlik, A. J., Moacanin, J.
Technical Report 32-481, February 1, 1964 (Confidential)

For abstract, see Entry C17.

Montgomery, D. R.

M18 A STUDY OF THE PHOTOMETRIC CONDITIONS AND IRIS REQUIREMENTS FOR A LUNAR APPROACH TELEVISION CAMERA
Montgomery, D. R., Willingham, D. E.
Technical Memorandum 33-151, September 15, 1963 (Unclassified)

To obtain optimum pictures of the lunar surface from a spacecraft following a descent trajectory, it is necessary to optimize the iris adjustment of the camera to be commensurate with the photometric conditions of the lunar scene. By using a photometric function generated from data obtained by Earth observations, in conjunction with camera exposure relationships, it is possible to compute the iris requirements peculiar to a given lunar impact point. This report presents the photometric conditions to be experienced on the west longitude coordinates of the lunar surface for given arrival days extending over a 2-year period. Additionally, computations utilizing the exposure relationships have yielded the iris requirements dictated by the photometric conditions to be experienced.

Morecroft, J. H.

M19 SCIENTIFIC DATA TRANSLATOR OPERATION AND MAINTENANCE MANUAL
Morecroft, J. H., Linnenkamp, C. J.
Technical Memorandum 33-90, August 30, 1962 (Unclassified)

This memorandum describes the design, function, and operation of the scientific data translator. Troubleshooting procedures for locating defective logic cards are included.

Muhleman, D. O.

M20 THE ELECTRICAL CHARACTERISTICS OF THE ATMOSPHERE AND SURFACE OF VENUS FROM RADAR OBSERVATIONS
Muhleman, D. O.
Technical Report 32-423 (Unclassified)
(Reprinted from *Icarus*, v. 1, no. 5, 6, May 1963)

Radar observations of Venus were made of wavelengths of 12.5 and 68 cm during several months around the 1961 inferior conjunction. These observations have been quantitatively compared for possible dispersion effects caused by the atmosphere of Venus and the interplanetary medium. A possible effect of the plasma has been observed at 68 cm through correlations of the radar echo characteristics with solar activity. On the assumption that this correlation was real, a crude model for the ionosphere of Venus has been developed. The model yields a maximum electron density at Venus of approximately 10^7 cm^{-3}, corresponding to a plasma frequency of about 27 Mc. The absence of relative dispersion and absorption effects between the two propagation frequencies is interpreted to indicate that all plasma phenomena were small. In particular, the proposed "ionospheric" model as the source of the Venusian radio spectrum is shown to be inconsistent with the radar observations. An analysis of the observed echo power indicates the average dielectric constant of the Venusian surface material to be less than 7 but greater than 3, with no large upward variations during the observations. This low value of the dielectric constant and the absence of measurable variations in the echo power (and, consequently, in the dielectric constant) are interpreted to indicate that no large bodies of water exist on the Venusian surface.

M21 RELATIONSHIP BETWEEN THE SYSTEM OF ASTRONOMICAL CONSTANTS AND THE RADAR DETERMINATIONS OF THE ASTRONOMICAL UNIT
Muhleman, D. O.
Technical Report 32-477, January 15, 1964 (Unclassified)

This report is concerned with the author's work on the radar determination of the astronomical unit and with the significance of current radar observations on the system of astronomical constants. It is limited principally to that part of the system which is obviously affected by the radar observations.

Because of the many theoretical relationships between the constants, a certain group of them has been selected (primarily by Newcomb and de Sitter) as fundamental. The discussion suggests that this particular division of the constants may be profitably revised because of the inclusion of radar measurements of distances and velocities to the observational material of dynamical astronomy.

Münch, G.

M22 THE DETECTION OF WATER VAPOR ON MARS
Spinrad, H., Münch, G., Kaplan, L. D.
Technical Report 32-454 (Unclassified)
(Reprinted from *The Astrophysical Journal*, v. 137, no. 4, pp. 1319–1321, May 1963)

For abstract, see Entry S21.

M23 AN ANALYSIS OF THE SPECTRUM OF MARS
Kaplan, L. D., Münch, G., Spinrad, H.
Technical Report 32-554 (Unclassified)
(Reprinted from *The Astrophysical Journal*, v. 139, no. 1, January 1, 1964)

For abstract, see Entry K03.

Nagler, R. G.

N01 DEGRADATION OF HOMOGENEOUS POLYMERIC MATERIALS EXPOSED TO HIGH HEAT FLUXES
Nagler, R. G.
Technical Report 32-527, February 1, 1964 (Unclassified)

An arc-imaging furnace was used to expose polymeric materials to a variety of heating rates under static or near-static flow conditions and under reduced pressures. Data obtained on polymethylmethacrylate, polytetrafluoroethylene, and polyethylene show a linear relationship between heat input and surface recession which is consistent with theory. Comprehensive measurements of polymer reflectivities and transmissivities are necessary before any detailed analysis of the data is made. The degradation products collected in this investigation do not agree with those previously reported for these polymers at similar temperatures and heating rates.

N02 TRANSIENT TECHNIQUES FOR DETERMINING THE THERMAL CONDUCTIVITY OF HOMOGENEOUS POLYMERIC MATERIALS AT ELEVATED TEMPERATURES
Nagler, R. G.
Technical Report 32-552, January 20, 1964 (Unclassified)

Linear thermal conductivity relations above room temperature were found from transient temperature-time data for polyethylene, polytetrafluoroethylene, and polymethylmethacrylate. The relations agree well with the literature for the same temperature ranges, but the computer time and cost of obtaining data points are significantly greater when compared to other measuring techniques of equivalent accuracy.

Narasimha, R.

N03 EVALUATION OF THE INTEGRAL $\int_0^\infty v^n \exp\left[-(v-u)^2 - \frac{x}{v}\right] dv$
Chahine, M. T., Narasimha, R.
Technical Report 32-459, August 5, 1963 (Unclassified)

For abstract, see Entry C04.

Nash, D. B.

N04 NEW TECHNIQUE FOR QUANTITATIVE SiO_2 DETERMINATIONS OF SILICATE MATERIALS BY X-RAY DIFFRACTION ANALYSIS OF GLASS
Nash, D. B.
Technical Report 32-515, July 25, 1963 (Unclassified)

Results of an experimental X-ray study on 96 synthetic glasses show that the 2θ positions of glass diffraction maxima have an inverse relationship to SiO_2 concentration in silicate glasses. This relationship is the basis of a new technique for semiquantitative determinations of SiO_2 in silicate materials by X-ray diffraction methods. Samples to be examined are fused and the resulting glass scanned from 12- to 40-deg 2θ using CuKα radiation. The mean 2θ position of the diffraction maximum is a measure of the SiO_2 content of the glass. Calibration curves for both weight and molecular percent SiO_2 vs. 2θ are presented. The technique requires only small, unweighed amounts of sample for analysis; it is simple, rapid, and utilizes standard diffraction equipment without modification. Its accuracy, at present, allows SiO_2 determinations to within ± 1 to 4% of the actual concentration.

Nead, M. W.

N05 THE ORBIT DETERMINATION PROGRAM OF THE JET PROPULSION LABORATORY
Warner, M. R., Nead, M. W., Hudson, R. H.
Technical Memorandum 33-168, March 18, 1964 (Unclassified)

For abstract, see Entry W01.

Nelson, D. A.

N06 THE INFLUENCE OF SHAPE ON AERODYNAMIC DAMPING OF OSCILLATORY MOTION DURING MARS ATMOSPHERE ENTRY AND MEASUREMENT OF PITCH DAMPING AT LARGE OSCILLATION AMPLITUDES
Dayman, B., Jr., Brayshaw, J. M., Jr., Nelson, D. A., Jaffe, P., Babineaux, T. L.
Technical Report 32-380, February 28, 1963 (Unclassified)

For abstract, see Entry D04.

Neugebauer, G.

N07 THE *MARINER* 2 INFRARED RADIOMETER EXPERIMENT
Chase, S. C., Kaplan, L. D., Neugebauer, G.
Technical Report 32-484 (Unclassified)
(Reprinted from the *Journal of Geophysical Research*, v. 68, no. 22, pp. 6157–6169, November 1963)

For abstract, see Entry C06.

Neugebauer, M.

N08 THE SOLAR-WIND VELOCITY AND ITS CORRELATION WITH COSMIC-RAY VARIATIONS AND WITH SOLAR AND GEOMAGNETIC ACTIVITY
Snyder, C. W., Neugebauer, M., Rao, U. R.
Technical Report 32-514, October 15, 1963 (Unclassified)

For abstract, see Entry S15.

Newnham, J. A.

N09 AN ULTRA HIGH-SPEED LOW-COST PRINTER SYSTEM
Newnham, J. A.
Technical Report 32-465, August 8, 1963 (Unclassified)

This report describes the design and operation of a 20,000-character per second printer system designed and built by the Jet Propulsion Laboratory Instrumentation Section for a cost of less than $25,000. Although this printer was developed for use with a specific digital recording system, the concepts involved, and much of the equipment used, could have a wide variety of applications.

Newton, J. F., Jr.

N10 INVESTIGATION OF LIQUID AND GASEOUS SECONDARY INJECTION PHENOMENA ON A FLAT PLATE WITH $M = 2.01$ TO $M = 4.54$
Dowdy, M. W., Newton, J. F., Jr.
Technical Report 32-542, December 23, 1963 (Unclassified)

For abstract, see Entry D08.

Nielsen, T. H.

N11 THERMAL EXPANSION OF YTTRIA-STABILIZED ZIRCONIA
Nielsen, T. H., Leipold, M. H.
Technical Report 32-600 (Unclassified)
(Reprinted from the *Journal of the American Ceramic Society*, v. 47, no. 3, March 1964)

Due to limited information available on zirconia at temperatures above 1500°C in an oxidizing environment, a study was initiated to measure the thermal expansion of this material in air and in a high-oxygen atmosphere.

Orozco, E. G.

O01 USERS' DESCRIPTION OF JPL EPHEMERIS TAPES
Peabody, P. R., Scott, J. F., Orozco, E. G.
Technical Report 32-580, March 2, 1964 (Unclassified)

For abstract, see Entry P02.

O02 JPL EPHEMERIS TAPES E9510, E9511, AND E9512
Peabody, P. R., Scott, J. F., Orozco, E. G.
Technical Memorandum 33-167, March 2, 1964 (Unclassified)

For abstract, see Entry P03.

Peabody, P. R.

P01 PLANETARY POSITION-VELOCITY EPHEMERIDES OBTAINED BY SPECIAL PERTURBATIONS
Peabody, P. R., Block, N.
Technical Report 32-545 (Unclassified)
(Reprinted from *AIAA Journal*, v. 1, no. 12, pp. 2812–2815, December 1963)

Position-velocity ephemerides of Venus and the Earth–Moon system have been generated using special perturbation methods in which conditions at initial epoch are determined so that the subsequent positions are in best agreement with the Newcomb ephemerides in the least-squares sense. The ephemerides so obtained made possible the 1961 Jet Propulsion Laboratory (JPL) radar observations of Venus, and were used in subsequent determination of the published JPL value of the astronomical unit. They were also used in generating acquisition ephemerides for future radar observations of Venus and in calculating preflight *Mariner* standard trajectories. Comparison of the residuals between the Newcomb and the new ephemerides discloses clearly the major discrepancies in the Newcomb theory. The success of the method has led to the current development of an ephemeris library system that will be used to develop internally consistent position-velocity ephemerides of all the planets and the Moon and that will be of greatest possible accuracy over long arcs.

P02 USERS' DESCRIPTION OF JPL EPHEMERIS TAPES
Peabody, P. R., Scott, J. F., Orozco, E. G.
Technical Report 32-580, March 2, 1964 (Unclassified)

A system for developing magnetic tape ephemerides of the Moon and the planets has been established at the Jet Propulsion Laboratory. Details pertinent to the distribution of these tapes and to their use in digital computer programs are given. In addition, the important features of the system relating to motivation, data acquisition and generation, and ephemeris tape development are described, as are procedures for assuring the accuracy of the data.

P03 JPL EPHEMERIS TAPES E9510, E9511, AND E9512
Peabody, P. R., Scott, J. F., Orozco, E. G.
Technical Memorandum 33-167, March 2, 1964 (Unclassified)

The first issue of JPL Ephemeris Tapes is described. These tapes contain the positions and velocities of the planets and the Moon, plus nutations and nutation rates in longitude and obliquity, together with second and fourth modified differences, for the interval December 30, 1949 to January 5, 2000.

Pfeiffer, C. G.

P04 SEQUENTIAL ESTIMATION OF CORRELATED STOCHASTIC VARIABLES
Pfeiffer, C. G.
Technical Report 32-445, July 1, 1963 (Unclassified)

A technique is developed for estimating the components of the sequence of correlated random vectors $\{\mathbf{x}_1, \mathbf{x}_2, \cdots, \mathbf{x}_n, \cdots\}$, when given the sequence of linearly related data vectors $\{\phi_1, \phi_2, \cdots, \phi_n, \cdots\}$. It is shown to be a necessary and sufficient condition that the minimum variance estimate of $\mathbf{x}_n$ depend only upon ϕ_n, and that the previously computed estimate of $\mathbf{x}_{n-1}$ is that all $\mathbf{x}_i$ be "sequentially correlated." This is a condition placed upon the covariance matrix de-

scribing the otherwise unspecified physical process that generates the x_i. Examples of sequentially correlated processes are given, and an application to the deep-space orbit determination problem is discussed.

P05 A TECHNIQUE FOR OPTIMUM FINAL VALUE CONTROL OF POWERED FLIGHT TRAJECTORIES
Pfeiffer, C. G.
Technical Report 32-447, June 1, 1963 (Unclassified)

The linear perturbation equations describing the first variation of the state variables along a powered flight path are employed to develop the necessary conditions which must be satisfied on an optimized standard trajectory. It is shown that the minimization of some explicit function of the end coordinates, subject to certain other boundary functions being zero, can be interpreted as the limiting case of minimizing the sum of the squares of variations in these functions. Employing this interpretation, a control law is developed to obtain neighboring optimum trajectories in the presence of small initial condition disturbances. The variations in the boundary functions resulting from this control law are derived, and the effect of varying the final time is discussed. It is shown that the system is always stable, and is "in the limit" controllable. The technique is applied to the control of satellite orbit injection.

P06 A DYNAMIC PROGRAMMING ANALYSIS OF MULTIPLE GUIDANCE CORRECTIONS OF A TRAJECTORY
Pfeiffer, C. G.
Technical Report 32-513, November 15, 1963 (Unclassified)

The problem of deciding when to apply guidance corrections to the perturbed trajectory of a spacecraft is treated from the point of view of dynamic programming. 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 specified, 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.

P07 CONTINUOUS ESTIMATION OF SEQUENTIALLY CORRELATED RANDOM VARIABLES
Pfeiffer, C. G.
Technical Report 32-524, October 30, 1963 (Unclassified)

The concept of a stochastic process is discussed, and sequential correlation is defined. Equations are presented for obtaining the minimum variance estimate of the state of the process when given linearly related data sampled at discrete times. These results are extended to the continuous case, yielding a linear differential equation for the time-varying estimate. This equation is solved to obtain an integral representation of the estimate. An application of the estimation technique is developed.

P08 UNIFIED GUIDANCE ANALYSIS IN DESIGN OF SPACE TRAJECTORIES
Soong, T. T., Pfeiffer, C. G., Hamburg, R.
Technical Report 32-577, January 31, 1964 (Unclassified)

For abstract, see Entry S17.

P09 EARTH–VENUS TRAJECTORIES, 1967
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 3, Part A, June 15, 1963 (Unclassified)

For abstract, see Entry C11.

P10 EARTH–VENUS TRAJECTORIES, 1967
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 3, Part B, July 1, 1963 (Unclassified)

For abstract, see Entry C11.

P11 EARTH–VENUS TRAJECTORIES, 1967
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 3, Part C, July 15, 1963 (Unclassified)

For abstract, see Entry C11.

P12 EARTH–VENUS TRAJECTORIES, 1968–1969
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 4, Part A, August 1, 1963 (Unclassified)

For abstract, see Entry C11.

P13 EARTH–VENUS TRAJECTORIES, 1968–1969
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 4, Part B, August 15, 1963 (Unclassified)

For abstract, see Entry C11.

P14 EARTH–VENUS TRAJECTORIES, 1968–1969
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 4, Part C, September 3, 1963 (Unclassified)

For abstract, see Entry C11.

P15 EARTH–VENUS TRAJECTORIES, 1970
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 5, Part A, September 16, 1963 (Unclassified)

For abstract, see Entry C11.

P16 EARTH–VENUS TRAJECTORIES, 1970
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 5, Part B, October 1, 1963 (Unclassified)

For abstract, see Entry C11.

P17 EARTH–VENUS TRAJECTORIES, 1970
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 5, Part C, October 15, 1963 (Unclassified)

For abstract, see Entry C11.

P18 EARTH–MARS TRAJECTORIES, 1964
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-100, Volume 1, Part A, March 1, 1964 (Unclassified)

For abstract, see Entry C12.

Phillips, W. M.

P19 LITHIUM-BOILING POTASSIUM REFRACTORY METAL LOOP FACILITY
Davis, J. P., Kikin, G. M., Phillips, W. M., Wolfson, L. S.
Technical Report 32-508, August 31, 1963 (Unclassified)

For abstract, see Entry D02.

Plamondon, J. A.

P20 ANALYSIS OF MOVABLE LOUVERS FOR TEMPERATURE CONTROL
Plamondon, J. A.
Technical Report 32-555, January 1, 1964 (Unclassified)

Movable shutters or louvers have been and will be employed on several spacecraft for active thermal control. The thermal performance of louvers, and their controlling parameters are analyzed, and seven equations describing the thermal behavior of a louver array are derived. Six of the equations, forming a simultaneous set consisting of three linear integral equations and three linear algebraic equations, describe the heat-transfer characteristics of an array. The seventh gives the relative thermal performance of an array in terms of effective emissivity. The equations are solved numerically, and effective emissivity is plotted as a function of louver blade position for various values of the dimensionless parameters that appear in the governing heat-transfer equations. The results are compared with experimental results obtained for the *Mariner 2* louver system.

Posner, E. C.

P21 OPTIMAL SEARCH PROCEDURES
Posner, E. C.
Technical Report 32-475 (Unclassified)
(Reprinted from *IEEE Transactions on Information Theory*, v. IT-9, no. 3, pp. 157–160, July 1963)

A restricted class of search procedures is set up for a satellite lost in a region of the sky. The satellite must be found by a radar search. The procedures under consideration allow the use of preliminary search, which may be made with a wider beam than is required for the final search. The purpose of the preliminary search is to obtain a ranking of the various portions of the sky, so that the final search can examine the more likely regions of the sky first. It is shown that a preliminary search can reduce the expected search time, regardless of the beam width used. It is also shown that the preliminary search with the narrowest possible beam is best.

P22 SYSTEMATIC STATISTICS USED FOR DATA COMPRESSION IN SPACE TELEMETRY
Eisenberger, I., Posner, E. C.
Technical Report 32-510, October 1, 1963 (Unclassified)

For abstract, see Entry E03.

P23 PROPERTIES OF ERROR-CORRECTING CODES AT LOW SIGNAL-TO-NOISE RATIOS
Posner, E. C.
Technical Report 32-602, June 15, 1964 (Unclassified)

The use of error-correcting codes on a white Gaussian channel as the signal-to-noise ratio (S/N) approaches zero is considered. Two criteria of performance are used: the expected number of information bits in error and the probability of word error. It is shown that if bit-by-bit detection is used, and if the expected number of bits in error is to be minimized, then maximum-likelihood decoding should be abandoned at low S/N. In fact, coding should be abandoned altogether at low S/N in favor of longer integration time per bit. If word error probability is to be minimized, then error-correcting codes using bit-by-bit detection hardly yield any gain, and usually result in a loss. However, orthogonal codes using correlation detection give a gain approaching 3.4 db as the length of the code increases without bound.

Poynter, R. L.

P24 MICROWAVE SPECTRUM, QUADRUPOLAR COUPLING CONSTANTS, AND DIPOLE MOMENT OF CHLOROBENZENE
Poynter, R. L.
Technical Report 32-488 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 39, no. 8, pp. 1962–1966, October 1963)

The microwave spectrum of chlorobenzene has been observed in the frequency range between 8000 and 30,000 Mc. An analysis of this spectrum gives the following values for the rotational constants for the two isotopic species, $C_6H_5Cl^{35}$ and $C_6H_5Cl^{37}$: $A = 5672.951$ Mc, $B = 1576.774$ Mc, $C = 1233.672$ Mc for the Cl^{35} isotopic species; and $A = 5672.530$ Mc, $B = 1532.790$ Mc, $C = 1206.571$ Mc for the Cl^{37} isotopic species. The quadrupolar coupling constants which were obtained from the quadrupolar hyperfine structure are $eqQ = 71.10$ Mc for Cl^{35} and $eqQ = -56.10$ Mc for the Cl^{37}. The quadrupolar asymmetry parameter η cannot be determined from the microwave spectrum. The observed dipole moment is 1.78 ± 0.06 D.

P25 THE STRUCTURE OF $C_2B_5H_7$
Beaudet, R. A., Poynter, R. L.
Technical Report 32-609 (Unclassified)
(Reprinted from the *Journal of the American Chemical Society*, v. 86, pp. 1258–1259, March 20, 1964)

For abstract, see Entry B06.

Randall, J. C.

R01 WEAR ANALYSIS OF NONLUBRICATED SPUR GEARS
Randall, J. C.
Technical Memorandum 33-139, June 1963 (Unclassified)

This paper establishes a method of determining wear rates for nonlubricated, fine-pitch, precision instrument spur gears. The concepts of wear and the problems associated with applying these concepts to the unique action of spur-gear surfaces are discussed. The properties of the involute curve are included only to the extent deemed necessary to analyze thoroughly the gear-wear problem. Wear data for test gears run at various loads and speeds are collected to determine the wear rates for the most popular materials currently in use. Design curves are made for the following five materials (or surfaces) relating wear rates to calculated Hertz' stresses: 303 stainless steel; 2024-T4 aluminum; anodized 2024-T4 aluminum; anodized 2024-T4 aluminum treated with molybdenum disulphide; and Delrin. Design curves consisting of any one or combination of the above materials can be used to analyze wear rates of a gear train.

In addition to the data presented in the wear charts, this paper proposes a method for using the wear data to select between the following two popular methods of computing dynamic load: the American Standards Association Specification B6.11-1951, and Tuplin's method, both of which are slight modifications of Buckingham's original spur-gear formulas.

Rao, U. R.

R02 THE SOLAR-WIND VELOCITY AND ITS CORRELATION WITH COSMIC-RAY VARIATIONS AND WITH SOLAR AND GEOMAGNETIC ACTIVITY
Snyder, C. W., Neugebauer, M., Rao, U. R.
Technical Report 32-514, October 15, 1963 (Unclassified)

For abstract, see Entry S15.

Raper, O. F.

R03 HARTLEY BAND EXTINCTION COEFFICIENTS OF OZONE IN THE GAS PHASE AND IN LIQUID NITROGEN, CARBON MONOXIDE, AND ARGON
DeMore, W. B., Raper, O.
Technical Report 32-567 (Unclassified)
(Reprinted from *Journal of Physical Chemistry*, v. 68, pp. 412–414, 1964)

For abstract, see Entry D05.

R04 REACTION OF $O(^1D)$ WITH CO
Raper, O. F., DeMore, W. B.
Technical Report 32-571 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 40, no. 4, pp. 1053–1057, February 15, 1964)

The reaction of $O(^1D)$ with CO by ultraviolet (2537-Å) photolysis of dilute O_3–CO solutions at 77°K is studied, using a method similar to that in a recent study of the $O(^1D)$–N_2 reaction.

R05 REACTION OF ELECTRONICALLY EXCITED O_2 WITH CO
Raper, O. F., DeMore, W. B.
Technical Report 32-572 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 40, no. 4, pp. 1047–1052, February 15, 1964)

Definite evidence is reported for the reaction of electronically excited O_2 with CO to produce O_3 and CO_2. Primarily, the experiments involve photolysis of liquid mixtures of O_2 and CO of 77°K with 2537-Å radiation.

Rapp, N. S.

R06 POLYMER DEGRADATION. I. COLUMN ELUTION FRACTIONATION AND THERMAL DEGRADATION OF POLYOXYPROPYLENE GLYCOL-TOLUENE DIISOCYANATE (PPG–TDI) POLYMERS
Rapp, N. S., Ingham, J. D.
Technical Report 32-433 (Unclassified)
(Reprinted from *Journal of Polymer Science, Part A: General Papers*, v. 2, pp. 689–704, 1964)

Satisfactory experimental column-elution fractionation procedures for undegraded and thermally degraded PPG–TDI polymers have been developed. These procedures demonstrate the applicability of column elution fractionation to condensation polymers and should be particularly adaptable to other polyurethanes. Differential distributions were calculated by use of the empirical relations suggested by Tung, thus eliminating the need for graphical differentiation of the integral curves. The molecular weight distributions were found to

approximate theoretically the most probable distributions calculated from Flory's equation. The results obtained show that, for moderate extents of bond scission, the molecular weight distributions of PPG–TDI are invariant. It is concluded that the most likely mechanism of thermal degradation in a vacuum is a random scission process.

Rechtin, E.

R07 TELECOMMUNICATION ASPECTS OF A MANNED MARS MISSION
Victor, W. K., Titsworth, R. C., Rechtin, E.
Technical Report 32-501, August 20, 1963 (Unclassified)

For abstract, see Entry V03.

Rembaum, A.

R08 GRAFT AND BLOCK COPOLYMERS OF SOME VINYL AROMATIC HYDROCARBONS
Rembaum, A., Moacanin, J., Cuddihy, E. F.
Technical Report 32-474 (Unclassified)
(Reprinted from *Journal of Polymer Science, Part C: Polymer Symposia*, no. 4, pp. 529–549, 1964)

Graft and block copolymers having poly-4-vinylbiphenyl or poly-2-vinylnapthalene backbones and polyethylene oxide branches were prepared, and the properties of these compared to those of homopolymers and blends. The preparations were characterized by their solubility behavior as well as by chemical and spectral analyses. The mechanical properties were investigated by means of torsional modulus vs. temperature measurements. The reaction mechanisms and relative stabilities of the various species are discussed in terms of molecular orbital calculations. For the poly-2-vinylnapthalene grafts and blends the modulus exhibited a minimum of about 65°C. A tentative explanation is offered for this phenomenon.

R09 DEGRADATION OF THE POLYACENAPHTHYLENE–SODIUM COMPLEX
Rembaum, A.
Technical Report 32-517 (Unclassified)
(Reprinted from *Journal of Polymer Science, Part B: Polymer Letters*, v. 2, pp. 117–121, 1964)

On the basis of the electron spin resonance, the ultraviolet spectrum, and chemical results, the author concludes that polyacenaphthylene in the presence of Na undergoes very rapid bond dissociation with the formation of polymeric anions from which the acenaphthylene radical anion is split off. The conclusions concerning the degradation of the polymer are supported by the finding that the original weight-average molecular weight of polyacenaphthylene of 500,000, after complexing with sodium at room temperature for 1 hr, yielded a polymer of 75,000 mol. wt., while the weight of the methanol extract amounted to less than 1 percent.

R10 THE OCCURRENCE OF CHAIN TRANSFER IN THE ANIONIC POLYMERIZATION OF 9-VINYLANTHRACENE
Eisenberg, E., Rembaum, A.
Technical Report 32-576 (Unclassified)
(Reprinted from *Journal of Polymer Science, Part B: Polymer Letters*, v. 2, pp. 157–162, 1964)

For abstract, see Entry E02.

Richardson, E. H.

R11 HIGH DISPERSION SPECTRA OF THE OUTER PLANETS. II. A NEW UPPER LIMIT FOR THE WATER VAPOR CONTENT OF THE MARTIAN ATMOSPHERE
Spinrad, H., Richardson, E. H.
Technical Report 32-462 (Unclassified)
(Reprinted from *Icarus*, v. 2, pp. 49–53, June 1963)

For abstract, see Entry S22.

Riise, H. N.

R12 DEVELOPMENT AND PERFORMANCE OF THE JPL GLASS-LINED METAL MIRRORS FOR THE SOLAR SYSTEM IN THE 25-FOOT SPACE SIMULATOR
Riise, H. N.
Technical Memorandum 33-171, June 3, 1964 (Unclassified)

The original optical system for the Jet Propulsion Laboratory's 25-ft Space Simulator included a number of stainless steel mirrors. These mirrors were unsatisfactory when compared with glass because they required refiguring when recoated, which was both costly and time consuming. They also gave less reflectivity and degraded more readily than glass mirrors.

It is shown experimentally that glass-metal mirrors can intercept high-energy solar radiation without damage to the reflective coating, the glass, the bond or to the substrate metal. The combination should not be used in a mirror requiring a highly accurate figure, however, since the glass and metal have different coefficients of thermal expansion. This problem can be minimized by (1) making the mass of the metal large as compared to that of the glass, and (2) keeping the temperature relatively constant by making the substrate metal highly conductive and by water cooling it.

Roffe, G. A.

R13 THE FREE-PISTON SHOCK TUBE DRIVER: A PRELIMINARY THEORETICAL STUDY
Roffe, G. A.
Technical Report 32-560, December 15, 1963 (Unclassified)

The concept of a free-piston shock tube driver is discussed in detail, and an analysis is made of the heat losses encountered in the compression process. Design optimization is discussed and methods of controlling driver performance are outlined in detail.

Roth, R. Y.

R14 EARTH–VENUS TRAJECTORIES, 1967
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 3, Part A, June 15, 1963 (Unclassified)

For abstract, see Entry C11.

R15 EARTH–VENUS TRAJECTORIES, 1967
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 3, Part B, July 1, 1963 (Unclassified)

For abstract, see Entry C11.

R16 EARTH–VENUS TRAJECTORIES, 1967
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 3, Part C, July 15, 1963 (Unclassified)

For abstract, see Entry C11.

R17 EARTH–VENUS TRAJECTORIES, 1968–1969
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 4, Part A, August 1, 1963 (Unclassified)

For abstract, see Entry C11.

R18 EARTH–VENUS TRAJECTORIES, 1968–1969
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 4, Part B, August 15, 1963 (Unclassified)

For abstract, see Entry C11.

R19 EARTH–VENUS TRAJECTORIES, 1968–1969
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 4, Part C, September 3, 1963 (Unclassified)

For abstract, see Entry C11.

R20 EARTH–VENUS TRAJECTORIES, 1970
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 5, Part A, September 16, 1963 (Unclassified)

For abstract, see Entry C11.

R21 EARTH–VENUS TRAJECTORIES, 1970
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 5, Part B, October 1, 1963 (Unclassified)

For abstract, see Entry C11.

R22 EARTH–VENUS TRAJECTORIES, 1970
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-99, Volume 5, Part C, October 15, 1963 (Unclassified)

For abstract, see Entry C11.

R23 EARTH–MARS TRAJECTORIES, 1964
Clarke, V. C., Jr., Roth, R. Y., Bollman, W. E., Hamilton, T. W., Pfeiffer, C. G.
Technical Memorandum 33-100, Volume 1, Part A, March 1, 1964 (Unclassified)

For abstract, see Entry C12.

Rowley, R. W.

R24 AN EXPERIMENTAL INVESTIGATION OF UNCOOLED THRUST CHAMBER MATERIALS FOR USE IN STORABLE LIQUID PROPELLANT ROCKET ENGINES
Rowley, R. W.
Technical Report 32-561, February 15, 1964 (Unclassified)

An experimental investigation of the comparative merits of various uncooled thrust chamber materials was conducted by performing engine tests in which N_2O_4/N_2H_4 propellants were used at a nominal mixture ratio of 1.0. The chamber pressure was 150 psia and the nominal sea-level thrust was 85 lb. Erosion of graphites, ablative plastics, and refractory metals was found to be a function of the local thermal and chemical environments existing at the thrust chamber wall. The role of a particular impinging-stream injector in influencing local conditions at the wall was determined by (1) evaluating the properties of the spray produced by nonreacting liquids, and (2) measuring local heat-transfer rates to the chamber wall in the operating rocket engine by means of embedded thermocouples and a transient conduction analysis. Local erosion of Refrasil–phenolic, pyrolytic graphite, and ZT graphite nozzle throats tested with this injector was found to be qualitatively related to these local gas-side boundary conditions.

Runcorn, S. K.

R25 THE INTERIOR OF THE MOON
Runcorn, S. K.
Technical Report 32-529, December 15, 1963 (Unclassified)

The differences in the moments of inertia of the Moon and its ellipticity toward the Earth are between 15 and 40 times those calculated on a hydrostatic theory. Of possible explana-

tions, the most satisfactory is that convection, described by second degree harmonics, is occurring. Second order convection implies the existence of a small core, presumably iron, and results in a new discussion of the Moon's evolution and thermal history.

R26 MEASUREMENTS OF PLANETARY ELECTRIC CURRENTS
Runcorn, S. K.
Technical Report 32-608 (Unclassified)
(Reprinted from *Nature*, v. 202, no. 4927, pp. 10–13, April 4, 1964)

A previous suggestion by the author is the basis for an experiment which utilizes the abandoned telegraph cables in the Pacific. According to the suggestion, steady electric currents originating in the Earth's core might be detectable at the surface, and that such leakage currents, if measurable, would convey important information about the distribution and intensity of those currents causing the main geomagnetic field. Details and results of the experiment are reported.

San Miguel, A.

S01 SOME EXPERIMENTAL AND THEORETICAL SIGNIFICANCES ASSOCIATED WITH IRRADIATED PROPELLANT
San Miguel, A., Duran, E. N.
Technical Report 32-518, November 1, 1963 (Unclassified)

The mechanical properties of polyurethane solid propellant are degraded significantly by irradiation dosages greater than 10^6 rad. Four mechanical tests that provide sufficient data to characterize the degradation are described. These tests consist of (1) swelling, (2) torsion, (3) uniaxial tension, and (4) multiaxial tension and compression. The experimental data are characterized in terms of average molecular weight between cross-links (M_c), percent sol, small-strain shear modulus, tension modulus, and strain energy for increasing irradiation dosage. Comparisons between the various test data provide insight into the underlying effects of mechanical property degradation. Conclusions obtained in this study indicate that (1) the usefulness of M_c is questionable with regard to defining ionizing radiation degradation in a composite propellant such as polyurethane, (2) the torsion test is a simple and expedient method that may be used to study irradiated propellant quantitatively, (3) certain aspects of the kinetic theory of rubber elasticity are not quantitatively applicable to polyurethane propellant, and (4) the degradation response of irradiated propellant obtained from a uniaxial tension test typifies the degradation response of irradiated propellant obtained from multiaxial tests.

S02 SOME LOW-MODULUS BIREFRINGENT RESINS
San Miguel, A., Duran, E. N.
Technical Report 32-556 (Unclassified)
(Reprinted from *Experimental Mechanics*, March 1964)

Information is given to enable the photoelastician to select and prepare a clear, bubble-free, constant-thickness, low-modulus (500 psi or less) birefringent resin. Various urethane formulations are examined. The effects of environment, mixing, casting, molds, cure, post-cure and calibration are discussed, and a procedure to select a particular formulation is suggested.

S03 A NORMAL-INCIDENCE REFLECTIVE POLARISCOPE FOR VISCOELASTICITY MEASUREMENTS
San Miguel, A., Silver, R. H.
Technical Report 32-573, June 1, 1964 (Unclassified)

A normal-incidence reflective polariscope, together with some auxiliary instrumentation, is described. The instrument consists of eight unit polariscopes, suitably oriented, which are indexed into position within a short period of time to obtain a set of eight data. The data obtained provide sufficient information to separate the principal strains obtained at different time intervals. The primary experimental objective was to design an inflated cylinder test, analogous to the loading experienced in a solid propellant rocket, that would enable reasonable measurements of the triaxial surface-layer strains of a viscoelastic material as a function of time. The stress geometry imposed on the viscoelastic material was that of an unrestricted, internally pressurized, thick-walled tubular cylinder. The material investigated was polyurethane solid propellant. Two different methods to reduce the biaxial strains in a low-modulus birefringent polyurethane coating are also described.

S04 CONTINUED STUDIES WITH THE INFLATED CYLINDER TEST VIA CONTINUOUS-MEDIA THEORY
San Miguel, A.
Technical Memorandum 33-156, November 23, 1963 (Unclassified)

A continued study to characterize the mechanical properties of solid propellant via continuous-media theory and the inflated cylinder test is discussed. It is shown that the inflated cylinder test can measure, within experimental error, the triaxial strain state at various point regions on a finite incompressible unfilled polyurethane cylinder. The concept of strain energy, as proposed for composite propellants, is reviewed, and an insight into the physical meaning of the ratio of the difference in strain invariants is discussed.

Sato, H.

S05 ARC DISCHARGE IN A PARALLEL FLOW OF ARGON
Sato, H.
Technical Report 32-520, October 31, 1963 (Unclassified)

A dc arc discharge was made in a parallel subsonic flow of argon with a discharge current of about 70 amp and a flow velocity as large as 27 m/sec at a pressure of 300 torr, and

as large as 70 m/sec at 100 torr. The flow stabilizes the arc, and when the discharge current is kept constant, the observed diameter of the arc decreases and the voltage-drop across electrodes increases as the flow speed is increased. Detailed experimental results indicate that the electric field intensity in the positive column increases almost linearly with the flow speed. A spectroscopic measurement shows a temperature rise near the arc axis as an effect of the flow. Measurements of the time-mean velocity, as well as the fluctuation, were made by use of a hot-wire anemometer. Assuming thermal equilibrium, physical properties of an argon plasma were calculated. The heat balance of a long cylindrical plasma with radial gas flow was treated theoretically. The solution of the energy equation shows a fair agreement with the experimental results for the field intensity and temperature distributions.

Sauer, C. G., Jr.

S06 OPTIMUM EARTH-TO-MARS ROUNDTRIP TRAJECTORIES UTILIZING A LOW-THRUST POWER-LIMITED PROPULSION SYSTEM
Sauer, C. G., Jr., Melbourne, W. G.
Technical Report 32-376, March 29, 1963 (Unclassified)

The payload capability of a vehicle containing a low-thrust power-limited propulsion system for an Earth-to-Mars round-trip mission is investigated. A family of tangential constant-acceleration trajectories is employed for the Earth-escape and Earth-capture phases, and families of variable-thrust transfer trajectories are used for both the heliocentric transfer phase between the Earth and Mars and the return phase from Mars to Earth. Total transfer times of approximately 120 to 800 days are investigated for reconnaissance times at Mars of 0 to 144 days and 636 to 780 days. A comparison of the payload capabilities for these missions is made for powerplant specific masses of 0.1 to 10 kg/kw. The results presented show that a considerable payload is possible for total transfer times as low as 120 to 150 days when a powerplant having a specific mass of 0.1 kg/kw is utilized.

Schiffer, R. A.

S07 CORRELATION OF LAUNCH-VEHICLE WIND-TUNNEL AERODYNAMIC NOISE WITH SPACECRAFT FLIGHT VIBRATION DATA
Schiffer, R. A.
Technical Report 32-619, May 1, 1964 (Unclassified)

It has been observed that the maximum vibration levels experienced by a launch vehicle occur in the regions of q_{max} and transonic flight. Flight vibration data from *Ranger* launches 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. Correlation is also explored between the average vibration response spectra calculated by using a suggested empirical method, and the 95-percentile log-normal acceleration confidence level obtained by spectral analysis of the flight data.

Scott, J. F.

S08 USERS' DESCRIPTION OF JPL EPHEMERIS TAPES
Peabody, P. R., Scott, J. F., Orozco, E. G.
Technical Report 32-580, March 2, 1964 (Unclassified)

For abstract, see Entry P02.

S09 JPL EPHEMERIS TAPES E9510, E9511, AND E9512
Peabody, P.R., Scott, J. F., Orozco, E. G.
Technical Memorandum 33-167, March 2, 1964 (Unclassified)

For abstract, see Entry P03.

Scott, R. F.

S10 THE BEARING CAPACITY OF SIMULATED LUNAR SURFACES IN VACUUM
Bernett, E. C., Scott, R. F., Jaffe, L. D., Frink, E. P., Martens, H. E.
Technical Report 32-326, August 15, 1963 (Unclassified)

For abstract, see Entry B07.

Shapiro, B. L.

S11 GEMINAL PROTON–PROTON COUPLING CONSTANTS IN CH_2=N–SYSTEMS
Shapiro, B. L., Ebersole, S. J., Karabatsos, G. J., Vane, F. M., Manatt, S. L.
Technical Report 32-538 (Unclassified)
(Reprinted from *The Journal of the American Chemical Society*, v. 85, pp. 4041–4042, October 18, 1963)

It is commonly known that J_{HH}(gem) in the sp^2-type CH_2 groups of olefins is usually small in magnitude and can be either positive or negative; there is a fairly good inverse correlation with the electronegativity of the substituent in CH_2=CH–X compounds. These olefinic J_{HH} (gem) values fall outside the range 0 ± 3.5 cps only for the cases of substitution by elements of very low electronegativity, such as Al, Li, and Mg, where values in the range (+) 6 to 8 cps are observed. In this paper, observations of J_{HH} (gem) in a number of CH_2=N–compounds are reported, in tabular form, in which very different values are obtained.

Silver, R. H.

S12 A NORMAL-INCIDENCE REFLECTIVE POLARISCOPE FOR VISCOELASTICITY MEASUREMENTS
San Miguel, A., Silver, R. H.
Technical Report 32-573, June 1, 1964 (Unclassified)

For abstract, see Entry S03.

Sjogren, W. L.

S13 THE *RANGER* 5 FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Sjogren, W. L., Kirhofer, W. E., Cain, D. L., Wollenhaupt, W. R., Hamilton, T. W.
Technical Report 32-562, December 6, 1963 (Unclassified)

This report describes the current best estimate of the *Ranger* 5 flight path and the way in which it was determined. The spacecraft was tracked in the two-way doppler mode until 8 hr after launch—the time of power depletion. The transmitter in the rough-landing capsule was tracked for 11 days after launch, except during occultation by the Moon.

A new orbit determination program which treats the effects of station location and physical constant errors was used to estimate the flight path. The results reported on $GM_{\oplus}$ (universal gravitational constant times the Earth's mass) by *Ranger* 4 are re-evaluated more accurately to confirm the previous results.

Smith, A. H.

S14 *MARINER* 2 SOLAR PANEL DESIGN AND FLIGHT PERFORMANCE
Zoutendyk, J. A., Vondra, R. J., Smith, A. H.,
Technical Report 32-455, June 28, 1963 (Unclassified)

For abstract, see Entry Z01.

Snyder, C. W.

S15 THE SOLAR-WIND VELOCITY AND ITS CORRELATION WITH COSMIC-RAY VARIATIONS AND WITH SOLAR AND GEOMAGNETIC ACTIVITY
Snyder, C. W., Neugebauer, M., Rao, U. R.
Technical Report 32-514, October 15, 1963 (Unclassified)

Mariner 2 obtained data on the interplanetary plasma during the period August 29, 1962, through January 3, 1963. The daily average of plasma velocity is presented and compared with data on cosmic-ray diurnal variations and with indices of solar and geomagnetic activity for this period. The only close correlation found is that between plasma velocity and the geomagnetic index K_p. The plasma velocity showed a very strong 27-day recurrence tendency and a close association with M-region geomagnetic storms, which indicates that solar M-regions are emitters of high-velocity plasma. No dependence of plasma velocity on solar distance between 1.0 and 0.7 AU could be detected.

Soong, T. T.

S16 OUT-OF-PLANE PERTURBATIONS OF A CIRCULAR SATELLITE ORBIT
Soong, T. T.
Technical Report 32-420 (Unclassified)
Reprinted from *AIAA Journal*, v. 1, no. 12, pp. 2862–2863, December 1963)

The validity of the first-order approximation concerning the out-of-plane motion of a long lifetime satellite is investigated. Using a circular orbit for simplicity, it is shown that the effect of small deviations in in-plane parameters on the statistics of the out-of-plane motion may become significant, indicating the need of considering higher-order terms in certain cases.

S17 UNIFIED GUIDANCE ANALYSIS IN DESIGN OF SPACE TRAJECTORIES
Soong, T. T., Pfeiffer, C. G., Hamburg, R.
Technical Report 32-577, January 31, 1964 (Unclassified)

Based on the fact that all ballistic space trajectories can be piecewise approximated by conic sections, certain geometric and dynamic similarities of these trajectories permit a systematic and unified guidance investigation. This report develops a set of dimensionless differential corrections and a "proper" coordinate system suitable for generalized guidance analysis. Numerical results are presented, in graphic form, which are applicable to the calculation of target dispersions due to random injection errors and the determination of required midcourse corrective maneuvers.

Spehalski, R. J.

S18 FINAL REPORT ON *MARINER* 2 TEMPERATURE CONTROL
Lewis, D. W., Gram, M. B., Spehalski, R. J., Dumas, L. N.
Technical Memorandum 33-140, July 1, 1963 (Unclassified)

For abstract, see Entry L12.

Spencer, D. F.

S19 AN EVALUATION OF THE COMMUNICATION BLACKOUT PROBLEM FOR A BLUNT MARS-ENTRY CAPSULE AND A POTENTIAL METHOD FOR THE ELIMINATION OF BLACKOUT
Spencer, D. F.
Technical Report 32-594, April 15, 1964 (Unclassified)

Unless preventive methods are utilized, it appears that the communications link from a blunt body entering the Martian atmosphere will be blacked out during entry because of the free electron concentration in the wake of the capsule. Estimates of the free electron concentration in the wake indicate peak values of approximately 3×10^{12} electrons/cm^3, whereas the critical electron concentration for S-band transmission at 2295 Mc is 10^{11} electrons/cm^3. The injection of a high-electron-affinity fluid such as carbon tetrachloride may reduce the free electron concentration below this critical value. The amount of fluid required is estimated to be on the order of 1–10 lb. The latter statement must be experimentally confirmed, however, before the use of an auxiliary fluid-injection system can be fully evaluated.

Spinrad, H.

S20 HIGH DISPERSION SPECTRA OF THE OUTER PLANETS. 1. JUPITER IN THE VISUAL AND RED
Spinrad, H., Trafton, L. M.
Technical Report 32-437 (Unclassified)
(Reprinted from *Icarus*, v. 2, pp. 19–28, June 1963)

High dispersion spectrograms of Jupiter partially resolve the red methane and ammonia bands and show new, weak lines. At times the Jovian ammonia and methane gases do not co-rotate with the cloud layer as evidenced by the anomalous inclination of their absorption lines. The measures are discussed in detail. The Jovian CH_4 lines in the $\lambda 6190$ band have been compared in detail with their laboratory and Saturnian counterparts. An upper limit to the total pressure above the Jovian cloud layer is estimated; from these data and a new H_2 abundance of about 27 km-atm, a limit to the H/He ratio is deduced. The H/C ratio for Jupiter, Saturn, and Uranus is found to be far below the corresponding ratio in the Sun and other stars. The locations of two new lines tentatively ascribed to Jupiter are given; a search for some other absorbers in this spectral region gave negative results.

S21 THE DETECTION OF WATER VAPOR ON MARS
Spinrad, H., Münch, G., Kaplan, L. D.
Technical Report 32-454 (Unclassified)
(Reprinted from *The Astrophysical Journal* v. 137, no. 4, pp. 1319–1321, May 1963)

Eleven weak lines of water vapor are found on a high dispersion near-infrared spectrogram of Mars taken at the coudé focus of the Mount Wilson 100-in. reflector on April 12–13, 1963. Tables and figures of the H_2O lines measured are given.

S22 HIGH DISPERSION SPECTRA OF THE OUTER PLANETS. II. A NEW UPPER LIMIT FOR THE WATER VAPOR CONTENT OF THE MARTIAN ATMOSPHERE
Spinrad, H., Richardson, E. H.
Technical Report 32-462 (Unclassified)
(Reprinted from *Icarus*, v. 2, pp. 49–53, June 1963)

On a very high dispersion spectrogram of Mars, H_2O lines near $\lambda 7200$ have been sought unsuccessfully. The plate was taken on a very dry night when the doppler shift was sufficient to displace any Mars H_2O lines 0.29 A from their telluric counterparts. From this data an upper limit is derived for the integrated Martian water vapor abundance of approximately 3.5×10^{-3} gm/cm^2 (35μ). The practical limits for detection of Martian water vapor by Earth-bound, balloon, and space-probe techniques indicate that spectroscopic observations from the Earth can be refined to a point where they are at least as sensitive as present infrared space experiments.

S23 SPECTROSCOPIC RESEARCH ON THE MAJOR PLANETS
Spinrad, H.
Technical Report 32-550 (Unclassified)
(Reprinted from *Applied Optics*, v. 3, no. 2, pp. 181–186, February 1964)

This is a partial review of spectroscopic research on the compositions, velocity fields, and thermal structures of the major planets as known in mid-1963.

S24 AN ANALYSIS OF THE SPECTRUM OF MARS
Kaplan, L. D., Münch, G., Spinrad, H.
Technical Report 32-554 (Unclassified)
(Reprinted from *The Astrophysical Journal*, v. 139, no. 1, January 1, 1964)

For abstract, see Entry K03.

Stearns, J. W.

S25 ELECTRICAL PROPULSION REQUIREMENTS FOR PLANETARY AND INTERPLANETARY SPACECRAFT
Stearns, J. W.
Technical Report 32-403, March 1, 1964 (Unclassified)

Assumptions are made concerning the nature of scientific payloads required for planetary exploration missions, and the minimum weight of spacecraft necessary to deliver a scientific payload to its destination in deep space. Although it is expected that early scientific exploration of the Moon, Venus, and Mars will be carried out most economically with chemically propelled spacecraft, it is suggested that scientific exploration of the remainder of the solar system could be accomplished most economically through the use of electrical propulsion.

With relatively small variations in propellant loading, a spacecraft of single basic design could perform any one of at least seven planetary and two interplanetary scientific missions beyond Venus and Mars. This spacecraft can use a two-stage *Saturn I-B* as a launch vehicle. The parameters for such a mission program are discussed, and the powerplant is defined. Finally, ultimate goals for a second-generation nuclear-electric spacecraft are anticipated, and basic scheduling criteria are established.

Stelzried, C. T.

S26 POST-AMPLIFIER NOISE TEMPERATURE CONTRIBUTION IN A LOW-NOISE RECEIVING SYSTEM
Stelzried, C. T.
Technical Report 32-446 (Unclassified)
(Reprinted from *Proceedings of the IEEE*, v. 52, no. 1, pp. 76–77, January 1964)

A derivation is given, in terms of a noise-figure meter reading, for the equivalent noise temperature of an amplifier terminated in a nonstandard temperature. The result is applied to the measurement of the post-amplifier noise temperature contribution in a low-noise receiving system.

Stern, G. S.

S27 THERMOELASTIC ANALYSIS OF A PARABOLIC SHELL
Stern, G. S.
Technical Report 32-479, August 1, 1963 (Unclassified)

The differential equations of equilibrium of a thin, homogeneous, isotropic, elastic shell of revolution subjected to axisymmetric thermal loading are established. In particular, the results are specialized to the case of a parabolic shell. An approximate solution of these equations is found by asymptotic integration. As an example, the stresses and rotation are computed for the case of a parabolic shell with an attached edge ring, subjected to a thermal gradient through the thickness of the shell.

Strand, L. D.

S28 LOW PRESSURE ROCKET EXTINCTION
Anderson, F. A., Strehlow, R. A., Strand, L. D.
Technical Report 32-509 (Unclassified)
(Reprinted from the *AIAA Journal*, v. 1, no. 11, pp. 2669–2671, November 1963)

For abstract, see Entry A02.

S29 AN EXPERIMENTAL INVESTIGATION OF THE LOW-PRESSURE COMBUSTION LIMITS OF SOME SOLID PROPELLANTS
Anderson, F. A., Strand, L. D., Strehlow, R. A.
Technical Memorandum 33-134, June 3, 1963 (Confidential)

For abstract, see Entry A03.

Strehlow, R. A.

S30 LOW PRESSURE ROCKET EXTINCTION
Anderson, F. A., Strehlow, R. A., Strand, L. D.
Technical Report 32-509 (Unclassified)
(Reprinted from the *AIAA Journal*, v. 1, no. 11, pp. 2669–2671, November 1963)

For abstract, see Entry A02.

S31 AN EXPERIMENTAL INVESTIGATION OF THE LOW-PRESSURE COMBUSTION LIMITS OF SOME SOLID PROPELLANTS
Anderson, F. A., Strand, L. D., Strehlow, R. A.
Technical Memorandum 33-134, June 3, 1963 (Confidential)

For abstract, see Entry A03.

Tam, M. K.

T01 *MARINER B* TELECOMMUNICATION SYSTEM RELIABILITY STUDY
Tam, M. K.
Technical Memorandum 31-146, August 15, 1963 (Unclassified)

Functional reliability equations of the *Mariner B* telecommunication system are derived by using event algebra and a reliability model constructed from considerations of partial successes. These equations are enumerated and given in terms of other dependents within the spacecraft. Numerical values for the functional reliabilites are obtained on a parts-count basis. Three-dimensional graphical displays are constructed for each of the functional equations.

Reliability improvement, in general, is examined from the standpoint of functional blocks as well as on the basis of individual circuitry. A comprehensive comparison between the results of the *Mariner A* and the *Mariner B* reliability studies is presented.

Tardani, P. A.

T02 MADRID SITE SELECTION REPORT
Tardani, P. A.
Technical Memorandum 33-149, July 17, 1963 (Unclassified)

This memorandum summarizes the results of a survey of Spain for an area compatible with the site requirements of a deep space station. In cooperation with officials of the Instituto Nacional de Técnica Aeronáutica, an agency of the Spanish government, the area of Robledo de Chavela, approximately 35 mi west of Madrid, was tentatively selected.

Taylor, H. S.

T03 THE POTENTIAL ENERGY CURVE OF THE LOWEST LYING TRIPLET SIGMA STATE OF LITHIUM HYDRIDE
Taylor, H. S.
Technical Report 32-493, August 15, 1963 (Unclassified)

The potential energy curve of the lowest-lying triplet-sigma state of lithium hydride has been computed by a variational technique. Linear combinations of products of two-center molecular orbitals were used to approximate the wavefunction. All linear and nonlinear parameters are minimized and open-shell techniques are utilized. The triplet state is shown to be of a repulsive nature.

T04 MOLECULAR ORBITAL STUDY OF THE $B\ ^1\Sigma_u^+$ AND $^3\Sigma_u^+$ STATES OF THE HYDROGEN MOLECULE
Taylor, H. S.
Technical Report 32-499 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 39, no. 12, pp. 3375–3381, December 1963)

The molecular orbital method is applied to the calculation of the potential curve of the $B\ ^1\Sigma_u^+$ and the $^3\Sigma_u^+$ states of the hydrogen molecule. Results comparable to those obtained using much more complicated wavefunctions are obtained.

T05 SPIN PROPERTIES OF PAIR-CORRELATED ATOMIC AND MOLECULAR SINGLET WAVEFUNCTIONS
Levine, H. B., Geller, M., Taylor, H. S.
Technical Report 32-565 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 40, no. 2, pp. 595–602, January 15, 1964)

For abstract, see Entry L11.

T06 SECOND-ORDER PERTURBATION THEORY IN ATOMIC AND MOLECULAR QUANTUM MECHANICS (APPLICATION TO THE ELECTRIC DIPOLE AND QUADRUPOLE POLARIZABILITIES AND SHIELDING FACTORS OF THE BERYLLIUM ATOM)
Kelly, H. P., Taylor, H. S.
Technical Report 32-587 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 40, no. 6, pp. 1478–1485, March 15, 1964)

For abstract, see Entry K05.

Taylor, J. L.

T07 APPARATUS FOR TENSILE TESTING TO 5400°F IN VACUUM
Taylor, J. L.
Technical Report 32-358 (Unclassified)
(Reprinted from *The Review of Scientific Instruments*, v. 34, no. 5, pp. 500–504, May 1963)

An apparatus for tensile testing in vacuum to 5400°F is described. A load-elongation curve is plotted during testing of a standard specimen at a selected nominal strain rate between 0.005 and 5.0 in./in./min. The load train design provides that the grips, as well as the specimen, are in the furnace hot zone. The specimen is heated by radiation from an induction-heated susceptor, and its temperature is uniform within the detection limits of an optical pyrometer.

T08 TENSILE PROPERTIES OF TUNGSTEN FROM 2500 TO 5400°F IN VACUUM
Taylor, J. L., Boone, D. H.
Technical Report 32-359 (Unclassified)
(Reprinted from *American Society for Metals Transactions Quarterly*, v. 56, no. 3, pp. 643–655, September 1963)

The effects of temperature and strain rate on the tensile properties of recrystallized powder metallurgy tungsten rod were studied. Tests were conducted on a standard specimen (length/diameter $\simeq$ 4) at strain rates of 0.02 and 2.0 in./in./min. It was determined that the strain-hardening exponent varied between 0.075 and 0.90, increasing with increasing strain rate and decreasing temperature. Intercrystalline-type fracture was observed at the lower strain rate at all temperatures studied. This type of fracture is associated with void formation and growth and relatively low ductility values (between 22 and 55%) as measured by reduction in area. A ductility minimum occurs between 3000 and 4000°F (1650 and 2200°C). Ductile transgranular fracture, with reduction-in-area values between 90 and 100%, was found between 2500 and 5400°F (1370 and 2980°C) at 2.0 in./in./min, an order of magnitude lower strain rate than previously reported by others. Above 3000°F (1650°C) at the 2.0 in./in./min strain rate, stress-induced grain growth accompanied by a kind of work softening as shown by true stress-strain curves appears to account for the high ductility measured.

Arc-melted and extruded tungsten, and plasma-flame single-crystal tungsten in rod form were studied at the lower strain rate. These materials were found to have lower strength and higher ductility than powder metallurgy tungsten in the temperature range considered.

T09 TENSILE PROPERTIES OF PYROLYTIC TUNGSTEN FROM 1370° TO 2980°C IN VACUUM
Taylor, J. L., Boone, D. H.
Technical Report 32-463 (Unclassified)
(Reprinted from *Journal of the Less-Common Metals*, v. 6, pp. 157–164, 1964)

Some tensile properties of pyrolytic tungsten from 1370 to 2980°C are presented and compared with power metallurgy tungsten and plasma-flame single-crystal tungsten. A few engineering stress-strain curves are also given for pyrolytic and powder metallurgy tungsten.

T10 TENSILE PROPERTIES OF TUNGSTEN–3% RHENIUM AT TEMPERATURES OF 1400° TO 2900°C IN VACUUM
Taylor, J. L.
Technical Report 32-588, April 1, 1964 (Unclassified)

The tensile properties of recrystallized, doped powder-metallurgy tungsten–3% rhenium rod have been determined from 1370 to 2930°C in vacuum at a strain rate of 0.02 in./in./min. A comparison is made with recrystallized, doped powder-metallurgy tungsten (which shows comparatively poor ductility) and plasma-flame single-crystal tungsten (a very ductile material). The variation of strain-hardening exponent with temperature is shown for the two powder-metallurgy materials. Tungsten–3% rhenium has the highest strength and the lowest ductility of the three materials. At a test temperature of $\simeq$50% of the absolute melting point, both tungsten–3% rhenium and powder-metallurgy tungsten show decreased ductility and inter-crystalline fracture associated with void formation and growth. Ductility does not increase with increasing temperature above $\simeq$65% of the absolute melting point for tungsten–3% rhenium, as it does for powder-metallurgy tungsten; this is attributed to the absence of stress-induced grain growth during testing.

Tesnière, A. J.

T11 ANALYSIS OF HETEROGENEOUS REACTORS CONTAINING MODERATING FUEL ELEMENTS
Tesnière, A. J.
Technical Report 32-333, February 28, 1963 (Unclassified)

The Feinberg-Galanin method for heterogeneous reactors is formulated by using a two-group model rather than an age kernel. This treatment is then extended to take into account secondary effects, such as fast fission and thermalization of neutrons inside a rod which may contain moderator. The use of a single coefficient in a Feinberg-Galanin approach allows the source and sink strength of the fuel element to be related to the thermal flux only. By defining a set of four coefficients—α_1, β_1, α_2, and β_2—it is possible to relate the strengths of thermal- and fast-neutron sources and sinks to both thermal and fast fluxes. A method is presented for calculation of these coefficients.

Thompson, A. W.

T12 ROOM-TEMPERATURE FLEXURE PROPERTIES OF PYROLYTIC GRAPHITE
Thompson, A. W.
Technical Memorandum 33-159, November 25, 1963 (Unclassified)

Rectangular pyrolytic graphite bars were tested in flexure at room temperature. Specimens having three types of histories were studied: (1) as-deposited, (2) heated without load, and (3) deformed in tension parallel to the basal planes at 2760°C. A Chevenard Micromachine was used to perform three-point bending tests, and the photographic load-deflection curves which were obtained yielded calculated values of rupture stress and Young's modulus.

These data were generally lower than published results; typical as-deposited values parallel to the basal planes were 16,050 psi for rupture stress and 1.06×10^6 psi for Young's modulus. A value of 33.1×10^6 psi was obtained for the Young's modulus of a specimen deformed 14.1% at 2760°C. The relationships observed were as follows: rupture stress appeared to decrease with increasing prior deformation at 2760°C, and Young's modulus increased with increasing prior deformation at 2760°C within the region of basal slip and dewrinkling. Beyond the region of basal slip at 2760°C, Young's modulus decreased with increasing prior deformation at 2760°C.

Several criticisms of the testing method and the specimen size are discussed; as are the advantages which partially offset these objections.

Titsworth, R. C.

T13 CORRELATION PROPERTIES OF CYCLIC SEQUENCES
Titsworth, R. C.
Technical Report 32-388, July 1, 1963 (Unclassified)

In the unconstrained channel with additive Gaussian noise (where the optimum detector is based on correlation or matched filters), the quality of a code can be expressed as a function of the correlation values between code words. For a cyclic-sequence code, optimality reduces to a criterion to be met by the auto-correlation function of the sequence. This report presents methods for determining cyclic sequences with given correlation properties.

When the amount of equipment in the receiver is limited, matched filtering is no longer the optimal detection scheme. A better system, as shown here, is one which, by use of a Boolean function, combines several "component" sequences to generate the transmitted signal; the receiver consists of filters matched to each component.

The logic, the number of components, the requirements of the component sequences to optimize the system, and a general method for treating Boolean logics are given.

T14 OPTIMAL RANGING CODES
Titsworth, R. C.
Technical Report 32-411 (Unclassified)
(Reprinted from the *IEEE Transactions on Space Electronics and Telemetry*, v. SET-10, no. 1, pp. 19–30, March 1964)

An analysis of a continuous, coded ranging scheme is given. By use of a Boolean function, several "component" sequences are encoded into a transmitted signal. The receiver correlates the delayed return signal with different Boolean combinations of delayed replicas of the components to determine separately the time delay of each component sequence. From these delays, the total delay is computed.

By proper choice of encoding logic, number and type of components, and the decoding logics and procedure, the range can be found in a relatively short time. Optimal parameters of this ranging device are derived.

T15 TELECOMMUNICATION ASPECTS OF A MANNED MARS MISSION
Victor, W. K., Titsworth, R. C., Rechtin, E.
Technical Report 32-501, August 20, 1963 (Unclassified)

For abstract, see Entry V03.

Trafton, L. M.

T16 HIGH DISPERSION SPECTRA OF THE OUTER PLANETS. I. JUPITER IN THE VISUAL AND RED
Spinrad, H., Trafton, L. M.
Technical Report 32-437 (Unclassified)
(Reprinted from *Icarus*, v. 2, pp. 19–28, June 1963)

For abstract, see Entry S20.

Tschuikow-Roux, E.

T17 REACTION BETWEEN NITRIC OXIDE AND OZONE IN A SUPERSONIC NOZZLE
Marte, J. E., Tschuikow-Roux, E., Ford, H. W.
Technical Report 32-494 (Unclassified)
(Reprinted from *The Journal of Chemical Physics*, v. 39, no. 12, pp. 3277–3285, December 15, 1963)

For abstract, see Entry M07.

Udlock, D. E.

U01 ANALYSES FOR CHAIN AND STEREO ISOMERS IN DIPROPYLENE GLYCOL BY GAS–LIQUID PARTITION CHROMATOGRAPHY
Havlik, A. J., Udlock, D. E., Lawson, D. D.
Technical Memorandum 33-161, April 15, 1964 (Unclassified)

For abstract, see Entry H19.

Vane, F. M.

V01 GEMINAL PROTON–PROTON COUPLING CONSTANTS IN $CH_2{=}N{-}$SYSTEMS
Shapiro, B. L., Ebersole, S. J., Karabatsos, G. J., Vane, F. M., Manatt, S. L.
Technical Report 32-538 (Unclassified)
(Reprinted from *The Journal of the American Chemical Society*, v. 85, pp. 4041–4042, October 18, 1963)

For abstract, see Entry S11.

Vickers, J. M. F.

V02 A STUDY OF THERMAL SCALE MODELING TECHNIQUES
Vickers, J. M. F.
Technical Memorandum 33-153, September 30, 1963 (Unclassified)

The techniques which may be evolved from the basic laws of thermal scale modeling for spacecraft are described. All except two of these techniques can be rejected at once, since they require conditions which are very difficult to fulfill in practice. A comparison is made between the two remaining techniques—preserving temperature from prototype to model, and preserving materials from prototype to model. It is found that, for steady-state conditions, the technique of preserving temperature has inherent advantages over that of preserving materials, though much of this advantage is lost when transient conditions are to be modeled.

Victor, W. K.

V03 TELECOMMUNICATION ASPECTS OF A MANNED MARS MISSION
Victor, W. K., Titsworth, R. C., Rechtin, E.
Technical Report 32-501, August 20, 1963 (Unclassified)

A landing party on the surface of Mars will be able to maintain almost continuous high-quality communications with Earth by using a synchronous communications-relay satellite network established in orbit around Mars prior to the manned expedition. It is shown that real-time television is possible in either direction—from Earth to Mars or Mars to Earth—even at the maximum Earth–Mars distance of 400 million kilometers, and by utilizing conventional devices. The principal problem appears to be that of engineering these devices to ensure adequate long life and reliability for mission accomplishment.

An emergency teletype link is capable of direct Earth–Mars communications (bypassing the orbital relay) when the landing party's side of Mars is facing Earth. Temporary loss of communications will occur at semisynodic periods of approximately 13 months when the planets are in opposition or in conjunction. A communications blackout occurs when the Sun enters the main beam of either the Earth-based or the Mars-orbiter antenna. Computational results are included which indicate that this should not be a serious problem if considered during the design of the mission.

Vondra, R. J.

V04 *MARINER* 2 SOLAR PANEL DESIGN AND FLIGHT PERFORMANCE
Zoutendyk, J. A., Vondra, R. J., Smith, A. H.
Technical Report 32-455, June 28, 1963 (Unclassified)

For abstract, see Entry Z01.

von Roos, O.

V05 THE EFFECT OF ELECTRON SPIN PARAMAGNETISM ON THE VELOCITY OF SOUND IN METALS
von Roos, O.
Technical Report 32-507
(Reprinted from *The Physical Review*, v. 133, no. 1A, pp. A182–A183, January 1964)

By means of a simple calculation, it is shown that the interaction of an external magnetic field with the magnetic moment of the conduction of electrons in a metal gives rise to an increase in the velocity of sound which is independent of the angle between the direction of the magnetic field and the direction of propagation of the sound wave.

Warner, M. R.

W01 THE ORBIT DETERMINATION PROGRAM OF THE JET PROPULSION LABORATORY
Warner, M. R., Nead, M. W., Hudson, R. H.
Technical Memorandum 33-168, March 18, 1964 (Unclassified)

A computer program has been written at the Jet Propulsion Laboratory for determining the optimum least-squares estimates of spacecraft orbital parameters and certain physical and observational constants. The theoretical basis of the program, and flow diagrams of the computing procedure are discussed. The operation of the program, including input formats, is described.

White, W. F.

W02 THE DEVELOPMENT OF THE *SURVEYOR* GAS CHROMATOGRAPH
White, W. F.
Technical Report 32-425, May 15, 1963 (Unclassified)

This document reports the development of a gas chromatograph to be soft-landed on the surface of the Moon as part of the *Surveyor* scientific payload. While on the lunar surface, the gas chromatograph should provide an analysis of the volatile constituents in a sample of the lunar surface material. Provisions for thermal control of the operating instrument over a wide range of ambient temperatures are discussed, as well as packaging necessary to meet the severe vibration and temperature environments. Problems encountered in the design of subassemblies of the instrument are considered, such as solid sample handling and heating in the oven subassembly, programmed valving, column materials, sample detection, signal processing, and calibration.

Williams, H. E.

W03 SOME EXACT SOLUTIONS OF THE PROBLEM OF AXISYMMETRIC BENDING OF THIN SPHERICAL SHELLS
Williams, H. E.
Technical Report 32-416, April 1, 1963 (Unclassified)

The solution to the "exact" equation of equilibrium of an axisymmetrically loaded, thin, spherical shell is presented in the form of power series. These series are computed, and the resulting theory compared with the results of shallow-shell and quasi-cylindrical theories for the following cases: (1) influence coefficients of a complete edge-loaded shell, and (2) stresses and displacements of a shell loaded at the apex with a concentrated radial force.

Wilson, B.

W04 A GEOMETRICALLY NONLINEAR THEORY OF SHELLS
Wilson, B.
Technical Report 32-584, November 7, 1963 (Unclassified)

A general formulation of a geometrically nonlinear theory of shells is developed, utilizing basic concepts from vector and tensor analyses. Large deflections and rotations are considered, consistent with the assumption of linear stress-strain relations. In addition, the fundamental Kirchhoff hypothesis is introduced to reduce the shell problem to one of two dimensions. After the general theory governing the equilibrium configurations of a shell structure is established, the condition of stable or unstable equilibrium is examined.

Wolfson, L. S.

W05 LITHIUM-BOILING POTASSIUM REFRACTORY METAL LOOP FACILITY
Davis, J. P., Kikin, G. M., Phillips, W. M., Wolfson, L. S.
Technical Report 32-508, August 31, 1963 (Unclassified)

For abstract, see Entry D02.

Wollenhaupt, W. R.

W06 TRACKING SYSTEM DATA ANALYSIS REPORT *RANGER 4* FINAL REPORT
Wollenhaupt, W. R.
Technical Report 32-523, March 1, 1964 (Unclassified)

The analysis of the Deep Space Instrumentation Facility spacecraft tracking performance during the *Ranger 4* mission is summarized. 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 of the tracking data actually used in determining the spacecraft orbit, and the noise statistics of these data are also presented.

W07 THE *RANGER 5* FLIGHT PATH AND ITS DETERMINATION FROM TRACKING DATA
Sjogren, W. L., Kirhofer, W. E., Cain, D. L., Wollenhaupt, W. R., Hamilton, T. W.
Technical Report 32-562, December 6, 1963 (Unclassified)

For abstract, see Entry S13.

Wood, R. D.

W08 PLANETARY ENTRY SIMULATION BY MEANS OF COMBUSTION
Wood, R. D., Liaugminas, R.
Technical Report 32-614 (Unclassified)
(Reprinted from *American Institute of Aeronautics and Astronautics*, v. CP7, Aerodynamic Texting, March 1964)

The problem of planetary entry is examined in light of present-day knowledge of the atmospheres of Mars and Venus. Using typical entry trajectories, expected flight conditions and aerodynamic regimes can be considered and the flow parameter requirements for ground simulation estimated. The concept of simulation of these conditions by means of a combustion-heated hypervelocity wind tunnel is considered, and the region of applicability discussed.

Wrobel, J. R.

W09 EFFECTS OF FUEL INLET TEMPERATURE UPON THE PERFORMANCE OF A MONOPROPELLANT HYDRAZINE REACTION CHAMBER
Wrobel, J. R.
Technical Memorandum 33-132, July 7, 1963 (Unclassified)

The influence of the fuel inlet temperature upon the characteristic-velocity performance (c^*) of monopropellant-hydrazine catalytic-decomposition chambers is investigated analytically. A comparison of the assumption of "frozen" composition with statistically analyzed test data illustrates its adequacy for propulsion applications, but somewhat overestimates the temperature influence for gas generation applications.

Wu, C.-S.

W10 LANDAU DAMPING AND RESONANT ENERGY ABSORPTION
Wu, C.-S.
Technical Report 32-270 (Unclassified)
(Reprinted from *The Physical Review*, v. 127, no. 5, pp. 1419–1422, September 1962)

A physical interpretation (based on the Vlasov equations) of the Landau damping is given. It is shown that Landau's discussion and Kidal's calculation of resonant energy absorption are equivalent. It is also found possible to compare the analysis based on the Vlasov equations to Dawson's intuitive formulation.

W11 THE EFFECT OF IONIZATION AND RECOMBINATION ON THE ELECTRON DISTRIBUTION FUNCTION OF A SLIGHTLY IONIZED GAS WITH PRESENCE OF ELECTRIC AND MAGNETIC FIELDS
Wu, C.-S.
Technical Report 32-279 (Unclassified)
(Reprinted from "Proceedings Fifth International Conference on Ionization Phenomena in Gases, Munich 1961," pp. 214–222, North-Holland Publishing Company, Amsterdam)

In other literature, the effect of ionization and recombination on the electron distribution function of a slightly ionized gas was discussed for two extreme cases: very short free-life time and very long free-life time. The present paper investigates the general case and also takes into account the presence of external magnetic and electric fields. The general expressions of electron drift velocity and mean energy have been obtained by assuming that the electron collision frequency is independent of the electron velocity. The postulation is supposed to be valid for electrons of low energy.

W12 DAMPING OF QUANTIZED LONGITUDINAL PLASMA OSCILLATIONS
Klevans, E. H., Burt, P. B., Wu, C.-S.
Technical Report 32-553, April 15, 1964 (Unclassified)

For abstract, see Entry K10.

Yeh, C.

Y01 EXCITATION OF HIGHER ORDER MODES BY A STEP DISCONTINUITY OF A CIRCULAR WAVEGUIDE
Yeh, C.
Technical Report 32-496, February 1, 1964 (Unclassified)

This report considers the problem of excitation of higher-order modes by a step discontinuity in a circular waveguide with an incident dominant H_{11} mode. To solve this problem, an approximation method is used in which it is assumed that the tangential electric field at the discontinuity is zero everywhere except in the aperture, where it is equal to the incident tangential electric field. Relative amplitudes of these excited modes are discussed.

Zoutendyk, J. A.

Z01 *MARINER* 2 SOLAR PANEL DESIGN AND FLIGHT PERFORMANCE
Zoutendyk, J. A., Vondra, R. J., Smith, A. H.
Technical Report 32-455, June 28, 1963 (Unclassified)

The electrical power for *Mariner 2* was obtained from 10,710 boron-diffused, *p*-on-*n* silicon photovoltaic solar cells. The solar cells had dimensions of 1×2 cm and were flat-mounted on two rectangular aluminum structures which provided a combined cell support area of 25.5 ft^2. The power drain from the solar panels to the spacecraft load ranged from 150 to 195 w during the 130 days from launch until communication from the spacecraft was lost 21 days after Venus encounter. The Earth-to-space spectral correction factors for the two solar-cell panels were 0.88 and 0.91. The temperatures at which the panels operated during the mission ranged from 45 to 120°C.

SUMMARY PUBLICATIONS

QUARTERLY SUMMARY REPORT

This document is a quarterly summary of the research activities conducted by the Jet Propulsion Laboratory in the field of nondestructive testing of solid-propellant rocket motors; it is prepared through NASA for the Advanced Research Project Agency.

AB01 QUARTERLY SUMMARY REPORT
[APRIL 1 TO JUNE 30, 1963]
QSR No. 38-12, July 31, 1963 (Confidential)

AB02 QUARTERLY SUMMARY REPORT
[JULY 1 TO SEPTEMBER 30, 1963]
QSR No. 38-13, October 31, 1963 (Confidential)

AB03 QUARTERLY SUMMARY REPORT
[OCTOBER 1 TO DECEMBER 31, 1963]
QSR No. 38-14, January 31, 1964 (Confidential)

SPACE PROGRAMS SUMMARY

The Space Programs Summary is a six-volume, bimonthly publication designed to report on JPL space exploration programs, and related supporting research and advanced development projects.

Volumes I, II, and III report the progress of the Lunar, Planetary-Interplanetary, and Deep Space Network Programs, respectively; Volumes IV and V report the unclassified and classified activities, respectively, of the supporting research and advanced development progress. Volume VI consists of an unclassified digest of appropriate material from Volumes I, II, and III, and a reprint of the space science instrumentation studies of Volumes I and II.

Beginning with the Space Programs Summary 37-27 series, the Space Flight Operations Facility development progress, previously reported in Volume VI, is reported in Volume III. The scope of Volume III was expanded to incorporate the activities of the Deep Space Network. For preceding numbers and volumes, see Bibliography Nos. 39-1, 39-2, 39-3, and 39-4.

AB04 SPACE PROGRAMS SUMMARY NO. 37-22,
VOLUME I [MAY 1 TO JUNE 30, 1963]
The Lunar Program, July 31, 1963 (Confidential)

AB05 SPACE PROGRAMS SUMMARY NO. 37-22,
VOLUME II [MAY 1 TO JUNE 30, 1963]
The Planetary-Interplanetary Program, July 31, 1963 (Confidential)

AB06 SPACE PROGRAMS SUMMARY NO. 37-22,
VOLUME III [MAY 1 TO JUNE 30, 1963]
The Deep Space Instrumentation Facility, July 31, 1963 (Unclassified)

AB07 SPACE PROGRAMS SUMMARY NO. 37-22,
VOLUME IV [JUNE 1 TO JULY 31, 1963]
Supporting Research and Advanced Development, August 31, 1963 (Unclassified)

AB08 SPACE PROGRAMS SUMMARY NO. 37-22, VOLUME V [JUNE 1 TO JULY 31, 1963]
Supporting Research and Advanced Development, August 31, 1963 (Confidential)

AB09 SPACE PROGRAMS SUMMARY NO. 37-22, VOLUME VI [MAY 1 TO JULY 31, 1963]
Space Exploration Programs and Space Sciences, August 31, 1963 (Unclassified)

AB10 SPACE PROGRAMS SUMMARY NO. 37-23, VOLUME I [JULY 1 TO AUGUST 31, 1963]
The Lunar Program, September 30, 1963 (Confidential)

AB11 SPACE PROGRAMS SUMMARY NO. 37-23, VOLUME II [JULY 1 TO AUGUST 31, 1963]
The Planetary-Interplanetary Program, September 30, 1963 (Confidential)

AB12 SPACE PROGRAMS SUMMARY NO. 37-23, VOLUME III [JULY 1 TO AUGUST 31, 1963]
The Deep Space Instrumentation Facility, September 30, 1963 (Unclassified)

AB13 SPACE PROGRAMS SUMMARY NO. 37-23, VOLUME IV [AUGUST 1 TO SEPTEMBER 30, 1963]
Supporting Research and Advanced Development, October 31, 1963 (Unclassified)

AB14 SPACE PROGRAMS SUMMARY NO. 37-23, VOLUME V [AUGUST 1 TO SEPTEMBER 30, 1963]
Supporting Research and Advanced Development, October 31, 1963 (Confidential)

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Space Exploration Programs and Space Sciences, October 31, 1963 (Unclassified)

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The Lunar Program, November 30, 1963 (Confidental)

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Supporting Research and Advanced Development, February 29, 1964 (Unclassified)

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The Lunar Program, March 31, 1964 (Confidential)

AB29 SPACE PROGRAMS SUMMARY NO. 37-26, VOLUME II [JANUARY 1 TO FEBRUARY 29, 1964]
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AB30 SPACE PROGRAMS SUMMARY NO. 37-26, VOLUME III [JANUARY 1 TO FEBRUARY 29, 1964]
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AB31 SPACE PROGRAMS SUMMARY NO. 37-26, VOLUME IV [FEBRUARY 1 TO MARCH 31, 1964]
Supporting Research and Advanced Development, April 30, 1964 (Unclassified)

AB32 SPACE PROGRAMS SUMMARY NO. 37-26, VOLUME V [FEBRUARY 1 TO MARCH 31, 1964]
Supporting Research and Advanced Development, April 30, 1964 (Confidential)

AB33 SPACE PROGRAMS SUMMARY NO. 37-26, VOLUME VI [JANUARY 1 TO FEBRUARY 29, 1964]
Space Exploration Programs and Space Sciences, March 31, 1964 (Unclassified)

AB34 SPACE PROGRAMS SUMMARY NO. 37-27, VOLUME I [MARCH 1 TO APRIL 30, 1964]
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AB35 SPACE PROGRAMS SUMMARY NO. 37-27, VOLUME II [MARCH 1 TO APRIL 30, 1964]
The Planetary-Interplanetary Program, May 31, 1964 (Confidential)

AB36 SPACE PROGRAMS SUMMARY NO. 37-27, VOLUME III [MARCH 1 TO APRIL 30, 1964]
The Deep Space Network, May 31, 1964 (Unclassified)

AB37 SPACE PROGRAMS SUMMARY NO. 37-27, VOLUME V [APRIL 1 TO MAY 31, 1964]
Supporting Research and Advanced Development, June 30, 1964 (Confidential)

AB38 SPACE PROGRAMS SUMMARY NO. 37-27, VOLUME VI [MARCH 1 TO APRIL 30, 1964]
Space Exploration Programs and Space Sciences, May 31, 1964 (Unclassified)

ASTRONAUTICS INFORMATION

ABSTRACTS

(With Volume VIII, no. 2, the publication of the Astronautics Information Abstracts—Reports and Open Literature *series by the Jet Propulsion Laboratory has been discontinued. The subject areas formerly covered by this series are now incorporated in the equivalent NASA report publication* STAR *and the AIAA open literature publication* IAA.*)*

The *Astronautics Information Abstracts—Reports and Open Literature* is a monthly publication covering Jet Propulsion Laboratory Library holdings for the month indicated. Report and open literature citations are restricted to the subject of space flight and to applicable data and techniques. Cumulative author, subject, and source indexes are included for the current year.

AC01 ABSTRACTS—REPORTS AND OPEN LITERATURE, VOLUME VIII, NO. 1
Astronautics Information Abstracts 80,001 through 80,367, July 1963 (Unclassified)

AC02 ABSTRACTS—REPORTS AND OPEN LITERATURE, VOLUME VIII, NO. 2
Astronautics Information Abstracts 80,368 through 80,778, August 1963 (Unclassified)

LITERATURE SEARCHES

The technical staff of the Jet Propulsion Laboratory Library conducts extensive literature searching programs covering subjects selected by the Laboratory engineers and designed to meet their individual research requirements. Searches considered to be of interest to persons working in the field of astronautics are published for distribution to interested organizations.

AC03 TELEVISION, PHOTOGRAMMETRY, PHOTOMETRY, AND RADIOMETRY ADAPTABLE TO SPACE RECONNAISSANCE
Hayes, J., Compiler
Literature Search 490, November 1963 (Unclassified)

This Literature Search is divided into the following sections: Airborne Photography; Astronomical Photography; Television Development; Television Scanning; Television Bandwidth; Television Systems; Television Noise, Resolution, and Coding; Colorimetry and Illumination; and Photometry and Radiometry. Author and corporate source indexes are included.

AC04 ELECTRIC PROPULSION
Hayes, J., Compiler
Literature Search 587, June 1964 (Unclassified)

This Literature Search updates and supplements Astronautics Information Literature Search No. 428, "Electrically Propelled Spacecraft and Associated Subjects," May 1962.

References contained in this Search are categorized by the following subject headings: General (comprised of basic research and comparative studies of the types of propulsion covered in the other four sections); Electromagnetic; Electrostatic; Electrothermal; and Nuclear-Electric. Author and corporate source indexes are included.

TRANSLATIONS

Relevant articles from foreign journals and news media are translated, published and made available to interested organizations.

AC05 CLASSIFICATION OF SPACES SUPPORTING GRAVITATIONAL FIELDS
Petrov, A. Z.
Astronautics Information Translation 29, October 1, 1963 (Unclassified)
(Translated by M. Karweit from *Scientific Transactions of the Kazan State University Jubilee (1804–1954) Collection*, v. 114, Book 8, 1954)

This article gives an expanded proof of results derived earlier by the author and first published in *Reports of the Academy of Sciences*, v. 81, pp. 149–152, 1951. A classification scheme for the manifold T_4 supporting a gravitational field is established by investigating the algebraic structure of the curvature tensor. For each of the three principal types of gravitational field, the characteristic K-matrix and its canonical forms are derived.

AC06 ON THE IONOSPHERIC INTERPRETATION OF THE RESULTS OF RADIO OBSERVATIONS OF VENUS. PART I
Danilov, A. D., Yatsenko, S. P.
Astronautics Information Translation 30, November 29, 1963 (Unclassified)
(Translated from *Geomagnetizm i Aeronomiya*, v. 3, no. 4, pp. 585–593, 1963)

The ionosphere model appears to hold the greatest promise for an explanation of the data obtained by radio observations of Venus. The primary difficulties associated with this hypothesis and possible techniques for overcoming them are considered. The very high concentration of electrons in the Venus atmosphere, which is required to account for the radio observational data, may, in fact, exist if (1) radiative recombination is the recombining mechanism, and (2) the same ionizing agent acts in the night ionosphere of Venus as acts in the night ionosphere of the Earth.

AC07 A RADAR STUDY OF THE PLANET MARS IN THE SOVIET UNION
Kotelnikov, V. A., Dubrovin, V. M., Dubinskiy, B. A., Kislik, M. D., Kuznetsov, B. I., Petrov, G. M., Rabotyogov, A. P., Rzhiga, O. N., Shakhovskoy, A. M.
Astronautics Information Translation 31, December 18, 1963 (Unclassified)
(Translated from *Doklady Akademii Nauk SSSR*, v. 151, no. 4, pp. 811–814, 1963)

A radar study of Mars was conducted during the period of opposition in the first half of February 1963. It was performed by the Institute of Radar and Electronics of the USSR Academy of Sciences, together with several other organizations. Conditions under which the measurements were made and the results of the study are presented.

AC08 EXPERIMENTAL INVESTIGATIONS ON SOLID SPOILERS AND JET SPOILERS AT MACH NUMBERS OF 0.6 TO 2.8
Heyser, A., Maurer, F.
Astronautics Information Translation 32, February 21, 1964 (Unclassified)
(Translated from *Zeitschrift für Flugwissenschaften*, v. 10, no. 415, pp. 110–130, 1962)

Experimental investigations are reported regarding the effects of solid and jet spoilers on a flat plate in high-subsonic and supersonic tangential flow. The boundary layer of the plate is turbulent ahead of the separation at the spoiler. The height of the spoiler varies between 0.2 and 0.8 cm, and the ratio of the stagnation pressure of the control jet and the static pressure in the test section varies between 3 and 60. The results of force and pressure distribution measurements are reported and discussed in relation to the flow pattern, and are compared with the measurements thus far available. The lift-drag ratio of the solid spoiler is compared with an analogic term of the jet spoiler. This term is shown to be in the order of magnitude of 2 in the supersonic range for the solid spoiler at the end of the plate, and may be considerably exceeded in the case of the jet spoiler. High-frequency schlieren photographs have been produced of the spoiler in motion, in order to discuss the response time.

AC09 ON THE PRESENCE OF OXYGEN IN THE ATMOSPHERE OF VENUS
Prokofyev, V. K., Petrova, N. N.
Astronautics Information Translation 33, January 15, 1964 (Unclassified)
(Translated from *Izvestiya Krymskoi Astrofizicheskoi Observatorii*, v. 21, pp. 3–14, 1963)

The Venus spectrum is investigated for the presence of a weak absorption band of molecular oxygen (O_2) in the planet's atmosphere.

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