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A Selected Listing

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Introduction

WHAT *NASA SCIENTIFIC AND TECHNICAL REPORTS FOR 1968* IS

NASA Scientific and Technical Reports for 1968, A Selective Listing (NASA SP-7033) combines in a single publication a selective listing of NASA reports that were announced during 1968 in *Scientific and Technical Aerospace Reports (STAR)*, NASA's semimonthly announcement journal for the aerospace sciences. The documents listed were issued as part of the following NASA report series: *Special Publications* (NASA SP-), *Technical Reports* (NASA TR-), *Technical Notes* (NASA TN D-), *Technical Memorandums* (NASA TM X-), *Technical Translations* (NASA TT F-), and *Contractor Reports* (NASA CR-). The listing does not include references to journal articles that were published as a result of NASA-sponsored activities.

As in the case of the similar publication for 1967 (NASA SP-7029), the present volume has been limited to reports which were printed and widely distributed. Access to material thus omitted from this listing continues to be available through *STAR* and its Indexes.

HOW *NASA SCIENTIFIC AND TECHNICAL REPORTS FOR 1968* IS ORGANIZED

The arrangement of this publication is the same as that of *STAR*. The first section contains the bibliographic citations and abstracts arranged by *STAR* subject categories. The second section contains five indexes (subject, personal author, corporate source, report/accession number, and accession/report number.)

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The Preliminary Edition of the *NASA Thesaurus* (December 1967) (NASA SP-7030) is used as the authority for the indexing vocabulary that appears in the subject index. The *NASA Thesaurus* should be consulted in examining the current indexing vocabulary, including associated cross-reference structure. Only the subject terms that have been selected to describe the documents abstracted in this publication appear in the subject index. Copies of the *NASA Thesaurus* may be obtained from the Clearinghouse for Federal Scientific and Technical Information or the Superintendent of Documents, U.S. Government Printing Office at $8.50 for the three-volume set.

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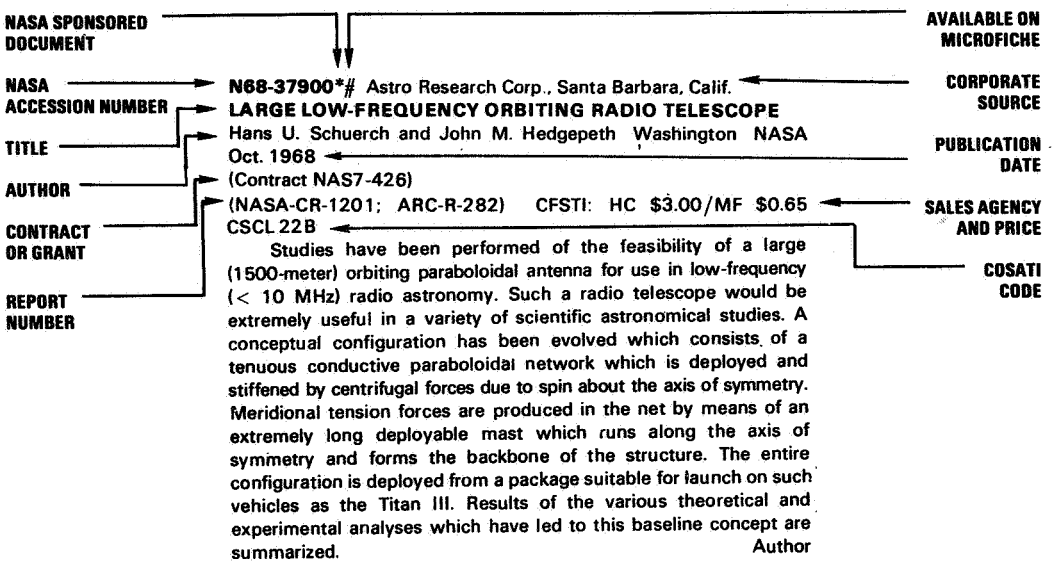
TYPICAL CITATION AND ABSTRACT



NASA Scientific and Technical Reports for 1968

a selected listing MAY 1969

01

AERODYNAMICS

Includes aerodynamics of bodies, combinations, internal flow in ducts and turbomachinery; wings, rotors, and control surfaces. For applications see: 02 Aircraft and 31 Space Vehicles. For related information see also: 12 Fluid Mechanics; and 33 Thermodynamics and Combustion.

N68-10060* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A MOVING-BELT GROUND PLANE FOR WIND-TUNNEL GROUND SIMULATION AND RESULTS FOR TWO JET-FLAP CONFIGURATIONS

Thomas R. Turner Washington NASA Nov. 1967 39 p refs (NASA-TN-D-4228) CFSTI: $3.00 CSCL 14B

A moving-belt ground plane designed to eliminate the ground boundary layer for tests in ground proximity has been installed in a 17-foot (5.18-meter) wind-tunnel test section at the Langley Research Center. The test station was calibrated with this moving belt installed, and the effects of ground proximity on the characteristics of a swept and an unswept full-span blowing-flap configuration have been investigated. The results indicate that the moving belt satisfactorily removes the boundary layer on the ground plane. The lift loss of models at small distances from the ground and high lifts is considerably less with the belt moving at stream velocity (boundary layer removed) than with the belt at zero velocity. For configurations with full-span lift devices, the data indicate that the moving-belt ground plane is not needed for ratios of wing height (in spans) to lift coefficient greater than about 0.050, but is desirable for smaller ratios. Author

N68-10093*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

WIND-TUNNEL INVESTIGATION OF A 3/8-SCALE AUTOMOBILE MODEL OVER A MOVING-BELT GROUND PLANE

Thomas R. Turner Washington, NASA Nov. 1967 36 p refs (NASA-TN-D-4229) CFSTI: HC $3.00/MF $0.65 CSCL 01A

An investigation of the effect of ground-plane boundary layer in wind-tunnel testing of a model automobile over a fixed ground plane has been made by using the endless moving-belt ground plane in the 17-foot test section of the Langley 300-MPH 7- by 10-foot tunnel. A 3/8-scale automobile model was tested with the ground-plane belt at free-stream velocity (i.e., with the boundary layer eliminated) as well as at a reduced velocity and zero velocity (i.e., with boundary layers). The results indicate that the boundary layer on the ground plane tends to increase the lift but has negligible effect on other components. The lift increment due to ground-plane boundary layer was smaller than that due to crosswinds or configuration changes such as a flush fairing on the underbody. Author

N68-10380* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

FREE-FLIGHT AERODYNAMIC CHARACTERISTICS OF A SLENDER CONE BETWEEN MACH NUMBERS OF 7 AND 8

Joseph H. Judd Washington NASA Nov. 1967 42 p refs (NASA-TN-D-4245) CSCL 01A

A free-flight test of a 3.56° half-angle cone configuration was made by use of the rocket test technique. The cone model was accelerated to a Mach number of 8 and a Reynolds number based on nominal body length of 25×10^6. Data are presented during the decelerating flight to a Mach number of 7 and a Reynolds number based on body length of 2.5×10^6 as the slowly spinning cone was disturbed in pitch by pulse rockets. The cone model demonstrated a good aerodynamic efficiency, having a lift–drag ratio of 2.77 at a Mach number of 7.3 and at an angle of incidence of 9°. During the decelerating flight a relatively steady value of the roll resonance parameter, approximately 0.8, was maintained. The measured variation of axial-force coefficient with resultant-force coefficient in the transverse plane agreed with estimated values obtained by using Newtonian theory and classical hypersonic similarity, although the estimated values obtained by using similarity were slightly lower. Author

N68-10529*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

USE OF SIMILARITY PARAMETERS FOR EXAMINATION OF GEOMETRY CHARACTERISTICS OF HIGH-EXPANSION-RATIO AXIAL-FLOW TURBINES

Arthur J. Glassman and Warner L. Stewart Washington NASA Nov. 1967 35 p refs
(NASA-TN-D-4248) CFSTI: HC $3.00/MF $0.65 CSCL 10A

The similarity parameters are discussed with respect to turbine stage and overall characteristics. Interrelations among the number of stages, the stage diameter variation, the turbine expansion ratio, and the stage-similarity-parameter variation are explored. The highest overall efficiency in a multistage turbine is attained when the stage similarity parameters are maintained approximately constant near the stage optimum values. A turbine with a constant mean diameter cannot meet this requirement, especially for a high-expansion-ratio application. Appropriate proportioning of stage work and stage diameter as a function of stage-exit volume flow is used to estimate geometry characteristics for a constant stage-parameter design. More stages are required for the constant stage-parameter design than for the constant mean-diameter design. For the high-expansion-ratio cases, the rate of increase of stage diameter may become so severe as to exceed practical limitations. A limit imposed on the stagewise increase in diameter resulted in a reduction in the overall diameter variation but in a further increase in the number of stages. The turbine geometry characteristics were obtained for a nuclear rocket, a mercury Rankine cycle, and alkali-metal Rankine cycle applications. Author

N68-11036*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
WIND-TUNNEL INVESTIGATION OF A DEFLECTED-SLIP-STREAM CRUISE-FAN V/STOL AIRCRAFT WING
William A. Newsom, Jr. Washington Dec. 1967 54 p refs
(NASA-TN-D-4262) CFSTI: HC $3.00/MF $0.65 CSCL 01A

An investigation was made of a wing with ducted fans mounted so that the slipstream would spread over most of the span of the wing. The wing was equipped with a double slotted flap and the ducts could be mounted at various positions on the leading edge. Tests were made for three different duct exit configurations over a range of angles of attack and fan thrust for various flap angles. The greatest amount of circulation lift was induced on the wing when the two ducts were mounted at the 1/4- and 3/4-semispan stations and when the slipstream from the ducts was divided with one-third of it going over the wing and two-thirds of it beneath the wing. The investigation also showed that chordwise fences on the upper surface of the flaps were effective in improving the turning effectiveness of the flaps and increasing the lift induced on the wing by the duct exit flow. The efficiency of the subject powered lift system was such that the model had a desirably low thrust required curve throughout the transition speed range. In this speed range the thrust required closely approximated that required as calculated from momentum relations based on the idealized assumption of an elliptical distribution of lift across the entire span of the wing. A slipstream deflection angle for hovering flight of 88° with a thrust loss of only 8% was obtained with the subject model. Author

N68-11253*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EFFECT OF THRUST AND ALTITUDE IN STEEP APPROACHES ON GROUND TRACK NOISE
John A. Zalovcik Washington Nov. 1967 13 p refs
(NASA-TN-D-4241) CFSTI: HC $3.00/MF $0.65 CSCL 01B

A brief analysis was made of measurements of sound pressure level taken during approaches of a four-engine medium-range turbojet transport to determine the variation of sound pressure level with thrust and altitude for various glide slope angles. The sound pressure level data were obtained at four ground stations during 3° approaches with several flap deflections which provided variations in airplane drag and hence in the required thrust. The thrust required for stabilized flight on the 3° glide slope was computed from lift–drag polars available for the airplane for the three flap deflections. By using the measured height of the aircraft above the four ground stations, the computed thrust, and the measured sound pressure level, the variation of sound pressure level with aircraft height and thrust for stabilized flight on 3° to 7° glide slopes was derived. The results of the analysis indicated that by increasing the glide slope from 3° to 6°, the value of the sound pressure level could be reduced 11.5 to 14.0 dB, depending on the ground station location. Of this reduction, about 7.5 dB would be due to reduction in thrust and the remainder (4 to 6.5 dB), to increase in altitude. Values of sound pressure level computed on the basis of this analysis at one ground station for several steep approach profiles flown showed good agreement with sound pressure level measurements made during the steep approaches. Author

N68-11640* National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
AERODYNAMIC STABILITY CHARACTERISTICS OF THE APOLLO LAUNCH ESCAPE VEHICLE (LEV) WITH CANARD SUFACES DEPLOYED
William C. Moseley, Jr. and Bass Redd Washington Dec. 1967 108 p refs
(NASA-TN-D-4280) CFSTI: $3.00 CSCL 22B

A series of wind-tunnel studies was made to determine both static and dynamic stability characteristics of the Apollo launch escape vehicle, with canard surfaces in the deployed (open) position. This configuration is known as the post-abort vehicle. Results indicate that these canard surfaces are effective in producing a desired destabilizing increment in pitching moment. Positive damping was generally indicated. Author

N68-11936*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
BALLISTIC-RANGE TESTS OF A DRAG-RING CONFIGURATION AT MACH NUMBERS AROUND 2
Charles E. De Rose Washington Dec. 1967 23 p ref
(NASA-TN-D-4291) CFSTI: HC $3.00/MF $0.65 CSCL 01A

Free-flight measurements of an unusual configuration proposed as a Mars atmospheric probe were made in the Ames Pressurized Ballistic Range. The configuration consisted of a cone-cylinder centerbody supported within a large conical-sector flare (called a drag ring) with a wide gap between the two components. Tests were made in air at a nominal Mach number of 2 and a Reynolds number, based on the drag-ring diameter of 50,000. All experimental data are compared with values obtained at a Mach number of 20 and with Newtonian theory to check the effect of a large change in flight velocity. A limited investigation was undertaken in the Pressurized Ballistic Range at Ames Research Center to study the drag, lift, and static and dynamic stability of this shape in air at a Mach number of approximately 2, and to photograph the flow around the free-flying model. The results of this investigation are reported here. Author

N68-11958*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EXPERIMENTAL PRESSURE DISTRIBUTIONS AND AERODYNAMIC CHARACTERISTICS OF A LOW-FINENESS-RATIO CYLINDER AT A MACH NUMBER OF 10.5 AND ANGLES OF ATTACK FROM 0° TO 90°
Thomas A. Blackstock and Philip E. Everhart Washington Dec. 1967 29 p refs
(NASA-TM-X-1487) CFSTI: HC $3.00/MF $0.65 CSCL 01A

An investigation was made in the continuous-flow hypersonic tunnel to measure the surface pressures and the force and moment characteristics of a fuel capsule designed for use on the Nimbus B weather satellite. The capsule, a fineness-ratio-2 cylinder with a recessed face, was tested at angles of attack from 0° to 90° at a Reynolds number of 0.8×10^6 based on free-stream conditions and cylinder length. At angles of attack from 37° to 90°, forces and moments were also measured on a corresponding cylinder

with a flat face. Pressures on the recessed face reached a maximum at angles of attack from 40° to 50°. Significant end effects on the pressure were concentrated within 1/2 diameter of the end of the cylinder. Analysis of the results indicated that normal force can be predicted within 15 percent by modified Newtonian theory. Agreement between experiment and theory for axial force was good near angles of attack of 0° and 90°, but the calculated results were generally somewhat low at other attitudes. The high pressure induced by the lip of the recess also produced a moderate increase in axial force, but had little effect on normal force. The recessed face greatly affected the pitching moment where large increases over the values for the flat-faced cylinder were noted. Author

N68-14747*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPUTER PROGRAM FOR DESIGN OF TWO DIMENSIONAL SUPERSONIC NOZZLE WITH SHARP EDGED THROAT

Michael R. Vanco and Louis J. Goldman Washington Jan. 1968 19 p refs

(NASA-TM-X-1502) CFSTI: HC$3.00/MF$0.65 CSCL 10A

The FORTRAN IV computer program for the design of a two-dimensional supersonic nozzle with a sharp-edged throat is presented along with the equations used. The nozzle, which has uniform parallel flow at the exit, is designed on the basis of two-dimensional isentropic flow of a perfect gas. The program requires as input the exit Mach number and the specific-heat ratio. The output yields the nozzle contour for the supersonic portion. Input and output for a sample case are included. Author

N68-15743*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COLD-AIR INVESTIGATION OF A TURBINE FOR HIGH-TEMPERATURE-ENGINE APPLICATION. 3: OVERALL STAGE PERFORMANCE

Warren J. Whitney, Edward M. Szanca, Bernard Bider, and Daniel E. Monroe Washington Feb. 1968 23 p refs

(NASA-TN-D-4389) CFSTI: HC$3.00/MF$0.65 CSCL 10A

An experimental investigation was made to determine the performance of a 30-inch (0.762-m) single-stage turbine, designed for high-engine temperature application. The characterizing features for this application, pertinent to the turbine aerodynamic performance, are thick blade profiles, blunt leading and trailing edges, and low solidity. The turbine developed equivalent design specific work output at equivalent design speed with an efficiency of 0.923, which was the highest efficiency obtained over the range of conditions investigated. The equivalent mass flow, 40.64 pounds per second (18.434 kg/sec), is 1.8 percent greater than the design mass flow. It was concluded that the compromising of the airfoil shapes, which was necessary because of cooling considerations, did not impair the turbine performance. The design mean radius velocity diagram is compared with that calculated from the experimental results obtained at equivalent design speed and equivalent design specific work output. The comparison indicates that an overexpansion occurred across the stator and that the reaction across the rotor was reduced. This effect was attributed to an excessive passage area allowance at the rotor outlet which resulted from an assumed design efficiency which was lower than the experimentally obtained efficiency. Author

N68-15778*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

COMPARISON OF EXPERIMENTAL AND THEORETICAL SHOCK SHAPES AND PRESSURE DISTRIBUTIONS ON FLAT-FACED CYLINDERS AT MACH 10.5

Mamoru Inouye, Joseph G. Marvin, and A. Richard Sinclair Washington NASA Feb. 1968 21 p refs

(NASA-TN-D-4397) CFSTI: HC$3.00/MF$0.65 CSCL 01A

Shock-wave shapes and surface pressures were measured on flat-faced cylinders with shoulder to base radius ratios of 0.0, 0.05, 0.15, 0.25, and 0.5. The measured values were compared with one- and two-strip numerical solutions obtained by the method of integral relations. The two-strip solutions predicted adequately both the shock shapes and surface pressures. The one-strip solutions predicted adequately the shock shapes but underestimated the surface pressures. The shock-wave standoff distances decreased linearly with increasing shoulder radius. The computed stagnation-point velocity gradients increased with increasing shoulder radius, but not linearly. Author

N68-16299*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

WIND TUNNEL INVESTIGATION OF THREE PROPOSED LAUNCH VEHICLES AT MACH NUMBERS FROM 2.30 TO 4.63

A. B. Blair, Jr. and Melvin M. Carmel Washington Feb. 1968 66 p

(NASA-TM-X-1498) CFSTI: HC$3.00/MF$0.65 CSCL 01A

A wind tunnel investigation has been made to determine the aerodynamic characteristics of three 1/12.4-scale models of proposed multi-stage launch vehicles. Tests of the second stage alone were made of the models. The investigation included tests of models both with and without fins and auxiliary boosters. The results of the investigation indicated approximately linear variations of the aerodynamic coefficients with angle of attack and sideslip over the range of the tests. The first-stage fins were effective in providing stabilizing increments of pitching and yawing moment although the increments decreased with increasing Mach number The rolling moment due to sideslip appeared to be reasonably small over the range of the tests. Author

N68-16480*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

SUPERSONIC AERODYNAMIC CHARACTERISTICS OF A MODEL OF AN AIR-TO-GROUND MISSILE

Clyde Hayes Washington Feb. 1968 40 p

(NASA-TM-X-1491) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An investigation was conducted to determine the aerodynamic characteristics of a model of an air-to-ground missile simulating both the boost- and glide-phase configurations. The results include the effects of fin size and sweep angle as well as the effects of the size and deflection of the control wings. The investigation was conducted for model roll angels of 0° and 45° at Mach numbers of 1.60 and 2.00 at a Reynolds number of 8.41×10^6 based on the body length. The results of the investigation indicated that the body–fin combination was generally stable about the assumed moment center for the range of fin size and fin sweep angle of the tests, although at Mach number 2.00 and at a sweep angle of 65° regions of instability were indicated for angles of attack above about 9°. The addition of the control wings had little effect on the longitudinal stability but did produce a substantial increase in normal-force curve slope and in axial force. Deflection of the control wings was effective in providing increments of side force and normal force with essentially no effect on pitching or yawing moments. The presence of wing slots, which simulated slots into which the wings fold, had no effect on the aerodynamic characteristics of the model. Author

N68-17555*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

INVISCID HYPERSONIC FLOW OVER A BLUNT BODY WITH HIGH RATES OF MASS AND HEAT TRANSFER

E. Dale Martin Washington Mar. 1968 54 p refs

(NASA-TN-D-4252) CFSTI: HC$3.00/MF$0.65 CSCL 01A

A study of steady hypersonic flow over a blunt body with a very high rate of continuous mass transfer from the body surface,

with heat conduction, is presented. An approximate analysis is made of the inviscid flow over a sphere with large mass flux. Lighthill's well-known constant-density inviscid blunt-body flow solution was previously extended by Vinokur and Sanders and by Cresci and Libby to include inviscid flow at a high rate out of the body surface. The present analysis further extends Cresci and Libby's solution to include the effects of the boundary shock wave, a thin viscous region dominated by viscous-compressive stresses (rather than viscous shear) and the associated heat conduction in the gas adjacent to the body surface. These effects are important to consider when there is a significant source of translational nonequilibrium at the body surface (such as absorption of intense radiation and the accompanying large heat conduction). Author

N68-17880*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EFFECTS OF LEE-SURFACE VOLUME ADDITION ON LONGITUDINAL AERODYNAMICS OF A HIGH-LIFT–DRAG-RATIO WING-BODY CONFIGURATION AT MACH 6.0

David R. Stone and George C. Ashby, Jr. Washington Mar. 1968 30 p refs

(NASA-TN-D-4361) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An aerodynamic investigation of the addition of volume to the leeward surface of a basic high-wing configuration has been made with volume additions varying from 9 percent to 92 percent of the basic wing-body volume. The free-stream Reynolds number based on body length was 9.5×10^6. For a given volume addition, the experimental results show that span-height ratio, cross-sectional shape, and longitudinal contour had only secondary effects on the maximum lift–drag ratio. Calculations using shock theory indicate the effects of these parameters are overshadowed by the interaction between the volume-addition shock and the wing-body shock. The results indicate that a practical design practice would be to place the forebody volume addition at the wing apex, and the amount of afterbody volume added would thus be limited by the center-of-gravity location and the associated pitch characteristics of the vehicle. For a constant afterbody length, the maximum lift–drag-ratio variation with volume addition was found to be correlated by the parameter comprised of the product of the forebody slope and the percent volume added. Author

N68-17896*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

PRESSURE DISTRIBUTIONS AND AERODYNAMIC CHARACTERISTICS OF 90° AND 15° BLUNTED CONES IN NITROGEN AND HELIUM AT MACH 20

Theodore R. Creel, Jr., Charles G. Miller, III, Dal V. Maddalon, and Ralph D. Watson Washington Mar. 1968 37 p refs

(NASA-TN-D-4314) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An experimental investigation to determine the pressure distributions and force and moment characteristics on a 9° semiapex angle spherically blunted cone was conducted in nitrogen in the Langley hotshot tunnel. Pressure distributions were obtained in the Langley 22-inch helium tunnel on 9° semiapex angle spherically blunted and flat-faced cones and on a 15° semiapex angle spherically blunted cone. The results of this investigation indicated that pressure distributions on the 9° and 15° semiapex angle spherically blunted cones at zero angle of attack were underpredicted by ideal gas inviscid theory, but a theory accounting for viscous effects predicted the pressure distribution on the 9° spherically blunted cone in nitrogen. Blast-wave-type correlation parameters were observed to yield a fair correlation of pressure distributions obtained on the most windward meridian for angles of attack of 5° to 40° when an effective cone angle was used. Newtonian theory adequately predicted the radial pressure distributions on the windward side of the 9° and 15° semiapex angle spherically blunted cones. The shock shapes of the 9° and 15° cones were correlated by using blast-wave-type correlating parameters. Force and moment coefficients for the 9° spherically blunted cone in nitrogen were in good agreement with those of other investigations using air and nitrogen as test gases. Author

N68-17899*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A REAL-GAS STUDY OF LOW-DENSITY WEDGE-INDUCED LAMINAR SEPARATION ON A HIGHLY COOLED BLUNT FLAT PLATE AT $M_\infty = 12$

John B. Anders and C. L. W. Edwards Washington Mar. 1968 40 p refs

(NASA-TN-D-4320) CFSTI: HC$3.00/MF$0.65 CSCL 01A

A study has been made of real-gas wedge-induced laminar separation. A series of experimental tests on a blunt flat plate with a trailing-edge flap was made at a free-stream Mach number of 12 and a free-stream Reynolds number of 10^4/ft (3.3×10^4/m). The tests were conducted for stagnation enthalpies ranging from 1465 Btu/lbm (3.41 MJ/kg) to 2030 Btu/lbm (4.73 MJ/kg). A calculation technique is developed to predict the chordwise extent of wedge-induced laminar separation and agrees reasonably well with the present real-gas experimental data. The computed effect of free-stream Reynolds number and total enthalpy on the extent of separation is demonstrated. Sample calculations are shown for equilibrium and frozen flow for a range of total enthalpies. Author

N68-18189*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

WIND TUNNEL INVESTIGATION OF TECHNIQUES FOR REDUCING COWL DRAG OF AN AXISYMMETRIC EXTERNAL-COMPRESSION INLET AT MACH 2.49

James E. Calogeras and Edward T. Meleason Washington Mar. 1968 33 p refs

(NASA-TM-X-1516) CFSTI: HC$3.00/MF$0.65 CSCL 01A

A wind-tunnel investigation was made at Mach 2.49 to determine the effectiveness of two techniques for cowl-drag reduction on an axisymmetric external-compression inlet. The first method involved reducing the external cowl-lip angle from 25° to values of 15° and 6° Use of the flatter cowls deliberately violated the criterion for internal cowl-lip shock attachment to affect a tradeoff between cowl pressure drag and induced additive drag. Results showed an increase in external drag over that associated with the 25° cowl, and inlet performance was significantly reduced with use of the flatter cowls. The second method used a low-external-angle visor with the 25° cowl. An air gap existed between the cowl and the visor base to aid in starting the inlet, and several gap sizes were investigated. With the smallest air gap tested, external drag was reduced by 54 percent with only a small loss in performance. With a larger air gap sized to permit self-start at Mach 2.5, external drag was reduced by 35 percent; this reduction, however, was accompanied by some loss in overall inlet performance associated with flow expansion into the visor gap. Author

N68-18720*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

COMPARISON OF THE MACH 3.0 AERODYNAMIC CHARACTERISTICS OF TENSION STRING, TENSION SHELL, AND 120° CONICAL SHAPES

James Wayne Sawyer Washington Mar. 1968 30 p refs

(NASA-TN-D-4360) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An investigation was conducted at a Mach number of 3.0 to determine aerodynamic characteristics of three decelerator shapes based on the tension string structural concept. The shapes were tested at angles of attack up to 12° and at free-stream Reynolds numbers, based on maximum body diameter, of approximately 1.0×10^6 and 3.0×10^6. A comparison was made between the aerodynamic characteristics thus obtained and published results for a 120° cone and comparable tension shell configurations. The results showed that the tension string shapes were more susceptible to flow separation than the tension shell shapes, but the aerodynamic coefficients of the tension string shapes were not affected by the onset of flow separation as much as were the aerodynamic characteristics of the tension shell shapes. The

aerodynamic coefficients, static stability, and aerodynamic centers of the tension string shapes showed little sensitivity to variation in body length and nose radius and, in general, approximated those of the cone. Author

N68-19063*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EFFECT OF TWO-DIMENSIONAL MULTIPLE SINE-WAVE PROTRUSIONS OF THE PRESSURE AND HEAT-TRANSFER DISTRIBUTIONS FOR A FLAT PLATE AT MACH 6

Aubrey M. Cary, Jr. and E. Leon Morrisette Washington Mar. 1968 57 p refs

(NASA-TN-D-4437) CFSTI: HC $3.00/MF $0.65 CSCL 01A

Surface pressure and heat transfer were measured and oil-flow patterns were observed on two-dimensional, shallow, multiple sine-wave protrusions embedded in a flat surface. The maximum laminar heating on multiple waves was found to correlate empirically with results from previous investigations. The maximum turbulent heating for a series of waves decreased rapidly from wave to wave. Tests with single waves and with the first wave of the multiple-wave model indicated that the maximum turbulent heating on single waves increased almost linearly with decreasing width-height ratio of the wave. The method used to predict the maximum turbulent heating gave fair results when there was no boundary-layer separation prior to the wave. Author

N68-19180*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

ANALOG STUDY OF THE LONGITUDINAL RESPONSE OF A SWEPT-WING TRANSPORT AIRPLANE TO WIND SHEAR AND SUSTAINED GUSTS DURING LANDING APPROACH

C. Thomas Snyder Washington Apr. 1968 20 p refs

(NASA-TN-D-4477) CFSTI: HC $3.00/MF $0.65 CSCL 01B

Analog-computed time histories and altitude-ground track plots indicate the longitudinal responses of the airplane to varying wind conditions. Controls-fixed runs first demonstrated the differences in responses of an airplane to horizontal gusts and to vertical gusts. Airplane static stability, lift-curve slope, lift-drag ratio, and airplane size were varied while the airplane, with controls fixed, was subjected to wind shear and sustained gusts. Controlled responses showed the effect of maintaining constant pitch attitude or constant airspeed during flight in a wind shear region, into a downdraft, and into a combined wind shear and downdraft. Realistic combinations of downdraft and shear (of decreasing head wind) were found that could significantly steepen descent with little initial attitude change. In fact, the initial changes in attitude and airspeed might induce the pilot to steepen the flight path further. Author

N68-19189*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

LARGE-SCALE WIND-TUNNEL TESTS OF AN AIRPLANE MODEL WITH TWO PROPELLERS AND ROTATING CYLINDER FLAPS

James A. Weiberg and Berl Gamse Washington Mar. 1968 49 p refs

(NASA-TN-D-4489) CFSTI: HC $3.00/MF $0.65 CSCL 01A

Wind-tunnel tests were made of a model of a twin turbo-propeller airplane with rotating cylinder flaps. The model had a straight untapered wing of aspect ratio 3.57 equipped with end plates. Cylinder rotation provided a lift coefficient increment of 2.0 and a maximum lift coefficient of 4.0 with 60° flap deflection and zero propeller thrust. A maximum lift coefficient of 9.1 was obtained with a thrust coefficient of 4. The cylinder rotational speed required varied with flap deflection and was independent of angle of attack and slipstream velocity. For a flap deflection of 60° and a free-stream velocity of 40 knots, the cylinder power required was approximately 0.7 horsepower per foot of cylinder length. Author

N68-19206*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

PRELIMINARY STUDY OF DRAG REDUCTION FOR COASTING MISSILES AT MACH NUMBERS FROM 1.57 TO 4.63

Dennis E. Fuller and Donald L. Wassum Washington Apr. 1968 66 p

(NASA-TM-X-1537) CFSTI: HC $3.00/MF $0.65 CSCL 16D

An investigation of various body alterations aimed at reducing the drag of a missile during power-off flight was made. Tests were made for conical afterbody closures of two lengths (with and without slots), afterbody perforations, and afterbody scoops. The investigation was made at Mach numbers from 1.57 to 4.63, angles of attack from about −4° to 4°, and a Reynolds number of 9.84×10^6 per meter. The results indicated that a conical afterbody closure with a closure-length–body-diameter ratio of about 2.9 effected sizable reductions in drag and increases in lift-drag ratio for the test Mach number range; for the lower test Mach numbers an afterbody closure with a closure-length–body-diameter ratio of about 1.4 provided an increase in drag and a decrease in lift-drag ratio. A reduction in the ratio of a slot area to cone area for the long afterbody closure led to progressive decreases in drag coefficient with corresponding increases in lift-drag ratio. Afterbody perforations provided a means of obtaining moderate drag reductions throughout the test Mach number range. Author

N68-19237*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF BOATTAIL JUNCTURE SHAPE ON PRESSURE DRAG COEFFICIENTS OF ISOLATED AFTERBODIES

George D. Shrewsbury Washington Mar. 1968 34 p refs

(NASA-TM-X-1517) CFSTI: HC $3.00/MF $0.65 CSCL 01A

A variety of afterbodies were tested on a sting-supported model of a closed-inlet nacelle. Jet effects were simulated with a cylinder positioned downstream of the afterbody base. Axial-force coefficients were obtained for a 7° conical boattail and various 15° boattailed afterbodies on which the boattail juncture with the cylindrical portion of the nacelle had been smoothed with different radii of curvature. Data were obtained over a Mach number range of 0.56 to 1.00 at angles of attack from 0 to 8°. The results indicate that increasing the boattail radius of curvature generally delays the occurrence of the transonic drag rise. Author

N68-19341*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

A METHOD FOR THE SURFACE INSTALLATION AND FAIRING OF STATIC-PRESSURE ORIFICES ON A LARGE SUPERSONIC-CRUISE AIRPLANE

Norman V. Taillon Washington Mar. 1968 12 p

(NASA-TM-X-1530) CFSTI: HC $3.00/MF $0.65 CSCL 01C

A method for installing and fairing static-pressure orifices on the wing surface of a supersonic airplane without penetrating the skin is described. Orifice discs were fixed to pressure tubes which were, in turn, attached to the ferrous skin by welded straps. The assembly was faired over with a temperature-resistant aerodynamic smoothing compound hand-milled flush with the orifices. Some deviation from the mold line is inherent in the method; however, analytical estimates indicate that the effect on local aerodynamic pressures is negligible for this installation. The smoothing compound has been found to be operationally suitable at a Mach number of 3. Author

N68-19954*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

AN INVESTIGATION OF EXTREMELY FLEXIBLE LIFTING ROTORS

Matthew M. Winston Washington Apr. 1968 28 p refs

(NASA-TN-D-4465) CFSTI: HC $3.00/MF $0.65 CSCL 01A

This investigation includes analytical and experimental studies of rotors with very low structural stiffness and single-surface, deformable airfoils. The analytical study focused on the planform and tip-mass requirements necessary to prevent luffing (fabric instability) of a completely flexible blade and included consideration of the

aeroelastic characteristics of flexible blades having chordwise stiffeners spaced along the blade. The experimental investigation focused on determining the hovering characteristics of a 30-foot-(9.144-meter-) diameter flexible rotor. The results of the analytical study indicate that very careful planform design and judicious choice of tip mass are required to prevent luffing on a completely flexible blade. Tip-mass requirements with the attendant increase in overall rotor weight indicate that large rotors of this type are not assured the performance benefits of low disk loadings that were initially expected. Although partial stiffening of the blade chord makes planform and tip-mass design requirements less critical, both types of flexible rotors may operate at disk loadings higher than initially expected, since rotor size-weight relationships may be dictated by requirements for aeroelastic stability. The experimental study indicates that low hovering efficiencies and high power consumption resulted from blade deformations and excessive twist; however, the aerodynamically-induced camber developed during operation provided high mean lift coefficients. Author

N68-20330*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE OF ANNULAR PLUG AND EXPANSION-DEFLECTION NOZZLES INCLUDING EXTERNAL FLOW EFFECTS AT TRANSONIC MACH NUMBERS

Robert A. Wasko Washington Apr. 1968 33 p

(NASA-TN-D-4462) CFSTI: HC$3.00/MF$0.65 CSCL 21H

Experiments covered the Mach number range from 0.56 to 2.0 and included the effects of base bleed as well as variations in plug length and nozzle internal expansion. The full-length plug nozzle performed nearly constant and with optimum quiescence, while the expansion-deflection (ED) nozzle performed only similar to a conical convergent-divergent (CD) nozzle. Thus, the plug nozzle was altitude compensating, while the ED nozzle was not. Plug nozzle efficiency ranged from 98.4% at a pressure ratio of 68 (corresponding to sea-level altitude) to 99% at the design pressure ratio of 290. ED and CD nozzle efficiencies were, respectively, 92.3 and 92.6% at sea level, and 97.6 and 97.8% at the design point. Truncation of the plug nozzles with internal expansion to a nominal 21, 10, and 0% of full plug length resulted in decreased nozzle performance that varied from 96.4, 95.3, and 94.9% at sea level to 98.3, 97.0, and 96.8%, respectively, at the design point. Base bleed improved the truncated plug nozzles with internal expansion. However, ED nozzle performance improved only at pressure ratios above design. Elimination of internal expansion and external plug surface caused poor nozzle performance. Maximum performance loss due to external flow effects was 2.5% of the ideal thrust and occurred below Mach 1.0. Secondary flow reduced the performance loss to as little as 1.75% of ideal thrust. K.W.

N68-20370*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

LARGE-SCALE WIND-TUNNEL INVESTIGATION OF AN AIRPLANE MODEL WITH A TILT WING OF ASPECT RATIO 8.4, AND FOUR PROPELLERS, IN THE PRESENCE OF A GROUND PLANE

Stanley O. Dickinson, V. Robert Page, and Wallace H. Deckert Washington Apr. 1968 80 p refs

(NASA-TN-D-4493) CFSTI: HC$3.00/MF$0.65 CSCL 01A

Aerodynamic characteristics of a large-scale model of a tilt-wing V/STOL transport aircraft are presented. The investigation was conducted in Ames 40- by 80-foot wind tunnel at various heights above a fixed ground plane. Free-stream Reynolds number varied from 0 to 2.9 million. Model configurations included wing tilt angles from 0° to 90°, trailing-edge flap deflections from 0° to 60°, and partial-span wing leading-edge slats. Results show ground proximity decreased lift up to 20 percent (depending on wing tilt angle), decreased drag, and increased nose-down pitching moment. Author

N68-21374*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPUTER PROGRAM FOR CALCULATING VELOCITIES AND STREAMLINES ON A BLADE-TO-BLADE STREAM SURFACE OF A TURBOMACHINE

Theodore Katsanis Washington Apr. 1968 100 p refs

(NASA-TN-D-4525) CFSTI: HC$3.00/MF$0.65 CSCL 10A

A FORTRAN IV computer program was written that gives the solution of the two-dimensional, subsonic, compressible (or incompressible), nonviscous flow problem for a rotating or stationary circular cascade of blades on a blade-to-blade surface of revolution. The flow may be axial, radial, or mixed. There may be a change in stream channel thickness in the through-flow direction. The computer program requires the basic cascade geometry, the meridional stream channel coordinates, fluid total conditions, weight flow, and inlet and outlet flow angles. The output includes streamline coordinates, velocity magnitude and direction throughout the passage, and the blade surface velocities. The method is based on the stream function with the solution of the simultaneous, nonlinear, finite-difference equations being obtained by two major levels of iteration. The inner iteration consists of the solution of simultaneous linear equations by successive overrelaxation, using an estimated optimum overrelaxation factor. The outer iteration then changes the coefficients of the simultaneous equations to compensate for compressibility. Author

N68-21579*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

INTERFERENCE EFFECTS OF CANARD CONTROLS ON THE LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF A WINGED BODY AT MACH 10

Cuyler W. Brooks, Jr. (M.S. Thesis—Virginia Univ.) Washington Apr. 1968 73 p refs

(NASA-TN-D-4436) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An experimental investigation of the interference effects of canard controls on two hypersonic winged configurations was made at a Mach number of 10 in the Langley 15-inch hypersonic flow apparatus. The effect of variations in canard size and shape, body length, wing planform, and wing vertical position was determined. The results indicate that the canard control induces a broad pattern of interference in which the average flow angle over the wing and body surfaces downstream of the canard varies significantly from the free-stream value. The magnitude of the interference increases with increasing canard deflection and, in general, with increasing angle of attack. The most significant configuration parameters (aside from canard deflection) are wing position and canard size. The low-wing configurations are affected considerably less by interference than the high-wing configurations, especially at higher angles of attack. As would be expected, the larger canard causes larger disturbances in the flow than does the smaller canard. Author

N68-21681*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EXPERIMENTAL PRESSURE DISTRIBUTIONS ON A BLUNT LIFTING-ENTRY BODY AT MACH 3.71

W. Douglas Morris and Lana M. Couch Washington Apr. 1968 53 p refs

(NASA-TN-D-4494) CFSTI: $3.00 CSCL 01A

An experimental investigation was conducted to determine the pressure distribution on a blunted 15° half-cone–wedge lifting-entry body. The tests were conducted at a Mach number of 3.71 and Reynolds numbers per foot of 2.81×10^6 and 4.68×10^6 (Reynolds numbers per meter of 9.22×10^6 and 15.35×10^6). The angle-of-attack range was from −40° to 40°, and the angle-of-sideslip range was from −10° to 10°. A modified Newtonian method was compared with the data and, in general, found to predict the trends as well as the magnitude over the angle-of-attack and angle-of-sideslip ranges. Author

N68-21692*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPARATIVE STUDY OF MIXED- AND ISOLATED-FLOW METHODS FOR COOLED-TURBINE PERFORMANCE ANALYSES

Warren J. Whitney Washington Apr. 1968 39 p refs

(NASA-TM-X-1572) CFSTI: HC$3.00/MF$0.65 CSCL 01A

The two methods are described and then compared by using two simplified example turbines, one being a two-stage impulse type and the other a two-stage reaction turbine. The agreement in efficiency predicted by the two methods is within ±0.01 for total coolant fractions up to 0.156 and within ±0.013 at the highest total coolant fraction considered, which was 0.22. Author

N68-21703*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AN EXPERIMENTAL INVESTIGATION OF THE RESTART AREA RATIO OF A MACH 3.0 AXISYMMETRIC MIXED COMPRESSION INLET

Glenn A. Mitchell and Robert W. Cubbison Washington Apr. 1968 25 p refs

(NASA-TM-X-1547) CFSTI: HC$3.00/MF$0.65 CSCL 01A

Restart area ratios were obtained for the test inlet from Mach number 2.5 to 3.0 and compared to ratios from other inlets. All inlets restarted with throat areas smaller than required by theory to pass the flow through a simple normal shock at the cowl lip. Details of the unstarted inlet flow field were obtained at Mach 3. The unstarted inlet flow field was characterized by a separated region on the centerbody causing an oblique shock ahead of the throat. The size of the separated region was controlled by the inlet throat area, and the separation terminated at the throat station. The restart throat area was smaller than predicted because of the higher pressure recovery produced by the multiple shock structure. Author

N68-21940*# National Aeronautics and Space Administration. Langley Research Center, Cleveland, Ohio.

AERODYNAMIC CHARACTERISTICS IN PITCH OF A MODIFIED-HALF-RING-WING-BODY COMBINATION AT MACH 2.16 TO 3.70

Odell A. Morris and Milton Lamb Washington Apr. 1968 40 p refs

(NASA-TM-X-1551) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An investigation has been conducted at Mach numbers from 2.16 to 3.70 to determine the aerodynamic characteristics in pitch of a modified-half-ring-wing model. The investigation also included tests of a swept-wing model. Both models had a wide flat body and could be fitted with various forebody and afterbody sections. Results of the investigation indicated that favorable interference-lift effects were obtained for both wing-body models at zero angle of attack, the largest effects occurring for the modified-half-ring-wing model. The maximum lift–drag ratios, however, were obtained with the swept-wing model since it produced greater lift-curve slopes than the modified-half-ring-wing model. The changes in forebody and afterbody shapes investigated for both models produced no significant changes in maximum lift–drag ratios, as compared with the ratios for the basic symmetrical body shape. Author

N68-21941*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

A METHOD FOR PREDICTING SHOCK SHAPES AND PRESSURE DISTRIBUTIONS FOR A WIDE VARIETY OF BLUNT BODIES AT ZERO ANGLE OF ATTACK

George E. Kaattari Washington Apr. 1968 41 p refs

(NASA-TN-D-4539) CFSTI: HC$3.00/MF$0.65 CSCL 01A

A method is presented for determining shock envelopes and pressure distributions for a variety of blunt bodies at zero angle of attack. Correlation functions obtained from exact solutions are used to relate the shock standoff distance, at the stagnation and sonic points, to the body geometry. These functions were obtained for a perfect gas but may be applied for real gases in equilibrium flows. The method is restricted to cases where the bow shock is detached from the body and the flow over the forward face is subsonic. Results given by the method are shown to be in good agreement with experimental values. Author

N68-21950*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

ANALYTICAL AND EXPERIMENTAL STUDY OF DYNAMIC CHARACTERISTICS OF TURBOPUMPS

H. Ohashi Washington Apr. 1968 115 p refs

(NASA-TN-D-4298) CFSTI: HC$3.00/MF$0.65 CSCL 13K

The response of pressure rise of turbopumps to fluctuating flow rate was studied analytically and experimentally. Unsteady flow around a two-dimensional, linear cascade of airfoils was solved and the frequency response of the deflection angle of the cascade was calculated for the periodically oscillating inlet condition. Based on the unsteady cascade theory, the dynamic characteristics of turbopumps were analyzed. For the evaluation of an approximate response, a simplified model theory was also developed, which enables the calculation to be made without entering into the details of the pump design. An experimental investigation was made to determine the dynamic characteristics of a centrifugal pump. The test showed that the analytical calculation was close to the experimental result. The limiting fluctuating frequency under which the dynamic characteristics agree with the quasi-static ones, was determined from the test result. The time constant of the response of pressure rise to a step-like change of flow rate was also derived. Author

N68-22002*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EFFECTS OF SIMULATED WING DAMAGE ON THE AERODYNAMIC CHARACTERISTICS OF A SWEPT-WING AIRPLANE MODEL

Clyde Hayes Washington Apr. 1968 70 p

(NASA-TM-X-1550) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An investigation was conducted to determine the effects of simulated wing damage on the aerodynamic characteristics of a swept-wing airplane model. Wing damage was simulated by removal of either a leading-edge portion or a trailing-edge portion of one wing panel or by removal of an entire wing panel. The investigation was conducted at Mach numbers from 1.70 to 2.86 at a constant Reynolds number of 2.25×10^6 per foot (7.38×10^6 per meter). The results of the investigation indicated that removing the leading- or trailing-edge portion of the wing or removing the entire wing panel led to a decrease in both lift-curve slope and maximum lift–drag ratio. At the lower Mach numbers, removal of the trailing edge caused a rolling moment slightly larger than that caused by removal of the leading edge. At the higher Mach numbers, however, the effect on rolling moment due to removal of the trailing edge was less than that caused by removal of the leading edge even though a larger area of the wing was removed. Except when the entire wing panel was removed, the roll induced by wing asymmetry could be offset by sideslip within reasonable limits of angle of attack and sideslip. Author

N68-22475*# Therm Advanced Research, Inc., Ithaca, N. Y.

INVISCID FLOW FIELD INDUCED BY A ROTOR IN GROUND EFFECT

Michael D. Greenberg and Alvin L. Kaskel Washington NASA May 1968 54 p refs

(Contract NAS1-6349)

(NASA-CR-1027) CFSTI: $3.00 CSCL 01A

The inviscid flow field induced by a rotor in ground effect is calculated based upon an actuator disk model of the rotor, for the case of a constant circulation distribution over the blade radius. The governing nonlinear integral equations are solved by a systematic iterative scheme which is similar to the Newton–Raphson method for the solution of nonlinear algebraic equations. Numerical results are presented for both the ground-effect case and the out-of-ground-effect limit. Author

N68-24617# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

APPROXIMATION OF THE SPANWISE DISTRIBUTION OF WIND-TUNNEL-BOUNDARY INTERFERENCE ON LIFT OF WINGS IN RECTANGULAR PERFORATED-WALL TEST SECTIONS

Ray H. Wright and Benferd L. Schilling Washington May 1968 39 p refs

(NASA-TR-R-285) CFSTI: HC$3.00/MF$0.65

An approximation method was developed for calculating the spanwise distribution of wind-tunnel-boundary upwash interference on lift of wings in rectangular perforated-wall test sections. This method is applied to square test sections with an assumed effective permeability constant of 0.6. A problem of considerable difficulty in practical application of the method presented is the estimation of an effective permeability constant. Because of the variation of the upwash interference with Mach number and of the influence of boundary layer on the effective permeability factor, the boundary interference in a perforated-wall wind-tunnel test section at high subsonic Mach numbers is likely to be of the nature of that in an open-throat tunnel. Author

N68-25093*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

CALCULATION OF AXISYMMETRIC SUPERSONIC FLOW PAST BLUNT BODIES WITH SONIC CORNERS, INCLUDING A PROGRAM DESCRIPTION AND LISTING

Jerry C. South, Jr. Washington May 1968 63 p refs

(NASA-TN-D-4563) CFSTI: HC$3.00/MF$0.65 CSCL 01A

A program for the approximate calculation of supersonic flow of an ideal gas past blunt bodies with sonic corners is described. Numerical solutions are obtained for the system of differential equations derived from the one-strip integral (Belotserkovskii) method. Aerodynamic results of interest include the surface pressure and velocity distributions, the shape and location of the detached bow shock wave, and the forebody pressure drag coefficient. Comparison of the calculations with experimental data is given, with particular emphasis on spherically blunted cones of large apex angle. For this configuration, a simple method is suggested for estimating angle-of-attack pressure distributions. Other shapes included are a circular disk and a spherical cap convex or concave to the stream. The program operation and listing in FORTRAN IV language are given in the appendixes. Author

N68-25916*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

DYNAMIC RESPONSE OF A FAMILY OF AXISYMMETRIC HAMMERHEAD MODELS TO UNSTEADY AERODYNAMIC LOADING

Robert C. Robinson, Phillip R. Wilcox, Bruno J. Gambucci, and Robert E. George Washington Jun. 1968 42 p refs

(NASA-TN-D-4504) CFSTI: HC$3.00/MF$0.65 CSCL 01A

The effects of boattail angle and diameter ratio on the unsteady aerodynamic loading on hammerhead launch vehicles were studied in wind-tunnel tests of 13 related dynamic models using the partial-mode model technique. The test Mach numbers ranged from 0.80 to 2.50 and the Reynolds numbers from 3.2×10^6 to 4.5×10^6 based on maximum diameter of the models. It was found that the unsteady aerodynamic loading was the result of two phenomena: buffeting due to separated flow and dynamic instability due to fluctuations between separated and attached flow. Author

N68-25919*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

AERODYNAMIC CHARACTERISTICS OF A LARGE-SCALE MODEL WITH UNSWEPT WING AND AUGMENTED JET FLAP

David G. Koenig, Victor R. Corsiglia, and Jospeh P. Morelli (Army Aeron. Res. Lab.) Washington Jun. 1968 90 p refs

(NASA-TN-D-4610) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An investigation was made to determine the aerodynamic characteristics of a complete model equipped with an augmented jet flap. The augmented jet flap is a jet flap with the primary jet thrust increased by means of an ejector system installed in the wing trailing-edge flap. The flap was installed on the inboard part of the wing, and blown ailerons were installed on the outboard part. Tests were made with and without the horizontal tail at zero airspeed and at a dynamic pressure of 8 psf corresponding to a Reynolds number of 3.0×10^6. The measured thrust of the augmented jet flap was about 1.42 times that of the measured primary jet for flap deflections of 60° and 70° and 1.25 times the isentropic jet thrust. This ratio did not significantly decrease at forward speed. A maximum life coefficient of 6 was measured for a jet coefficient of 1.30 when the model was equipped with full-span leading-edge slats. Symmetrical aileron deflection and flap boundary-layer control were effective in producing lift increments at model attitudes below that for wing stall. With the horizontal tail installed, the variation of pitching moment with angle of attack was stable up to and including wing stall. Comparisons with jet flap test results on the basis of the same static thrust output of the systems indicated that the present augmented-jet flap configuration produced slightly higher lift increments and had more forward center-of-pressure locations. For the same isotropic primary thrust, the augmented jet flap produced 50 percent more jet force and 22 percent more lift than the jet flap. Author

N68-28220*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

TRANSITION AND FLOW REATTACHMENT BEHIND AN APOLLO-LIKE BODY AT MACH NUMBERS TO 9

Robert L. Kruse Washington Jul. 1968 31 p refs

(NASA-TN-D-4645) CFSTI: HC$3.00/MF$0.65 CSCL 01A

Transition from laminar to turbulent flow in the near wake of a bluff body has been studied in the Ames Pressurized Ballistic Range. The location of transition and the reattachment of the separated flow have been determined from shadowgraphs and have been correlated on the basis of Mach number, Reynolds number, and angle of attack. The Mach numbers ranged from 1 to 9, the Reynolds numbers (based on body diameter) from 0.25×10^6 to 5×10^6 and the angles of attack from 0° to 25°. Author

N68-28268*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

AN INVESTIGATION OF FULL-SCALE HELICOPTER ROTORS AT HIGH ADVANCE RATIOS AND ADVANCING TIP MACH NUMBERS

John L. McCloud III, James C. Biggers, and Robert H. Stroub Washington Jul. 1968 135 p

(NASA-TN-D-4632) CFSTI: HC$3.00/MF$0.65 CSCL 01A

Five full-scale rotors were investigated at various advance ratios and advancing tip Mach numbers in the Ames 40- by 80-foot wind tunnel. The primary differences between rotors were twist, articulation, and tip airfoil section. Four of the rotors incorporated the NACA 0012 airfoil section over the entire blade length. The fifty rotor had tapering thickness and incorporated leading-edge camber over the outer 20% of the blade radius. The fully articulated rotor with zero twist blades was tested at advance ratios from 0.30 to 1.05. The other rotors were investigated in the 0.30 to 0.50 advance-ratio range. The teetering rotor with tapered

tip blades was tested at advancing blade tip Mach numbers up to 1.00. Force, moment, power, and control-setting data were obtained for a wide range of lift and propulsive forces, and are presented without discussion. Author

N68-28447*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

WIND-TUNNEL INVESTIGATION OF THE STATIC AERODYNAMIC CHARACTERISTICS OF A MULTILOBE GLIDING PARACHUTE

George M. Ware and Charles E. Libbey Washington Jul. 1968 23 p refs

(NASA-TN-D-4672) CFSTI: HC$3.00/MF$0.65 CSCL 01B

An investigation has been conducted in the Langley full scale tunnel to determine the performance and static stability and control characteristics of a five-lobe gliding parachute. The model was completely void of any rigid structural members and utilized only the tension forces produced by aerodynamic loading to maintain the shape of the canopy. The configuration consisted of a five-lobe canopy, roughly rectangular in inflated planform with an airfoil-type leading edge. The tests were made over an angle-of-attack range from the lowest angle attained before wing collapse, which was about 22.5° to 90°, which corresponded approximately to the vertical-descent condition. Results indicate that maximum lift occurred at an angle of attack of about 25°. The model was longitudinally stable and could be trimmed at angles of attack from the minimum angle of the tests to 30°. In the angle-of-attack range from 30° to 75°, the model had no stable trim conditions but was stable and could be trimmed at angles of attack from 75° to 90°. The stable trim angle-of-attack ranges gave values of lift–drag ratio of 2.2 to about 1.5 in the lower angle range and values near 0 in the higher angle range. The model was directionally stable and had positive effective dihedral at the lower angles of attack, but was directionally unstable and had negative effective dihedral over much of the range of angles of attack above 30°. Similarly, the model had satisfactory static lateral-control characteristics at angles of attack up to about 45°; however, because of a reversal in the direction of the yawing moment with control deflection, the model had unsatisfactory control characteristics at the higher angles of attack. Author

N68-28795*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE OF CENTERBODY VORTEX GENERATORS IN AN AXISYMMETRIC MIXED-COMPRESSION INLET AT MACH NUMBERS FROM 2.0 TO 3.0

Glenn A. Mitchell and Ronald W. Davis Washington Jul. 1968 34 p refs

(NASA-TN-D-4675) CFSTI: HC$3.00/MF$0.65 CSCL 01A

Three vortex generator configurations were installed aft of the inlet throat on the centerbody of a Mach 3.0 mixed compression inlet. The three were about equal in improving diffuser pressure recovery and all produced significant, although unequal, reductions in distortion. Only the most densely spaced configuration generated vortices that dissipated before reaching the compressor face. Vortex generators effectively energized the normally retarded flow adjacent to the centerbody even during supercritical operation where they were immersed in supersonic flow. Generators were also effective at inlet angles of attack to at least 5°. Author

N68-28817*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A THEORETICAL STUDY OF THE EFFECT OF PIVOT LOCATION ON THE AERODYNAMIC-CENTER MOVEMENT OF VARIABLE-SWEEP WINGS IN INCOMPRESSIBLE FLOW

John E. Lamar Washington Jul. 1968 29 p refs

(NASA-TN-D-4635) CFSTI: HC$3.00/MF$0.65 CSCL 01A

Theoretical studies of aerodynamic center movement have been conducted for a series of variable sweep wings in incompressible flow, which have unbroken leading and trailing edges and a skewed tip in the high sweep positions. Some comparisons of theoretical results with experimental results are made to validate the theoretical method. The low sweep outer panels and corresponding pivot locations, selected to be used with each high sweep wing having the same tip skew angle, are determined from two parameters: the ratio of low to high sweep wing span and the fraction of high-sweep normal chord at which the pivot is specified to be located. These studies indicate that for a given low sweep of the outer panel, the spanwise location of the pivot required to give a zero aerodynamic center movement in going from high sweep to low sweep of the outer panel seems to be essentially linearly related to the ratio of low to high sweep wing span in such a way that as the value of the span increase parameter becomes larger the pivot must move outboard. Furthermore, the lower the sweep of the outer panel, the farther outboard the pivot location must be. Author

N68-28830*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

WIND-TUNNEL STUDY TO EXPLORE THE USE OF SLOT SPOILERS TO MODULATE THE FLAP-INDUCED LIFT OF A WING

Joseph W. Sickle and Robert C. Henry Washington Jul. 1968 16 p refs

(NASA-TN-D-4664) CFSTI: HC$3.00/MF$0.65 CSCL 01A

This report presents the results of a preliminary study to explore a proposed new concept for achieving direct lift control on an airplane. The concept employs variable-width slot type spoilers to modulate the lift increment produced by a deflected flap. The study utilized a constant chord airfoil model wing modified to provide various size slots on both the wing and flap sections. Each configuration was tested through an angle-of-attack range of −2° to 16° in a low speed tunnel with a 12 foot octagonal test section. The tests were conducted at a Reynolds number of approximately 410,000. The results indicate that the use of a variable width slot is effective in controlling the lift increment obtained from flap deflection and that there is relatively little change in drag coefficient associated with slot width changes. Author

N68-28868*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A MODIFIED MULTHOPP APPROACH FOR PREDICTING LIFTING PRESSURES AND CAMBER SHAPE FOR COMPOSITE PLANFORMS IN SUBSONIC FLOW

John E. Lamar Washington Jul. 1968 80 p refs

(NASA-TN-D-4427) CFSTI: HC$3.00/MF$0.65 CSCL 01A

A modified version is presented of Multhopp's subsonic lifting surface theory which has been programed in two parts for the IBM 7094 electronic data processing system or Control Data 6400 computer system along with a discussion of the character of its results. The first part is used to find both basic and additional loadings over a given planform with known mean camber surface and the second part is used to determine the required mean camber surface for a given planform and set of loadings. For the loading program, various aerodynamic characteristics are determined on both simple and composite planforms when the spanwise loading is symmetrical. Studies are conducted to determine when these answers are most valid, and some results for delta, sweptback and

tapered, double delta, and variable sweep wings are compared with other theories and experiments to determine the accuracy of this method. Application of this method is then made in predicting the aerodynamic effects of changing the outer panel sweep of a variable sweep wing, of increasing the Mach number in the subsonic regime, and of incorporating twist and chamber in a wing. The first two applications also have experimental data presented for comparison. Comparisons are made for a two- and three-dimensional case to aid in the evaluation of the present method. One application is made for a highly sweptback and tapered planform. Author

N68-29405*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EXPERIMENTAL INVESTIGATION OF LAMINAR-FLOW SEPARATION ON A FLAT PLATE INDUCED BY DEFLECTED TRAILING-EDGE FLAP AT MACH 19

William D. Harvey Washington Aug. 1968 55 p refs

(NASA-TN-D-4671) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An experimental investigation to determine the pressure and heat-transfer distributions on a flat plate in laminar flow with deflected trailing-edge flap was conducted at a nominal free-stream Mach number of 19 and at Reynolds numbers per foot (per 30.48 cm) of 7.6×10^4 to 26×10^4. Model-geometry variables included flap width, flap length, and leading-edge bluntness. Neither the addition of end plates nor an increase in the width of the model without end plates resulted in true two-dimensional flow. The separated flow was found to be three-dimensional and significantly affected by variations in flap length and width for the sharp-leading-edge model. Separation length and maximum flap pressure apparently approach some maximum value for a given flap-deflection angle when the flap length is increased. Large decreases in separation length occurred with decreasing flap width even though the maximum flap pressure remained approximately constant. Blunting the leading edge reduced both the length of the separated region and the pressure rise through separation to plateau. For the flow over approximately the forward half of the flap, reasonably good agreement was obtained between the measured heating distributions and calculations obtained by using the measured pressure and the calculated value of Stanton number at the hinge line for the sharp plate; however, the predictions obtained for the blunt plate by this method were higher than the actual results when the flow was unseparated. Author

N68-29952*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

HYPERSONIC AERODYNAMIC CHARACTERISTICS OF LOW-WAVE-DRAG ELLIPTICAL-BODY-TAIL COMBINATIONS AS AFFECTED BY CHANGES IN STABILIZER CONFIGURATION

Charles H. Fox, Jr. and Bernard Spencer, Jr. Washington Aug. 1968 44 p refs

(NASA-TM-X-1620) CFSTI: HC$3.00/MF$0.65 CSCL 01A

This investigation represents the initial portion of a study to determine methods of providing stability from hypersonic through low subsonic speeds for vehicles with high hypersonic lift drag ratios. The results of this investigation indicate that the maximum untrimmed lift drag ratio is reduced approximately 15 percent due to the outboard stabilizers for either fineness ratio body. The resultant aerodynamic performance is, however, relatively insensitive to changes in the outboard stabilizer dihedral angle for any given configuration tested. For a moment reference location selected as 55 percent of the body length, the outboard stabilizers set at positive dihedral angles provide positive pitching moment at zero angle of attack, less out of trim pitching moment at maximum lift drag ratio, and resultantly less increase in stability variation with increasing angle of attack as compared with outboard stabilizers set at negative dihedral angles. In addition, the directional-stability parameter at maximum lift drag ratio varies nonlinearly with outboard stabilizer dihedral angle with a maximum stabilizing effect indicated in the dihedral angle region from 30° to 60° for positive dihedrals. Author

N68-29955*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EFFECT OF HINGE-LINE BLEED ON HEAT TRANSFER AND PRESSURE DISTRIBUTION OVER A WEDGE-FLAP COMBINATION AT MACH 10.4

H. Harris Hamilton and J. David Dearing Washington Aug. 1968 46 p refs

(NASA-TN-D-4686) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An experimental investigation has been conducted to determine the effect of boundary layer bleed on the heat transfer and pressure distributions over a wedge-flap combination with a gap between the wedge and flap. The model was tested, with the wedge at angles of attack of 6.83° and 12.83° and the flap deflected up to 30°, at a nominal free-stream Mach number of 10.4 and free stream Reynolds numbers (based on distance to the flap hinge line) of 0.8×10^6 and 3.6×10^6. At the lower free-stream Reynolds number, the boundary layer was laminar over the entire model. The pressure and heat transfer over the forward portion of the flap increased slightly as the gap size increased. At the higher free stream Reynolds number, the boundary layer was transitional at the hinge line for an angle of attack of 6.83° and was fully turbulent for an angle of attack of 12.83°. Under these conditions, the largest flap deflection of the tests did not separate the boundary layer even with the gap sealed, and increasing the gap size had very little effect on either the pressure or heat-transfer distributions. The turbulent heat transfer rate for deflected flap was predicted reasonably well by the Spalding and Chi turbulent theory by using boundary layer edge properties calculated from oblique shock theory and by assuming that the turbulent boundary layer originated at the flap hinge line. Author

N68-29994*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF VARIABLE STATOR AREA ON PERFORMANCE OF A SINGLE-STAGE TURBINE SUITABLE FOR AIR COOLING. 1: STATOR OVERALL PERFORMANCE WITH 130-PERCENT DESIGN AREA

Edward M. Szanca, Frank P. Behning, and Harold J. Schum Washington Aug. 1968 22 p refs

(NASA-TM-X-1632) CFSTI: HC$3.00/MF$0.65 CSCL 01A

The turbine is being investigated at stator area settings of 70, 100, and 130 percent of design. This report presents the overall stator performance at the open setting and compares the results with those obtained from design tests. Results are presented in terms of weight flow, outlet flow angle, blade surface static pressure and velocity distributions, as well as inner and outer wall static pressures as obtained over a stator pressure ratio range. Author

N68-30030*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

AERODYNAMIC CHARACTERISTICS OF TWO BLUNT, HALF-CONE WEDGE ENTRY CONFIGURATIONS AT MACH NUMBERS FROM 2.30 TO 4.63

Gerald V. Foster Washington Aug. 1968 35 p

(NASA-TM-X-1621) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An investigation has been conducted in the Langley Unitary Plan wind tunnel to determine the aerodynamic characteristics in combined pitch and sideslip for two blunt, half-cone–wedge entry vehicles at Mach numbers from 2.30 to 4.63. The vehicles differed primarily in length. The results of the investigation indicated that both configurations were longitudinally stable although the drag

level was greater for the short configuration. Both configurations exhibited positive directional stability and a positive dihedral effect throughout the ranges of angle of attack and Mach number; however, the parameters for the long configuration varied considerable with angle of attack. Author

N68-30033*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OVERALL PERFORMANCE IN ARGON OF A 6-INCH RADIAL-BLADED CENTRIFUGAL COMPRESSOR

Edward R. Tysl, Calvin L. Ball, Carl Weigel, and Laurence J. Heidelberg Washington Aug. 1968 28 p refs

(NASA-TM-X-1622) CFSTI: HC$3.00/MF$0.65 CSCL 01A

Overall and impeller performance is presented as a function of equivalent weight flow. At the design equivalent weight flow of 1.52 pounds per second (0.69 kg/sec) and design equivalent tip speed of 989 feet per second (301.5 m/sec) the compressor developed an overall total pressure ratio of 2.3 with an adiabatic efficiency of 76.5 percent. Peak efficiency at design speed was 78.0 percent and occurred at an equivalent weight flow of 1.35 pounds per second (0.61 kg/sec). Author

N68-30128*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DILUTION-JET MIXING STUDY FOR GAS-TURBINE COMBUSTORS

Carl T. Norgren and Francis M. Humenik Aug. 1968 45 p refs

(NASA-TN-D-4695; E-4213) CFSTI: HC $3.00/MF $0.65 CSCL 01A

An experimental mixing study was undertaken to evaluate various dilution-jet entries. Thirteen geometries including four geometric variations on rectangular diluent jets with flush openings, attached scoops immersed in the diluent air stream, attached chutes immersed in the hot air stream, and a single geometry incorporating flush circular holes were investigated. Diluent and hot streams with a velocity ratio from 0.55 to 2.20 (diluent stream Mach range 0.082 to 0.232) were introduced into the rectangular configuration exhausting directly to the atmosphere. The mixed-stream exhaust temperature was in the order of 750° to 975°R. Test conditions were representative to scaled engine operation by geometric, velocity, and Reynolds number similarity. Author

N68-30595*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A WIND TUNNEL INVESTIGATION OF JET-WAKE EFFECT OF A HIGH-BYPASS ENGINE ON WING-NACELLE INTERFERENCE DRAG OF A SUBSONIC TRANSPORT

James C. Patterson, Jr. Washington Aug. 1968 43 p refs

(NASA-TN-D-4693) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An experimental wind-tunnel investigation was conducted recently to determine the aerodynamic interference associated with underwing fan-jet engine–pylon installations including the effect of a jet wake from a powered high bypass fan-jet engine. Tests were made on a semispan model of a typical transport airplane configuration. These tests were conducted over a Mach number range of 0.70 to 0.84, at angles of attack from 0° to 4°, and over a Reynolds number range of 6.67×10^6 to 7.38×10^6 based on the mean geometric chord of 58.30 centimeters. The data indicate that the interference drag for the type of underwing engine–pylon installation investigated may be favorable as a result of a reduction in induced drag associated with an inboard end-plate effect of the nacelle–pylon. The addition of engine power has a strong influence on aerodynamic interference. The longitudinal and vertical position of the engine relative to the wing also has a pronounced effect on interference drag. The greatest favorable interference was obtained during this investigation with the engine in the most forward longitudinal and lowest vertical test position. An increase in Mach number above the design speed has an adverse influence on the aerodynamic interference. Author

N68-31445*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.

AERODYNAMIC STABILITY CHARACTERISTICS OF THE APOLLO COMMAND MODULE

William C. Moseley, Jr., Ralph E. Graham, and Jack E. Hughes Washington Aug. 1968 171 p refs

(NASA-TN-D-4688) CFSTI: HC$3.00/MF$0.65 CSCL 01A

Results from wind-tunnel tests conducted during the design and development of the Apollo command module are presented. Investigations were made to develop static and dynamic stability data for the basic configuration of the command module. Parametric studies were conducted to determine the effects of varying certain geometric dimensions of the basic command module configuration. Studies of modifications designed to provide an increased lift-to-drag ratio were also conducted. Representative samples, from an extensive series of tests of alterations designed to eliminate an apex-forward trim condition, are included. Author

N68-31484*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

DESIGN OF BODIES TO PRODUCE SPECIFIED SONIC-BOOM SIGNATURES

Raymond L. Barger Washington Aug. 1968 10 p refs

(NASA-TN-D-4704) CFSTI: HC$3.00/MF$0.65 CSCL 01B

A mathematical procedure is described for calculating the shape of a body of revolution that will generate a specified signature at a given Mach number and lateral spacing from the body. The applicability of the method is contingent on the requirement that the signature be physically obtainable. Results of a wind-tunnel study with three sample bodies support qualitatively the validity of the theory. Author

N68-31515*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A MODIFIED MULTIHOPP APPROACH FOR PREDICTING LIFTING PRESSURES AND CAMBER SHAPE FOR COMPOSITE PLANFORMS IN SUBSONIC FLOW

John E. Lamar [1968] 143 p

(NASA-TN-D-4427, Sup.) CFSTI: HC $3.00/MF $0.65 CSCL 01A

This supplement contains information about the two main computer programs (Langley computer program A0313, loading program, and Langley computer program A0457, mean camber program) used to obtain the results presented in NASA Technical Note D-4427 along with two supplementary programs (Langley computer program A1590, aspect ratio program, and Langley computer program A1591, pivot determining program) used in obtaining input data for them. In part I of this supplement, the input and some output variables for each of the two main programs (A0313 and A0457) are presented and pertinent comments made. Further, sample listings of input and output data are shown and the entire computer program listings provided. In part II of this supplement, a discussion of the two supplementary programs is presented with a list of input data required, and sample input and output listings as well as program listings are given. Author

N68-31551*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

SUPERSONIC AERODYNAMICS OF LARGE-ANGLE CONES

James F. Campbell and Dorothy T. Howell Washington Aug. 1968 71 p refs

(NASA-TN-D-4719) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An investigation has been made to determine the supersonic aerodynamics of a series of conical bodies with semiapex angles from 40° to 90° (disk). The tests were performed at Mach numbers from 2.30 to 4.63, at angles of attack from −4° to 24°, and at a Reynolds number based on model (base) diameter of 0.8×10^6. These data were compared with those predicted by exact cone theory, modified Newtonian theory, and an integral relations method. Results of this study indicated that all the configurations are statically stable with the center of gravity located at the model base.

As the cone semiapex angle is increased, axial force increases, the rate of increase being largest between 40° and 50° cone configurations. Experimental values of axial force at an angle of attack of 0° are adequately predicted for all cone semiapex angles by utilizing a combination of exact theory and an integral relations method. As the cone semiapex angle is increased, normal force decreases, normal force being zero for the flat disk. Shock standoff distance varies almost linearly with cone semiapex angle and the inverse of Mach number squared; these trends are adequately predicted by an integral relations method. Author

N68-31990*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

APPLICATION OF THE LEADING-EDGE-SUCTION ANALOGY OF VORTEX LIFT TO THE DRAG DUE TO LIFT OF SHARP-EDGE DELTA WINGS

Edward C. Polhamus Washington Aug. 1968 14 p refs

(NASA-TN-D-4739) CFSTI: HC $3.00/MF $0.65 CSCL 01A

A study has been made of the application of the leading-edge-suction analogy of vortex lift to the prediction of the drag due to lift on thin sharp-edge delta wings in incompressible flow. The study included comparisons with experimental results over a range of aspect ratios from 0.25 to 2.0. The results indicated that the drag due to lift can be predicted accurately by the zero-leading-edge-suction assumption, provided the vortex lift is accounted for by the leading-edge-suction-analogy method of NASA Technical Note D-3767. It was also found that because of the vortex lift, the drag due to lift for wings of extremely low aspect ratio can be less than that for optimum potential flow. Author

N68-33043*# Bell Aerosystems Co., Buffalo, N. Y.

A GENERALIZED EXPERIMENTAL INVESTIGATION OF HOT GAS RECIRCULATION AND INGESTION FOR JET VTOL AIRCRAFT

Patrick E. Ryan, Richard J. Heim, and Wayne J. Cosgrove Washington NASA Sep. 1968 150 p refs

(Contract NAS1-6706)

(NASA-CR-1147) CFSTI: HC $3.00/MF $0.65 CSCL 21E

Results of a small scale experimental investigation into the engine inlet temperature rise and flow field caused by the recirculating hot exhaust gases from various simulated V/STOL jet engine arrangements in static proximity to ground are presented. Experimental data were obtained to evaluate the recirculating flow field and engine inlet temperature rise caused by hot exhaust jets impinging on the ground. The effect of engine spacing, height, exhaust deflection angle, exhaust nozzle geometry, and wing planform are included. Author

N68-33081*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

A COMPUTER PROGRAM FOR SYSTEMATICALLY ANALYZING FREE-FLIGHT DATA TO DETERMINE THE AERODYNAMICS OF AXISYMMETRIC BODIES

Gerald N. Malcolm and Gary T. Chapman Washington Sep. 1968 39 p refs

(NASA-TN-D-4766) CFSTI: HC $3.00/MF $0.65 CSCL 01A

The computer program analyzes free-flight motions to deduce coefficients of drag, lift, and static and dynamic stability from any set of free flight data complete enough to define the trajectory and angle history. Nonlinear behavior can be accurately assessed from the results of the data reduction program, and available methods are discussed. To demonstrate the effectiveness of the data reduction method, free flight tests of the AGARD standard hypersonic ballistic correlation model HB-2 were conducted. The results for lift and static and dynamic stability at a Mach number of 2 agreed well with conventional wind tunnel results. Significant differences were found in the drag data because of different base pressures believed due to sting effects in the wind tunnel tests. Author

N68-33374*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL INVESTIGATION OF THE DYNAMIC RESPONSE OF A SUPERSONIC INLET TO EXTERNAL AND INTERNAL DISTURBANCES

Joseph F. Wasserbauer and Daniel L. Whipple Washington Sep. 1968 28 p refs

(NASA-TM-X-1648) CFSTI: HC $3.00/MF $0.65 CSCL 01A

The terminal shock position and static-pressure responses of an inlet were measured at a Mach number of 3.0 in the 10-by 10-foot supersonic wind tunnel. Internal and external disturbances were investigated over frequency ranges of 0.3 to 200 and 0.1 to 12 Hz, respectively. For an internal disturbance, the dynamic response of the terminal shock and static pressure near the inlet throat exhibited a lag characteristic to about 40 Hz but encountered resonant conditions at about 85 and 180 Hz. For the external disturbance, the dynamic response of the terminal shock and static pressure near the inlet throat exhibited a lead characteristic. Author

N68-33451*# Rice Univ., Houston, Tex.

CONICAL BODIES OF GIVEN LENGTH AND VOLUME HAVING MAXIMUM LIFT-TO-DRAG RATIO AT HYPERSONIC SPEEDS. VARIATIONAL METHODS

Ho-Yi Huang Washington NASA Aug. 1968 29 p refs

(Grant NGR-44-006-063)

(NASA-CR-1156; Rept.-36) CFSTI: HC $3.00/MF $0.65 CSCL 01A

An investigation of the lift-to-drag ratio attainable by a slender, conical body flying at hypersonic speeds is presented under the assumptions that the pressure distribution is modified Newtonian and the surface-averaged friction coefficient is constant. Length and volume are given, and the values of the free-stream dynamic pressure, the factor modifying the Newtonian pressure distribution, and the surface-averaged friction coefficient are known *a priori*. The indirect methods of the calculus of variations are employed, and numerical solutions are found using an IBM 7040 computer. It is found that a one-parameter family of external solutions exists, the parameter being the dimensionless area S^*. It is also noted that the geometry of the optimum contour and the maximum value of the modified lift-to-drag ratio E^* are uniquely related to the dimensionless area S^*. Author

N68-33765*# Nielsen Engineering and Research, Inc., Palo Alto, Calif.

INVESTIGATION OF METHODS FOR PREDICTING THE AERODYNAMIC CHARACTERISTICS OF TWO-LOBED PARAWINGS

M. R. Mendenhall, S. B. Spangler, and J. N. Nielsen Washington NASA Sep. 1968 125 p refs

(Contract NAS1-6615)

(NASA-CR-1166) CFSTI: HC $3.00/MF $0.65 CSCL 01A

The present study seeks to develop accurate methods for predicting the longitudinal aerodynamic characteristics of two-lobed conical parawings with leading-edge booms for high aspect ratios and high slackness. For prediction purposes, the assumption was made that the booms and canopy can be considered separately. The canopy was then considered to have a known shape for purposes of determining its aerodynamic performance. Various theoretical methods were studied for determining canopy aerodynamic characteristics, including profile drag. Force increments due to the leading-edge booms were studied both analytically and empirically. Comparisons were made between theory and data for rigid wings of known shape with no leading-edge booms to check the canopy prediction methods. Comparisons were also made for flexible wings of triangular and NASA planforms with leading-edge booms for overall evaluation of the methods. The canopy shape assumption was checked by comparison with earlier slender-body results, and the aerodynamic performance was found to be insensitive to small shape differences. Author

N68-33836*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

AERODYNAMIC CHARACTERISTICS OF SEVERAL HYPERSONIC BOOST-GLIDE-TYPE CONFIGURATIONS AT MACH NUMBERS FROM 2.30 TO 4.63

Ernald B. Graves and Melvin M. Carmel Washington Sep. 1968 27 p refs

(NASA-TM-X-1601) CFSTI: HC$3.00/MF$0.65 CSCL 01A

Two all-wing and three wing-body configurations were tested through an angle-of-attack range from about $-4°$ to 33° and an angle-of-sideslip range from $-4°$ to 8° at a Reynolds number of 3×10^6 per foot (9.84×10^6 per meter). The results of the investigation indicate that the wing-body configurations produced higher values of maximum lift-drag ratio than those produced by the all-wing models. The high wing-body configurations tend to have a self-trimming capability as opposed to that for the low wing-body configurations. Each of the configurations produced a positive dihedral effect that increased with increasing angle of attack and decreased with increasing Mach number. The high wing-body models produced decreasing values of directional stability with increase in angle of attack, whereas the low wing-body provided increasing values of directional stability with increase in angle of attack. Author

N68-35141*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EFFECTS OF SEVERAL RAMP-FAIRING, UMBILICAL, AND PAD CONFIGURATIONS ON AERODYNAMIC HEATING TO APOLLO COMMAND MODULE AT MACH 8

James L. Hunt and Robert A. Jones Washington Sep. 1968 70 p refs

(NASA-TM-X-1640) CFSTI: HC$3.00/MF$0.65 CSCL 01A

Test were made at angles of attack of 18°, 22°, and 26° and free-stream Reynolds numbers, based on model diameter, of 0.76×10^6 and 1.48×10^6. For the ramp-fairing–umbilical configurations tested, the area of high interference heating on the body at the windward base of the leeward umbilical was reduced substantially below that which occurred for the configuration having a protruding leeward shear pad and a flush-face umbilical; however, no significant reduction in the peak interference heating factor was observed. The presence of a simulated wire bundle case on the windward face of the protruding leeward umbilical appeared to reduce the peak heating on the body at the base of the umbilical. The highest heating rates on the Apollo configurations tested occurred in the interference regions of the shear and compression pads. The magnitude of these interference heating rates was 3 to 4.5 times the stagnation-point value for an angle of attack of 22° and a free-stream Reynolds number of 0.76×10^6 based on model diameter. The placement of a recessed umbilical just downstream of the leading edge on the windward afterbody produced interference heating factors of 1.26 and 1.48 just downstream of the umbilical for Reynolds numbers of 0.76×10^6, respectively. These heating factors were about 74 percent lower than the lowest peak factors obtained with any of the protruding leeward umbilical configurations. Author

N68-35173*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

FLOW-FIELD INVESTIGATIONS ON THE X-15 AIRPLANE AND MODEL UP TO HYPERSONIC SPEEDS

L. J. McLain and Murray Palitz Washington Sep. 1968 33 p refs

(NASA-TN-D-4813) CFSTI: HC$3.00/MF$0.65 CSCL 01B

Flight measured impact pressures and local Mach numbers near the surface of the rear lower fuselage centerline, wing lower surface, and upper vertical tail of the X-15 airplane are presented and compared with calculated results and wind tunnel data. In addition, wind tunnel derived total pressures in the rear lower fuselage flow field are presented. The flight measurements are presented over a free stream Mach number range of 1 to 5.7 and an angle of attack range of 0° to 20°. The wind tunnel measurements cover a Mach number range of 4.0 to 8.0. The calculated predictions of Moeckel Love and Inouye Lomax at an angle of attack of 0° gave reasonable estimates of the flight measured flow field parameters in the three local flow regions. Flight measured impact pressures near the rear lower fuselage were somewhat lower than wind tunnel measurements, whereas the flight and wind tunnel measurements for the vertical tail and wing lower surface showed good agreement. Author

N68-35497*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

HEAT TRANSFER AND PRESSURE DISTRIBUTIONS ON SPHERICALLY BLUNTED 25° HALF-ANGLE CONE AT MACH 8 AND ANGLES OF ATTACK UP TO 90°

Dennis M. Bushnell, Robert A. Jones, and Jarrett K. Huffman Washington Oct. 1968 41 p refs

(NASA-TN-D-4792) CFSTI: HC$3.00/MF$0.65 CSCL 01A

Local heat transfer and pressure distributions were measured over the conical portion of the cone. The investigation was conducted at at Mach number of 8.00 and Reynolds numbers of 0.37×10^6 and 1.65×10^6 based on free stream conditions and model base diameter. The pressure data are generally in good agreement with the semiempirical theory over the entire angle-of-attack range. The heat-transfer data for angles of attack up to 45° are in agreement with predictions using the small-cross-flow theory; whereas, the data at higher angles of attack are fairly well represented by the swept-cylinder theory based on the local cone diameter. Author

N68-35523*# Fairchild Hiller Corp., Farmingdale, N. Y.

EFFECT ON BLUNTNESS ON HYPERSONIC TWO-DIMENSIONAL INLET TYPE FLOWS

Robert J. Sanator, John L. Boccio, and Dan Shamshins Washington NASA Oct. 1968 105 p refs

(Contract NAS7-416)

(NASA-CR-1145) CSCL 01A

Tests were performed on two geometric configurations—a flat plate and an isentropic compression ramp—each accommodating leading edges of three different radii. The nominal test Mach numbers were 7.3 and 10.55, with corresponding free-stream unit Reynolds number ranges of 0.25 to 2.0×10^6 per foot, and 0.75 to 2.0×10^6 per foot, respectively. Results generated during the test phases of this program are compared with theoretical analyses and reflect blunt leading edge effects on inviscid flow profiles, surface pressure phenomena and viscous layer growth along the models, with and without incident shock wave–boundary layer interactions. Author

N68-35617*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

SUBSONIC LONGITUDINAL AERODYNAMIC MEASUREMENTS ON A TRANSPORT MODEL IN TWO SLOTTED TUNNELS DIFFERING IN SIZE

Arvo A. Luoma, Richard J. Re, and Donald L. Loving Washington Oct. 1968 47 p refs

(NASA-TM-X-1660) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An investigation of the static longitudinal aerodynamic characteristics of the same 5-foot-span (1.5-meter) model of a large subsonic cargo-type transport was made in the Langley 8-foot transonic pressure tunnel and in the Langley 16-foot transonic tunnel at Mach numbers from 0.700 to 0.825. The Reynolds numbers, the test conditions, and the data-reduction procedures were the same in the two investigations. The agreement in the data obtained was generally satisfactory. The greatest differences in the comparisons usually occurred at lift coefficients beyond the cruise lift where probably unequal effects of flow separation, particularly at supercritical speeds, may be expected. The results indicate that a model having a wing span which is large relative to the width of the test section can be tested in a slotted wind tunnel at subsonic speeds and that the results of such tests can be used with

confidence provided the test techniques and data-reduction methods used adhere to acceptable standards developed for such tests. Author

N68-36081*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
AERODYNAMIC CHARACTERISTICS OF A FIVE JET VTOL CONFIGURATION IN THE TRANSITION SPEED RANGE
Richard J. Margason and Garl L. Gentry, Jr. Washington Oct. 1968 189 p refs
(NASA-TN-D-4812) CFSTI: HC$3.00/MF$0.65 CSCL 01A

A wind tunnel investigation was conducted of a powered model of a VTOL fighter airplane configuration, having three lift engines in the forward fuselage and two deflected lift cruise engines in the aft fuselage, to determine the aerodynamic characteristics of the model in the transition speed range. The jet induced interference showed that the expected increase in lift loss and nose up pitching moment with increasing forward speed was rather small because of the counteracting effects of the front and rear jets. A substantial part of the nose up interference pitching moment was found to be due to the engine inlet mass flow for this engine arrangement. These results showed that increasing angle of attack had very little effect on interference lift and drag but that significant increases in interference pitching moment can occur if the horizontal tail is on or below the wing chord plane. Further investigation of tail height showed that the jet induced downwash was highest for the low tail position but that the jet induced longitudinal instability was mild for the three tail positions used in the tests. The effects of ground proximity were found to be relatively small for this configuration. Author

N68-36112*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EFFECT OF LARGE SIDESLIP ANGLES ON STABILITY CHARACTERISTICS OF A T-TAIL TRANSPORT CONFIGURATION
Edward J. Ray Washington Oct. 1968 48 p refs
(NASA-TM-X-1665) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An investigation has been made to determine the effects of large sideslip angles on the static stability characteristics of a typical T-tail transport configuration. In addition, damping-in-roll derivatives were determined for the basic T-tail arrangement over an angle-of-attack range extending from about 0° to 36°. The effects of large sideslip variations on the pitching-moment characteristics were also ascertained for selected configurations. The study was made in the Langley high-speed 7- by 10-foot tunnel at a Mach number of 0.30 and a corresponding Reynolds number of 1.20×10^6. In order to assess this assumed linearity and to determine the lateral-directional characteristics over large sideslip ranges, several of the configurations were positioned at fixed angles of attack (range of 0° to 11°) and varied through sideslip angles extending from −22° to 22°. These tests indicated significant nonlinearities in the variation of yawing-moment coefficient with sideslip angle at relatively low angles of attack. Two aft nacelle locations were investigated and it was determined from this limited study that the static directional stability characteristics could be substantially influenced at moderate angles of attack and sideslip by the position of the nacelles on the rearward portion of the fuselage. Author

N68-36132*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE OF A COLLAPSIBLE PLUG NOZZLE HAVING EITHER TWO-POSITION CYLINDRICAL OR VARIABLE ANGLE FLOATING SHROUDS AT MACH NUMBERS FROM 0 TO 2.0
Robert A. Wasko and Douglas E. Harrington Washington Oct. 1968 44 p refs
(NASA-TM-X-1657) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An experimental study was made concerning the effects of two types of shroud geometry on the performance of a collapsible plug nozzle. Shroud geometries considered were a two position cylindrical shroud and a variable angle floating shroud. Quiescent performance was obtained at nozzle pressure ratios from 2 to 15, and external flow effects were obtained at Mach numbers from 0.56 to 1.97. At subsonic cruise, the performance of the two position shroud was nearly comparable to that of the floating shroud. However, the two position shroud had better performance for subsonic acceleration whereas the floating shroud had better performance at supersonic Mach numbers. Maximum external flow effects occurred at Mach 1.2 for both shroud configurations. Author

N68-36133*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF MODEL FOREBODY SHAPE ON PERFORATED TUNNEL WALL INTERFERENCE
Glen A. Mitchell Washington Oct. 1968 47 p refs
(NASA-TM-X-1656) CFSTI: HC$3.00/MF$0.65 CSCL 01A

A 0.73-percent blockage cylindrical body was tested in the 8- by 6-foot supersonic wind tunnel with several forebody shapes to determine the magnitude of wall interference effects on model pressure distributions. The test section Mach number was varied from 0.4 to 2.0, and the distribution of wall porosity was adjusted. The forebody shape variations included cones with half angles of 15° and 42°, and a tangent ogive with a length to diameter ratio of 3. Results were compared to data on a 10° conical forebody from a previous test. Author

N68-36134*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BLOCKAGE EFFECTS OF CONE-CYLINDER BODIES ON PERFORATED WIND TUNNEL WALL INTERFERENCE
Glenn A. Mitchell Washington Oct. 1968 63 p refs
(NASA-TM-X-1655) CFSTI: HC$3.00/MF$0.65 CSCL 01A

A variety of cone–cylinder models were tested in the 8- by 6-foot supersonic wind tunnel at speeds from Mach 0.5 to 2.0 to evaluate the effect of wall reflected disturbances on model pressure distribution. In all cases, a 10° half-angle conical forebody was used; and the cylinder diameter was varied from 4 inches (10.16 cm) to 16 inches (40.64 cm). There were additional variations in model position within the test section and also in tunnel wall porosity. Author

N68-36193*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
AERODYNAMIC CHARACTERISTICS OF BODIES OF REVOLUTION AT MACH NUMBERS FROM 1.50 to 2.86 AND ANGLES OF ATTACK TO 180°
Lloyd S. Jernell Washington Oct. 1968 40 p ref
(NASA-TM-X-1658) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An investigation has been conducted in the Langley Unitary Plan wind tunnel to determine the aerodynamic characteristics of a series of cylinder, cone-cylinder, and ogive-cylinder bodies with various nose and afterbody fineness ratios for angles of attack from 0° to 180° and Mach numbers from 1.50 to 2.86. The data indicated that with the center of gravity located at 50 percent of the body length, none of the test configurations were statically stable at angles of attack near 0° or 180°. The magnitude of the normal force was primarily dependent upon the magnitude of the planform area. Generally, the more rearward the planform-area centroid, the more rearward the center of pressure. Author

N68-36334*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
A HOVERING INVESTIGATION OF AN EXTREMELY FLEXIBLE LIFTING ROTOR
Matthew M. Winston Washington Oct. 1968 54 p refs
(NASA-TN-D-4820) CFSTI: HC$3.00/MF$0.65 CSCL 01A

A hovering investigation of an extremely flexible rotor was conducted to determine the effects of rotor-tip configuration and operating conditions on performance and to obtain a comparison with a conventional rotor. The results show the manner in which luffing (fabric instability) restricted the envelope of tip speed and collective pitch angles within which the rotor could be operated. In the range where the rotor could be operated, variations in tip speed altered the blade camber and resulted in substantial variations with tip speed in hovering performance, particularly at the higher thrust conditions. The results suggest the existence of optimum combinations of tip body mass, tip center of gravity, and tip stabilizer incidence for each value of tip speed since these variables determine the amount and distribution of blade camber and twist. The hovering efficiency of this rotor was poor in comparison with a conventional rotor. Because of the large amount of aerodynamically induced camber, however, the rotor attained very high mean lift coefficients. Author

N68-36509*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EFFECTS OF NOSE SHAPE AND FIN GEOMETRY ON STATIC STABILITY OF A HIGH-FINENESS-RATIO SOUNDING ROCKET
Dennis E. Fuller Washington Oct. 1968 29 p refs
(NASA-TM-X-1661) CFSTI: HC$3.00/MF$0.65 CSCL 01A

Tests were conducted in the Langley 4- by 4-foot supersonic pressure tunnel to determine the effects of variations in nose shape and fin geometry on the static stability of two sounding rocket models having length-diameter ratios of 18.20 and 23.77. Tests were made at a Mach number of 2.01 for angles of attack from about $-4°$ to $24°$ and for angles of sideslip from about $-5°$ to $9°$. The Reynolds number was 9.8×10^6 per meter. The results indicated that significant changes in nose shape and fin geometry had little effect in improving the pitching-moment nonlinearities of the high-fineness-ratio rockets. The fins of higher aspect ratio tended to improve the directional stability and to delay the induced rolling moments to higher angles of attack. Author

N68-37054*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EFFECT ON BASE DRAG OF RECESSING THE BASES OF CONICAL AFTERBODIES AT SUBSONIC AND TRANSONIC SPEEDS
William B. Compton, III Washington Oct. 1968 50 p refs
(NASA-TN-D-4821) CFSTI: HC$3.00/MF$0.65 CSCL 01A

An investigation was conducted to determine the effect on base drag of recessing the bases of truncated conical afterbodies. The drag of a flat base was compared with the drag of recessed bases of equal size for afterbodies having boattail angles of 0°, 3°, 5°, and 10° and having ratios of boattail length to maximum diameter of 1.0 and 1.5. For each boattail, the amount of base concavity was varied in several steps from a flat base to an open base. A fully conical afterbody with a boattail angle of 10° was tested also. The tests were run at an angle of attack of 0° and through a Mach number range of 0.3 to 1.3. The Reynolds number based on model length was in the range of 8×10^6 to 16×10^6 depending on the Mach number. In addition, boundary layer profiles and afterbody drag coefficient plots are included. Results indicate that recessing the base gives an increase in base pressure coefficient of 0.01 to 0.03, depending on the boattail, and hence a reduction in base drag. For a given boattail, base drag decreases with increasing base concavity up to a certain point, but, beyond this point, further concaving the base has little or no effect. The ratio of the amount of base concavity to base radius necessary to achieve maximum base drag reduction depends on the boattail angle and length. Author

N68-37065*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EFFECTS OF FLEXIBILITY ON LIFT AND PITCHING-MOMENT CHARACTERISTICS OF A SERIES OF LOW-ASPECT-RATIO WING-BODY COMBINATIONS AT TRANSONIC SPEEDS
Robert V. Doggett, Jr. and A. Gerald Rainey Washington Oct. 1968 49 p refs
(NASA-TN-D-4655) CFSTI: HC$3.00/MF$0.65 CSCL 01A

Measurements of lift and pitching moment were made on a series of low aspect ratio wing–body combinations of different stiffnesses in the Mach number range from 0.70 to 1.10 and at angles of attack up to 30°. The configurations consisted of three different delta wings in combination with a single conical-cylindrical body. The three delta wings differed in leading-edge-sweep angle, aspect ratio, and area. Both rigid and flexible models were tested at Reynolds numbers per meter of 10.5×10^6 and 5.9×10^6. The experimental results indicated that there is no appreciable effect of vehicle flexibility on the lift characteristics for the models tested. The pitching moment characteristics were affected by flexibility; in general, increasing flexibility produced an appreciable deterioration of the static longitudinal stability characteristics. The linear theory showed good agreement with the experimental results in values of the lift curve slope at the zero lift condition. One of the nonlinear theories showed fair agreement with the experimentally determined lift characteristics for all three configurations. None of the analytical methods used were completely adequate for the prediction of the lift and pitching moment characteristics throughout the entire angle of attack range of the investigation. Author

N68-37238*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
FLOW FIELD PROPERTIES NEAR AN ARROW WING-BODY MODEL AT MACH NUMBERS OF 1.60, 2.36, AND 2.96
Robert L. Weirich and Walter A. Vahl Washington Oct. 1968 136 p refs
(NASA-TN-D-4809) CFSTI: HC$3.00/MF$0.65 CSCL 01A

A wind-tunnel investigation was conducted at supersonic Mach numbers to determine the flow-field properties near an arrow-wing-body model at several stations which were considered to be potential locations for engine air inlets. The tests were conducted at Mach numbers of 1.60, 2.36, and 2.96 at a Reynolds number of 9.84×10^6 based on a 1-meter length. The model angle-of-attack range was 0° to 9° and the model angles of sideslip were 0°, 5°, and −5°. The local flow parameters—Mach number, upwash and sidewash angles, and ratio of local to free-stream total pressure—were measured by pressure-instrumented 15° half-angle conical probes. These local flow characteristics are presented as contour plots for the locations which were surveyed. The results of this investigation indicate that several locations are potentially suitable as inlet locations. Below the wing-body, the Mach numbers are less than the free-stream value and the flow is reasonably uniform except in the region of the wing-body juncture. Locations below the fuselage and below the wing appear suitable for inlets. Above the plane of the wing, the Mach number is generally greater than the free-stream value. However, near the fuselage the flow is uniform except at high angles of attack, and this region appears suitable as an inlet location. Author

N68-37255*# Air Vehicle Corp., La Jolla, Calif.
NONLINEAR LIFT AND PRESSURE DISTRIBUTION OF SLENDER CONICAL BODIES WITH STRAKES AT LOW SPEEDS

E. S. Levinsky and M. H. Y. Wei Washington NASA Oct. 1968 64 p refs
(Contract NAS2-3523)
(NASA-CR-1202) CFSTI: HC $3.00/MF $0.65 CSCL 01A

Nonlinear vortex lift and pressure distributions were obtained analytically for conical bodies of circular and elliptical cross-section with small span sharp-edged conical wings or strakes of arbitrary dihedral angle. The analytical approach, which is an extension of the Mangler and Smith theory for slender flat triangular wings, made use of a generalized conformal transformation to map this class of wing-bodies of high volumetric efficiency into a vertical slit. A single pair of spiral vortex sheets was assumed to originate from the leading edge of each strake. The shape and strength of the spiral vortex sheet were determined as part of the calculation procedure. The nonlinear theory was evaluated by comparing with low-speed wind tunnel force and pressure data obtained on a series of related models. Both theory and experiment indicated relatively large increases in lift with even the smallest strake sizes considered, viz., 10% of the body radius. Good correlation between theory and experiment was obtained over the complete angle of attack range for cones with strakes of 50% of the body radius or greater. For these configurations, the lift was approximately twice the linear theory value at angles of attack equal to twice the strake semi-apex angle. Author

N68-37365*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
WIND TUNNEL INVESTIGATION OF THE LOW SPEED HIGH LIFT AERODYNAMICS OF A ONE-FIFTH SCALE VARIABLE SWEEP SUPERSONIC TRANSPORT
Anthony M. Cook Washington Oct. 1968 126 p refs
(NASA-TN-D-4844) CFSTI: HC $3.00/MF $0.65 CSCL 01A

Low-speed aerodynamic characteristics of a large-scale variable-sweep supersonic transport model were determined in a 40- by 80-foot wind tunnel. Included are data for the model both in and out of ground effect. The results are presented as six-component aerodynamic force and moment data obtained at various angles of attack and sideslip. The investigation was made at a free-stream dynamic pressure of 25 pounds per square foot, corresponding to a Reynolds number of 11 million, based upon the mean aerodynamic chord of the fully swept wing. The majority of testing was directed toward the optimization of high-lift configurations and the investigation of longitudinal stability and control characteristics for the take-off and landing configurations. Data concerning low-speed flight at highter wing sweeps of 30°, 42°, and 72° are also presented. It is shown that the model maintained acceptable levels of longitudinal stability up to 13° angle of attack at high lift in both the landing and take-off configurations. The model also exhibited lateral and directional stability up to high angles of sideslip. Author

N68-37854*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
AERODYNAMIC CHARACTERISTICS OF A PARASOL-WING BODY COMBINATION UTILIZING FAVORABLE LIFT INTERFERENCE AT MACH NUMBERS FROM 3.00 TO 4.63
Odell A. Morris and Robert J. Mack Washington Oct. 1968 38 p 9 refs
(NASA-TN-D-4855) CFSTI: HC $3.00/MF $0.65 CSCL 01A

An investigation has been conducted in the Langley Unitary Plan wind tunnel at Mach numbers from 3.00 to 4.63 to determine the longitudinal aerodynamic characteristics of a parasol-wing–body model. The model has a swept wing with a curved leading edge and a body with circular cross sections and a Von Karman forebody shape. Variations in wing position and forebody shape were also studied. Results of the investigation show that large favorable lift interferences were obtained at zero angle of attack for all configurations with the largest interference values being measured at Mach numbers from 4.00 to 4.63 in tests of low, single strut configuration. Variation in wing vertical position from a high to a low position improved the interference lift increments at the higher Mach numbers (4.00 to 4.63) with a corresponding increase in the maximum values of the lift-drag ratio. Variations in forebody shape from the basic body resulted in only small changes in the maximum values of the lift-drag ratio. Theoretical calculations of the lift-drag curve for the basic configuration at a Mach number of 3.00 showed good agreement with the experimental data. Author

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AIRCRAFT

Includes fixed-wing airplanes, helicopters, gliders, balloons, ornithopters, etc; and specific types of complete aircraft (e.g., ground effect machines, STOL, and VTOL); flight tests; operating problems (e.g., sonic boom); safety and safety devices; economics; and stability and control. For basic research see: 01 Aerodynamics. For related information see also: 31 Space Vehicles; and 32 Structural Mechanics.

N68-10047*# Honeywell, Inc., Minneapolis, Minn.
DEVELOPMENT AND FLIGHT TESTING OF A FLUIDIC CONTROL SYSTEM
D. L. Rodgers Washington NASA Oct. 1967 146 p
(Contract NAS4-763)
(NASA-CR-913; Rept.-20175-FR2) CFSTI: HC $3.00/MF $0.65 CSCL 01D

A three-axis fluidic automatic flight control system was developed, installed, and flight tested in an Aero Commander 680 FP aircraft. The results of the analytical studies, system design work, and flight testing are presented in this report Author

N68-11147*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
WIND-TUNNEL INVESTIGATION OF THE FLOW FIELD BENEATH THE FUSELAGE OF THE X-15 AIRPLANE AT MACH NUMBERS FROM 4 TO 8
Earl J. Montoya and Murray Palitz Washington Nov. 1967 92 p refs
(NASA-TM-X-1469) CFSTI: HC $3.00/MF $0.65 CSCL 01C

Wind-tunnel data were obtained on the local flow field beneath the fuselage of a model of the X-15 airplane approximately 5 to 8 fuselage diameters aft of the model nose from the model surface to the bow shock. Multiple-tube rakes, model surface pressure orifices, and a cone probe were used to survey the flow field. Test results were obtained at free-stream Mach numbers from 4 to 8 and angles of attack from $-3°$ to $20°$ and were compared with theory and flight data. Results indicate that Mach number, impact pressure, and flow-angularity gradients exist between the vehicle's surface and the bow shock. These gradients generally become larger with both increased angle of attack and Mach number. Good agreement with theoretical results at zero angle of attack was obtained. Mass flow through a proposed hypersonic ramjet engine inlet positioned beneath the X-15 was determined by using both a two-dimensional oblique-shock-wave assumption and wind-tunnel results. The two-dimensional oblique-shock assumption predicted a larger inlet mass flow than was obtained from the wind-tunnel data. Author

N68-11174*# LTV Aerospace Corp., Dallas, Tex.
ADDITIONAL STUDIES ON THE FEASIBILITY OF V/STOL CONCEPTS FOR SHORT-HAUL TRANSPORT AIRCRAFT
K. R. Marsh Washington NASA Dec. 1967 46 p refs
(Contract NAS2-3036)
(NASA-CR-670(01)) CFSTI: HC $3.00/MF $0.65 CSCL 01C

Various V/STOL short haul transport aircraft design proposals were reevaluated in terms of size, range, noise levels, and other operating characteristics. Among the conclusions reported are: (1) Operation at nonoptimum cruise conditions would require revisions in the proposed aircraft designs. (2) Matching of propeller takeoff RPM and engine takeoff RPM would be economically advantageous and would provide reductions in far field noise characteristics. Matching resulted in increased cruise speeds for turboprop STOL aircraft; but for turboprop VTOL aircraft, reduced propeller takeoff tip speed and the increased engine takeoff RPM lowered hover performance, necessitating increases in engine size. (3) Existing noise prediction methods do not yield accurate propeller-driven aircraft noise predictions. E.C.

N68-11519*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EFFECT OF GROUND PROXIMITY ON THE LONGITUDINAL, LATERAL, AND CONTROL AERODYNAMIC CHARACTERISTICS OF A TILT-WING FOUR-PROPELLER V/STOL MODEL
Kenneth W. Goodson Washington Dec. 1967 112 p refs
(NASA-TN-D-4237) CFSTI: HC $3.00/MF $0.65 CSCL 01C

A wind tunnel investigation of a four propeller tilt wing V/STOL configuration was conducted to determine the longitudinal, lateral, and control aerodynamic characteristics in ground proximity. The tests were made utilizing the moving-belt ground plane. The investigation showed that reductions in lift and drag occurred on the tilt-wing configuration when in ground proximity. Smoke-flow observations showed that ground proximity caused the slipstream to be deflected forward of the model. At certain ground heights and wing-tile–flap-deflection angles, these self-generated disturbances became quite erratic. For some wing-flap angle combinations, the unsteady flow caused erratic yawing moments at 0° sideslip. Smoke flow observations also showed that the ground-height-to-chord ratio at which the onset of flow recirculation occurred was proportional to the ratio of disk loading to free-stream dynamic pressure. The extent of the recirculation in front of the wing was dependent upon the wing tile angle at a given flap deflection and ground height. Ground proximity reduced the aileron yaw control by about 50 percent for the design condition ($\delta_{a_L}=50°$; δ_{a_L} is the left-wing aileron deflection) at the lowest ground height of the tests. Increasing the aileron deflection to $\delta_{a_L}=-70°$ and deflection a 0.10-chord upper-surface spoiler increased the control yawing moment to about 70 percent of original out-of-ground-effect value obtained with $\delta_{a_L}=-50°$. Ground proximity also considerably reduced the adverse rolling moment due to aileron deflection for yaw control. Author

N68-11545*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
AN ANALYSIS OF THE LIMIT-CYCLE AND STRUCTURAL-RESONANCE CHARACTERISTICS OF THE X-15 STABILITY AUGMENTATION SYSTEM
Lawrence W. Taylor, Jr. and John W. Smith Washington Dec. 1967 52 p refs
(NASA-TN-D-4287) CFSTI: HC $3.00/MF $0.65 CSCL 01D

During the early flights of the X-15 airplane, two problems associated with the stability augmentation system were encountered: limit cycles, primarily in roll, and control-surface resonance. The limit cycles were usually only an annoyance to the pilot, but at flight conditions with the largest control power, the nature of the limit cycles changed abruptly to large-amplitude oscillations that could have caused complete loss of control. The

frequency and amplitude of the airplane-system limit cycles were calculated by using the describing-function technique together with a nonlinear mathematical model to represent the control system and the airplane. These calculated characteristics compared well with experimental results from flight, ground tests, and simulations. The calculations were repeated for two different electronic filters, the original and a subsequent, improved design, that were incorporated in the stability augmentation system. The calculated limit-cycle characteristics for the final filter did not agree as well with experimental results as did the characteristics calculated for the original filter. Author

N68-11627*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

LARGE-SCALE WIND-TUNNEL INVESTIGATION OF A MODEL WITH AN EXTERNAL JET-AUGMENTED FLAP

Jerry V. Kirk, David H. Hickey, and Kiyoshi Aoyagi Washington Dec. 1967 35 p refs

(NASA-TN-D-4278) CFSTI: HC $3.00/MF $0.65 CSCL 01C

An investigation has been conducted in the Ames 40- by 80-Foot Wind Tunnel of a large-scale model powered by turbojet engines. The wing had 38.5° sweep of the leading edge, an aspect ratio of 5.38, a taper ratio of 0.23, and a dihedral of 3° The wings airfoil section was an NACA 65-412. The trailing-edge flaps extended from 8 to 63 percent semispan. A small auxiliary flap spanned the main flap. The exhaust from the engines was directed against the flaps to augment lift. Longitudinal aerodynamic characteristics for various combinations of main and auxiliary flap deflections are shown for thrust coefficients from 0 to approximately 1.4. Limited longitudinal and lateral-directional characteristics are shown for a simulated engine-out condition. Results also demonstrate the feasibility of using the small auxiliary flap as a means of providing direct-lift flight-path control. Author

N68-11638*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

FLIGHT INVESTIGATION OF PERFORMANCE CHARACTERISTICS DURING LANDING APPROACH OF A LARGE POWERED-LIFT JET TRANSPORT

Albert W. Hall, Kalman J. Grunwald, and Perry L. Deal Washington Dec. 1967 27 p refs

(NASA-TN-D-4261) CFSTI: HC $3.00/MF $0.65 CSCL 01D

A flight investigation has been conducted to determine low-speed performance characteristics of an airplane employing a powered-lift system. The airplane used during this investigation was a modified jet transport which was equipped to provide engine compressor air for boundary-layer control over the wing trailing-edge flaps. It was found that for powered-lift aircraft the approach speeds should be based on a given percentage of the power-on stall speeds, but not less than a fixed margin above the stall speeds. These criteria provided adequate maneuver capability for all configurations during instrument approaches. These approach speeds fell slightly below the speeds for maximum lift-drag ratio for all configurations, but this speed-thrust instability caused no objectionable characteristics. Problems encountered during this program which should be considered for operational powered-lift aircraft design were uncomfortable airplane approach attitudes and insufficient thrust margin at low approach speeds and maximum landing weights. Automatic speed control was found to be very effective in reducing pilot workload during instrument approaches. Author

N68-11772*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

PREDICTION OF AIRCRAFT SONIC BOOM CHARACTERISTICS FROM EXPERIMENTAL NEAR FIELD RESULTS

Raymond M. Hicks and Joel P. Mendoza Washington Nov. 1967 14 p refs

(NASA-TM-X-1477) CFSTI: HC $3.00/MF $0.65 CSCL 01B

Near field pressure signature data measured in a wind tunnel were used for predicting aircraft sonic boom characteristics. With the data plus the theoretical concepts of Whitham, an experimental area function F(y) could be determined. Evaluation of the area function for the configuration in turn allows an assessment of the sonic boom pressure signature at any distance ratio greater than that used for the original measurement of the near field data. On the basis of limited tests of a 12-inch model of the XB-70 airplane, good correlations of wind tunnel to wind tunnel and wind tunnel to flight pressure signature results were obtained. A near field signature measured at a distance ratio of 1.0 and a Mach number of 1.8 was used to predict the over-pressure characteristics of the XB-70 configuration. The prediction was accurate at a near field distance ratio of 4.5, and a far field distance ratio of 290. Author

N68-13517*# Boeing Co., Renton, Wash.

STUDY OF AIRCRAFT IN SHORT HAUL TRANSPORTATION SYSTEMS

Washington NASA Jan. 1968 74 p

(Contract NAS2-3862)

(NASA-CR-986) CFSTI: HC $3.00/MF $0.65 CSCL 01C

The intercity operation of advanced short-haul transport aircraft were evaluated in several assumed transportation systems in the 1985 period. Three separate areas of the country, the Northeast, West Coast, and the Gulf Coast–Florida areas, were used in assessing the suitability of aircraft ranging from vertical takeoff and landing, through short takeoff and landing, to conventional takeoff and landing types. The figures of merit considered in comparing the relative suitability of the concepts included direct operating costs versus range, vehicle profitability on a systems wide basis, and the extent and magnitude of the noise generated by each concept. The sensitivity of mission performance to changes in the aircraft characteristics and system operations is determined and key problem areas where additional research may improve the aircraft transportation systems are identified. R.N.A.

N68-14090* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

MEASUREMENTS OF GROUND EFFECT ON A LOW-ASPECT-RATIO OGEE-WING AIRPLANE MODEL AND CALCULATIONS OF LANDING-FLARE TRAJECTORIES

Vernard E. Lockwood and W. Pelham Phillips Washington Jan. 1968 39 p refs

(NASA-TN-D-4329) CFSTI: $3.00 CSCL 01B

An investigation has been made to determine the ground effect on a 0.15-scale model of a fighter-type airplane having an ogee-wing planform. The characteristics in close proximity to the ground were determined by utilizing the moving-belt facility of the Langley 300-MPH 7- by 10-foot tunnel with and without ground-plane boundary-layer removal. Trim characteristics were determined for the model with and without landing gear. An analytical study showing the effect of airplane size on landing trajectories is also included. No significant differences in the aerodynamic characteristics were indicated with ground-plane boundary layer present or removed. The increases in lift-curve slope and longitudinal stability and the reduction in induced drag usually encountered by an airplane entering ground effect were noted. A landing-flare motion analysis using the experimentally determined data has indicated the descent rate at touchdown for a large low-aspect-ratio wing airplane of the supersonic transport size would be less than for a small airplane during a constant pitch attitude approach due to the longer time spent in ground effect. The descent rates encountered at touchdown were excessive for normal operational landings. Author

N68-14903* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EFFECTS OF PAVEMENT TEXTURE ON WET-RUNWAY BRAKING PERFORMANCE

Trafford J. W. Leland, Thomas J. Yager, and Upshur T. Joyner Washington Jan. 1968 37 p refs
(NASA-TN-D-4323) CFSTI: $3.00 CSCL 01B

An extensive test program was conducted at the Langley landing-loads track to investigate the effect on braking of tire tread pattern and tread materials for a variety of runway surfaces. Some of the tire test results were excerpted from this program and are presented to show the importance of runway surface texture in determining braking friction coefficient levels on wet runways. A technique for measuring the average texture depth of a given surface is suggested, and a limited correlation is shown between the texture depth measurements of four runway surfaces and the average friction coefficients developed by a smooth tire when braking on these wet surfaces. Surface wear due to traffic and weathering is shown to have a marked influence on the braking friction coefficient levels attained on wet runways. Author

N68-15894*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
STATIC AND DYNAMIC LONGITUDINAL STABILITY DERIVATIVES OF A POWERED 0.18-SCALE MODEL OF A FAN-IN-WING VTOL AIRCRAFT
Joseph R. Chambers and Sue B. Grafton Washington Feb. 1968 66 p refs
(NASA-TN-D-4322) CFSTI: HC $3.00/MF $0.65 CSCL 01C

An investigation was conducted to determine the static and dynamic longitudinal stability derivatives of a powered fan-in-wing V/STOL aircraft model for trimmed level flight at an angle of attack of 0°. The model had a lift fan located in each wing panel and a smaller fan located in the nose for pitch control. The investigation covered a range of values of thrust condition and oscillatory frequencies for the model with the horizontal tail both on and off. The results of the investigation indicate that the model was statically unstable with respect to angle of attack and was statically stable with respect to velocity for the lower speeds for fan-powered flight; these trends tended to reverse as the transition to conventional wingborne flight progressed. The model had positive damping in pitch (negative values of the damping-in-pitch parameter) throughout the ranges of test conditions investigated. Author

N68-15941*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
CALCULATION OF THE DYNAMIC LONGITUDINAL STABILITY OF A TILT-WING V/STOL AIRCRAFT AND CORRELATION WITH MODEL FLIGHT TESTS
Joseph R. Chambers and Sue B. Grafton Washington Feb. 1968 63 p refs
(NASA-TN-D-4344) CFSTI: HC $3.00/MF $0.65 CSCL 01C

An analytical study has been conducted to determine the important factors influencing the dynamic longitudinal stability characteristics of a typical tilt-wing V/STOL aircraft. Calculations have been made for the initial condition of steady level flight at wing incidences corresponding to speeds ranging from hovering to conventional forward flight. The results of the calculations have been compared with qualitative measurements of dynamic stability obtained during free-flight tests of a 1/9-scale model of the aircraft. The results of the investigation indicated that the control-fixed motions of the aircraft without artificial stabilization in hovering flight would be dominated by an unstable oscillation similar to that displayed by most helicopters. As the transition to conventional forward flight progressed, stability characteristics were encountered in which aperiodic divergent modes of motion, as well as unstable oscillations, were present. These results also indicated that the unstable oscillation occurring in the hovering and low-speed flight regions can be stabilized by the addition of a combination of pitch-rate and pitch-attitude stabilization, but that angle-of-attack stability must be increased if the aperiodic divergent modes of motion are to be made stable. Author

N68-16522*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
AN ANALYSIS OF VGH DATA FROM ONE TYPE OF FOUR-ENGINE TURBOJET TRANSPORT AIRPLANE DURING COMMERCIAL OPERATIONS
Paul A. Hunter Washington Feb. 1968 48 p refs
(NASA-TN-D-4330) CFSTI: HC $3.00/MF $0.65 CSCL 01C

An analysis of VGH records collected on one type of four-engine turbojet transport during routine commercial operations on two airlines has provided information on acceleration, turbulence, and airspeed operating practices. The data cover operations of two airplanes by one airline on eastern United States and Caribbean routes and of one airplane operated by a second airline on routes which ranged along the east coast of the United States, across the Caribbean Sea and along the west coast of South America. For the two airplanes operated by the same airline, the results were very similar in regard to the gust-velocity experiences and the accelerations caused by gusts, operational maneuvers, check-flight maneuvers, and landing impact. The results indicated that the acceleration experiences, the gust velocity experiences, and the airspeed operating practices were not significantly different for the airplanes operated by the two airlines. In general, the airspeeds in rough air (gust velocity $\geq$ 2 fps (0.6 m/sec)) were approximately equal to the airspeeds in smooth air. The results indicated, however, that the airspeeds in heavy turbulence (gust velocities higher than 20 fps (6.1 m/sec)) were generally lower than the average operating speeds. Author

N68-17023*# National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.
WIND-TUNNEL INVESTIGATION OF LATERAL AERODYNAMIC CHARACTERISTICS OF A POWERED FOUR-DUCT-PROPELLER VTOL MODEL IN TRANSITION
Kenneth P. Spreemann Washington Feb. 1968 76 p refs
(NASA-TN-D-4343) CFSTI: HC $3.00/MF $0.65 CSCL 01C

An investigation to determine the lateral and directional aerodynamic characteristics of a powered four-duct-propeller 1/5-scale model of a VTOL airplane was conducted in the 17-foot test section of the Langley 300-mph 7- by 10-foot tunnel. The model was tested through a sideslip-angle range at angles of attack of 0°, 8°, and 12° and with duct deflection angles from −5° to 90° at various thrust coefficients from hovering to conventional forward flight. The initial cruise configuration had neutral directional stability in the power-off-low-angle-of-attack conditions (0° and 8°) and became stable at the high-angle-of-attack condition (12°). A larger vertical tail having a higher aspect ratio than was used on the initial configuration provided a slightly stable model in the power-off condition; however, in the power-on condition, the model became unstable in the lower transition-speed range regardless of tail geometry. Tail-wing fairings of various sizes and shapes significantly increased the directional stability. Directional deflection of the elevons (vanes) in the ducts provided large control increments in roll and yaw through the transition-speed range; however, the total requirements for trim and control will necessitate the use of both elevon deflection and differential propeller thrust throughout the transition-speed range. Author

N68-17055*# National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.
SUBSONIC AND TRANSONIC FLUTTER AND FLOW INVESTIGATIONS OF THE T-TAIL OF A LARGE MULTIJET CARGO AIRPLANE
Maynard C. Sandford, Charles L. Ruhlin, and E. Carson Yates, Jr. Washington Feb. 1968 41 p refs
(126-14-02-03-23)
(NASA-TN-D-4316) CFSTI: HC $3.00/MF $0.65 CSCL 01C

Flutter and flow studies of the T tail of a large multijet cargo airplane have been conducted in the Langley transonic dynamics tunnel at Mach numbers up to 1.08. The tail and aft fuselage of the model employed were geometrically, dynamically,

and elastically scaled, whereas only the mass and stiffness characteristics of the forward fuselage, wings, and nacelles were simulated. The flutter studies included variations in fin-spar stiffness, stabilizer-pitch-actuator stiffness, rotational stiffnesses of elevators and rudder, as well as small variations in stabilizer juncture and included the use of vortex generators and fences, as well as modifications to the bullet-fairing shape. The results indicated that for a configuration with a weaker than design fin spar, the antisymmetric flutter boundary had a transonic dip amounting to a 41% reduction in dynamic pressure from the low speed value, the minimum occurring near Mach number 0.7. For the design configurations, no flutter occurred within the Mach number and dynamic-pressure ranges investigated. Separated flow over the fin and stabilizer was alleviated by the use of vortex generators, but flow over the aft portion of the bullet fairing remained separated. Author

N68-17391*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

A PILOTED SIMULATOR STUDY OF TAKEOFF PERFORMANCE AND HANDLING QUALITIES OF A DOUBLE DELTA SUPERSONIC TRANSPORT

C. Thomas Snyder and Charles T. Jackson, Jr. Washington Feb. 1968 49 p refs

(NASA-TN-D-4396) CFSTI: HC$3.00/MF$0.65 CSCL 14B

The takeoff characteristics of a generalized double-delta supersonic transport configuration were investigated in a fixed-cockpit simulator equipped with an external visual display. The objectives were to investigate performance and handling qualities, identify possible problem areas, and assist in the evaluation of certification requirements to be used during the development of the SST. The unaugmented SST exhibited: (1) excellent performance during normal takeoffs, (2) a greater probability of nacelle or tail scrapes than the SJT, indicating a need for more time for the rotation maneuver, a longer landing gear on the design tested, or higher lift-off speeds, (3) initial climb characteristics which were acceptable but unpleasant, due to a tendency toward pitch "wandering," aggravated by negative speed-drag stability, (4) good lateral-directional and engine-out characteristics, and (5) a performance sensitivity to lift-off speed abuse during marginal-thrust takeoffs, which indicated the need for review of the present airworthiness criterion regarding one-engine-inoperative first-segment climb. Author

N68-18250*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

LOW-SUBSONIC FLIGHT AND FORCE INVESTIGATION OF A SUPERSONIC TRANSPORT MODEL WITH A DOUBLE-DELTA WING

Delma C. Freeman, Jr. Washington Mar. 1968 47 p refs

(NASA-TN-D-4179) CFSTI: HC$3.00/MF$0.65 CSCL 01C

An investigation has been conducted in the Langley full-scale tunnel to determine the low-speed static and dynamic longitudinal and lateral stability characteristics of a 1/20-scale model of a double-delta supersonic commercial air transport configuration. The results of the investigation showed that the dynamic longitudinal stability and control characteristics of the model were generally satisfactory over the test angle-of-attack range except from about 20° to 25° where neutral or negative static longitudinal stability made flying difficult. The Dutch roll oscillation was well damped throughout most of the test angle-of-attack range but the damping decreased rapidly above an angle of attack of about 20°. The use of a roll-rate damper to provide artificial stabilization in roll generally gave satisfactory Dutch roll characteristics over the test angle-of-attack range. The directional stability was satisfactory at low angles of attack but deteriorated rapidly at the high angles of attack and the model diverged in yaw against full corrective control near an angle of attack of 28°. The lateral control characteristics were satisfactory over the test angle-of-attack range. Author

N68-18771*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

LARGE-SCALE WIND-TUNNEL TESTS OF A DEFLECTED SLIPSTREAM STOL MODEL WITH WINGS OF VARIOUS ASPECT RATIOS

V. Robert Page, Stanley O. Dickinson, and Wallace H. Deckert Washington Mar. 1968 56 p refs

(NASA-TN-D-4448) CFSTI: HC$3.00/MF$0.65 CSCL 01B

A wind-tunnel investigation was conducted to determine the longitudinal force characteristics of a large-scale model representative of a propeller-driven STOL transport aircraft. Longitudinal characteristics were obtained for a wing of aspect ratio of 5.7 that was fully immersed in the propeller slipstream and for wings of greater span (up to aspect ratio 8.1) that were only partially immersed in the propeller slipstream. Test configurations included: three wing spans, full-span leading-edge slats, full-span triple-slotted trailing-edge flaps deflected from 0° to 100°, two directions of propeller rotation, and spanwise variation of propeller thrust. Test results show that lift coefficient increased and drag coefficient decreased as the wing tips were extended outboard. Leading-edge slats controlled the progression of flow separation and extended the angle of attack for maximum lift approximately 10° For each wing span tested descent capability could be improved by spanwise variation of propeller thrust. However, the spanwise variation of propeller thrust was most effective on the short span wing. Author

N68-19065*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

WING SURFACE PRESSURE DATA FROM LARGE-SCALE WIND-TUNNEL TESTS OF A PROPELLER-DRIVEN STOL MODEL

V. Robert Page and Paul T. Soderman Washington Mar. 1968 65 p ref

(NASA-TM-X-1527) CFSTI: HC$3.00/MF$0.65 CSCL 01C

The model tested is representative of a propeller-driven STOL transport aircraft. The variables include the effect of: trailing-edge flap deflection (0° to 100°), spanwise variation of propeller thrust, wing leading-edge slats, and propeller thrust and rotation on the three wing spans tested. Wing pressure distribution data and integrated chordwise normal-force coefficients are tabulated. Author

N68-19184*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

FLIGHT INVESTIGATION TO DETERMINE THE EFFECT OF LONGITUDINAL CHARACTERISTICS ON LOW-SPEED INSTRUMENT OPERATION

Daniel J. Di Carlo, James R. Kelly, and Robert W. Sommer Washington Mar. 1968 22 p refs

(NASA-TN-D-4364) CFSTI: HC$3.00/MF$0.65 CSCL 01D

A flight investigation using a variable-stability helicopter was conducted under instrument flight rules (IFR) to determine the effects of gross changes in longitudinal static stability characteristics on handling qualities for V/STOL operation. Various combinations of angle-of-attack stability, speed stability, pitch-rate damping, and longitudinal control sensitivity were evaluated by means of a simulated instrument task which was selected as being representative of low-speed instrument flight. Neutral to slightly stable angle-of-attack stability was found to be most satisfactory, regardless of the level of pitch-rate damping. Low unstable values of angle-of-attack stability were tolerable when sufficient pitch-rate damping was provided. Combinations of angle-of-attack stability and pitch-rate damping which provide minimum satisfactory handling qualities are in general agreement with current specifications for low values of angle-of-attack stability. Variations in the longitudinal control sensitivity had little effect on pilot rating over a wide range of values centered about the optimum tested. Author

N68-19620*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

REVIEW OF CAUSES AND ALLEVIATION OF LOW TIRE TRACTION ON WET RUNWAYS

Walter B. Horne, Thomas J. Yager, and Glenn R. Taylor Washington Apr. 1968 37 p refs

(NASA-TN-D-4406) CFSTI: HC $3.00/MF $0.65 CSCL 01B

Three main factors which cause loss of tire traction on wet runways, namely, dynamic hydroplaning, viscous hydroplaning, and tire tread rubber reversion are reviewed. Consideration is given to the interaction of certain variables such as pavement surface texture, runway water depth, tire tread design, vertical tire load, and tire inflation pressure with these factors. A method for measuring average texture depth of a runway surface is described and appears promising as a means of classifying runway surfaces as to their slipperiness when wet. Finally, two promising methods for increasing tire traction on wet runways are discussed; namely, air jets placed in front of tires and pavement grooving. Author

N68-21112*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

PROPOSED ANALYTICAL MODEL FOR THE FINAL STAGES OF LANDING A TRANSPORT AIRPLANE

Maurice D. White Washington Apr. 1968 14 p ref

(NASA-TN-D-4438) CFSTI: HC $3.00/MF $0.65 CSCL 01C

Methods for defining the certifying landing distances and approach speeds of transport airplanes are currently being reviewed. Revisions are being sought that would make the requirements and demonstration procedures account more realistically for operational practices and variables. As an aid in this task, a simple model is proposed for describing the final airborne stages of landing a transport airplane manually. The model separates the maneuver into three distinct phases, an initial flare, a float, and a touchdown. Methods are indicated for estimating the speed changes or lift increments associated with each phase. Assumptions regarding thrust management in the maneuver are shown to be important. The considerations that affect these assumptions are discussed and indicate how the thrust would probably be managed in normal operations. Limited flight data are described which confirm the main elements of the model. Additional refinement of the model is desirable to make it useful in the development of more rational rules for certifying landing characteristics. Author

N68-21413*# National Aeronautics and Space Administration, Washington, D. C.

SONIC BOOM RESEARCH

A. R. Seebass, ed. 1967 115 p refs Proc. of NASA Conf. on Res. on the Generation and Propagation of Sonic Booms, Washington, 12 Apr. 1967

(NASA-SP-147) GPO: HC $0.50; CFSTI: MF $0.65 CSCL 01B

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N68-21834*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

PRELIMINARY MEASURED AND PREDICTED XB-70 ENGINE NOISE

Paul L. Lasagna and Norman J. Mc Leod Washington Apr. 1968 21 p refs

(NASA-TM-X-1565) CFSTI: HC $3.00/MF $0.65 CSCL 01C

Noise measurements on the ground were made during takeoffs, a landing, and a flyby of the XB-70 airplane. Noise predictions made by using the SAE method differed from the measured levels. The substitution of standard-day atmosphere for actual atmosphere improved the comparison of the measured and predicted noise spectra. Further investigation is needed to determine the reasons for the difference between the measured and the predicted levels. Perceived noise levels of the XB-70 were approximately 7 PNdB to 10 PNdB higher than the maximum overall sound-pressure levels in decibels. Author

N68-22033*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

AN INVESTIGATION OF THE HELICOPTER HEIGHT VELOCITY DIAGRAM SHOWING EFFECTS OF DENSITY ALTITUDE AND GROSS WEIGHT

Robert J. Pegg Washington May 1968 33 p refs

(NASA-TN-D-4536) CFSTI: HC $3.00/MF $0.65 CSCL 01C

Within the limitations of the available data, this report is intended to provide a method by which experimentally determined helicopter height-velocity diagrams may be modified to show the effects of density altitude and gross weight. Variations in the established height-velocity diagram can be predicted for changes in density altitude and gross weight by using a generalized nondimensional curve. This generalized curve is based on semiempirical functions derived from flight-test data. During the flight testing of new helicopter designs, this semiempirical method can be used advantageously to predict changes in autorotation characteristics. This method can also predict the approximate shape of the height-velocity diagram while preliminary designs of a helicopter are being made. To illustrate the use of the semiempirical procedure, a detailed numerical example is given. The step-by-step calculations show the use of the curves and equations. Author

N68-22291*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

SUMMARY OF VGH DATA COLLECTED ON ONE TYPE OF TWIN-ENGINE JET AIRPLANE DURING AIRLINE OPERATIONS

Paul A. Hunter and Marian E. Brazziel Washington May 1968 32 p refs

(NASA-TN-D-4529) CFSTI: HC $3.00/MF $0.65 CSCL 01C

A VGH data sample collected on two identical twin-engine turbojet airplanes during routine airline operations has been analyzed to determine the operational experiences of the airplanes. The results indicate that the gust and maneuver accelerations are comparable to corresponding results for turboprop airplanes. Accelerations due to oscillatory motions were of low amplitude, were experienced infrequently, and are considered insignificant in regard to the total airplane acceleration experience. The results indicate that the gust velocity experience for the twin-engine jet airplane is significantly lower than the experience for two types of turboprop airplanes and is comparable to that for a four-engine turbojet transport. Placard-speed exceedances were relatively infrequent and were generally less than 6 knots beyond the overspeed warning bell. The results indicate that, in general, airspeed reduction was practiced during the more severe turbulence. The landing-impact accelerations, which were quite severe during the initial airplane operation, were reduced to a level comparable to that of several other two- and three-engine jet transports after a modification of the landing gear. Author

N68-22886*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

METHOD OF CALCULATING THE NORMAL MODES AND FREQUENCIES OF A BRANCHED TIMOSHENKO BEAM

Francis J. Shaker Washington May 1968 41 p refs

(NASA-TN-D-4560) CFSTI: HC $3.00/MF $0.65 CSCL 20K

The method is essentially a modified Stodola method and requires an iteration procedure to determine the normal modes and frequencies of the system. In this method, an arbitrary deflection, consistent with the boundary condition, is assumed. Also, because of the presence of the spring-mass system, the frequency is not a constant factor in the governing equations and must also be assumed. Knowing the deflection and frequency, the corresponding shears, moments, slopes, and new deflection can be determined by integrating the governing differential equations of the system. The new deflection is then adjusted to satisfy the boundary conditions, and a new frequency is subsequently calculated. The process is then repeated, and the frequency is used as the criterion for convergence. Although the method can be applied for any type of boundary conditions, particular attention was given to those boundary conditions of interest in launch-vehicle dynamics, namely, the free-free beam and the cantilevered-free beam. Author

N68-23456*# National Aeronautics and Space Administration, Washington, D. C.

HELICOPTERS—CALCULATION AND DESIGN. VOLUME 2: VIBRATIONS AND DYNAMIC STABILITY

M. L. Mil' et al May 1968 484 p refs Transl. into ENGLISH of the book "Vertolety. Raschet i Proyektirovaniye. 2. Kolebaniya i Dinamicheskaya Prochnost" Moscow, Mashinostr. Press, 1967 p 1–470

(NASA-TT-F-519) CFSTI: HC $3.00/MF $0.65 CSCL 01C

This volume contains theory and problems of vibration, stress calculations for helicopters in flight, and particularly stress calculations for rotor blades. Covered are methods for calculating structural fatigue and vibrational amplitudes. The problem of coupled vibrations of rotor and fuselage is examined. The self-excitation phenomenon of ground resonance is discussed in detail for helicopters on the ground, during takeoff and landing, and during cruising flight. Theory and calculation methods are presented for analyzing bearing loads of major helicopter components under various operating conditions. K.W.

N68-23895*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TANKAGE SYSTEMS FOR A METHANE-FUELED SUPERSONIC TRANSPORT

Joseph D. Eisenberg and Rene E. Chambellan Washington May 1968 21 p refs

(NASA-TM-X-1591) CFSTI: HC $3.00/MF $0.65 CSCL 01C

The use of liquid-methane fuel promises economic improvement, but its cryogenic nature causes on-board storage problems. Should the fuel be loaded in a saturated condition, much fuel will flash off due to pressure reductions during climb. Pressurized tanks or subcooled fuel will solve this problem. Subcooled fuels require a pressurizing gas. Low solubility gases have low availability and must be salvaged. Bladders or stand-pipes to reduce the contact area may be used with soluble or condensible pressurizers. Analytical studies indicate that these methods, when used separately or in combination, offer potential solutions to the tankage problem. Author

N68-23901*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

A REVIEW OF TRANSPORT HANDLING-QUALITIES CRITERIA IN TERMS OF PRELIMINARY XB-70 FLIGHT EXPERIENCE

Bruce G. Powers Washington May 1968 33 p refs

(NASA-TM-X-1584) CFSTI: HC $3.00/MF $0.65 CSCL 01C

A preliminary flight evaluation of handling qualities of the unaugmented XB-70 airplane was made during the initial flight test and envelope-expansion program. The evaluations consisted of pilot ratings and comments on the longitudinal and lateral-directional characteristics. The pilot ratings were compared with several current handling-qualities criteria for transport aircraft to establish the applicability of these criteria to this class of airplane. The results of the study show that for the longitudinal mode fair correlation was obtained between the XB-70 handling qualities and specific criteria boundaries based on the short-period frequency and damping. It appears that a combination of many handling-qualities factors on the XB-70 airplane obscured the effects of any single handling-qualities parameter. These factors include excessive yaw due to aileron input, restricted sideslip limits, poor pitch and roll control harmony, and poor attitude and heading information. Author

N68-24245*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

FLIGHT TEST OF A 40-FOOT NOMINAL DIAMETER DISK GAP BAND PARACHUTE DEPLOYED AT A MACH NUMBER OF 1.91 AND A DYNAMIC PRESSURE OF 11.6 POUNDS PER SQUARE FOOT

John S. Preisser and Clinton V. Eckstrom Washington May 1968 38 p refs Film supplement number L-1000 to this report is available on loan from NASA. Langley Res. Center

(NASA-TM-X-1575) CFSTI: HC $3.00/MF $3.00/MF $0.65 CSCL 01C

A 40-foot nominal-diameter disk-gap-band parachute was flight tested. The test parachute was ejected by a deployment mortar from an instrumented payload at an altitude of 140,000 feet. The payload was at a Mach number of 1.91 and the dynamic pressure was 11.6 pounds per square foot at the time the parachute deployment mortar was fired. The parachute reached suspension line stretch in 0.43 second with a resultant snatch force loading of 1990 pounds. The maximum parachute opening load of 6500 pounds came 0.61 second later at a total elapsed time from mortar firing of 1.04 seconds. The first full inflation occurred at 1.12 seconds and stable inflation was achieved at approximately 1.60 seconds. The parachute had an average axial-force coefficient of 0.53 during the deceleration period. During the steady-state descent portion of the flight test, the average effective drag coefficient was also 0.53 and pitch-yaw oscillations of the canopy averaged less than 10° in the altitude region above 100,000 feet. Examination of the recovered parachute revealed that it was not damaged during the flight test. Author

N68-24476*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

TRENDS IN REPEATED LOADS ON TRANSPORT AIRPLANES

Thomas L. Coleman Washington May 1968 refs Presented at Symp. on Fatigue Design Procedures, Munich, 16–18 Jun. 1965

(NASA-TN-D-4586) CFSTI: HC $3.00/MF $0.65 CSCL 01C

Statistical loads data collected on piston- and turbine-powered transport airplanes during routine feeder-line, short-haul, and long-haul airline service from 1947 to 1965 are summarized. The data presented pertain to the repeated loads resulting from atmospheric turbulence, maneuvers, airplane oscillatory motions, landing contact, and ground operations. The data for several categories of airplanes are compared to show the trends in the loads with the evolution of the transports. The data are presented in terms of the normal accelerations measured near the center of gravity of the airplanes. It is shown that the distributions of repeated loads for various types of transports exhibit much less variation when expressed in terms of number of occurrences per flight rather than in terms of occurrence per flight mile. Author

N68-24498*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

PRELIMINARY FLIGHT EVALUATION OF THE STABILITY AND CONTROL DERIVATIVES AND DYNAMIC CHARACTERISTICS OF THE UNAUGMENTED XB-70-1 AIRPLANE INCLUDING COMPARISONS WITH PREDICTIONS

Chester W. Wolowicz, Larry W. Strutz, Glenn B. Gilyard, and Neil W. Matheny Washington May 1968 77 p refs

(NASA-TN-D-4578) CFSTI: HC$3.00/MF$0.65 CSCL 01C

Stability and control characteristics of the XB-70-1 airplane were evaluated from data obtained during the early phases of the flight-test program at Mach numbers extending to 2.56 and altitudes to 64,700 feet (19,700 meters). Flight-determined stability and control derivatives and dynamic characteristics for three wing-tip configurations were found generally to be in fair agreement with predictions based on wind-tunnel tests and theoretical estimates of structural flexibility effects. The results show the short-period and Dutch roll modes of the unaugmented aircraft to be positively damped for the flight conditions evaluated. The airplane exhibited negative (adverse) values of the aileron-yaw parameter $C_{n\delta_a}$ at Mach numbers above about 0.90, although proverse values were predicted. Positive values were obtained at subsonic speeds, but the flight-measured values were less than predicted. The flight-determined effective dihedral was negative for fully deflected wing tips (65°) and higher than predicted. The combination of negative effective dihedral and adverse aileron yaw was conducive to divergent pilot-induced oscillation tendencies. Flight tests showed a marked reduction in directional stability beyond approximately 2° of sideslip. This nonlinearity was found in wind-tunnel studies to be the result of canard interference. Author

N68-24499*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A SUMMARY OF ROTOR-HUB BENDING MOMENTS ENCOUNTERED BY A HIGH PERFORMANCE HINGELESS-ROTOR HELICOPTER DURING NAP-OF-THE-EARTH MANEUVERS

William J. Snyder Washington May 1968 31 p refs

(NASA-TN-D-4574) CFSTI: HC$3.00/MF$0.65

A brief investigation was recently undertaken to study the flying qualities and structural loads of a hingeless-rotor helicopter, the XH-51N, during nap-of-the-earth maneuvers. This investigation was part of Langley's continuing flight research with hingeless-rotor helicopters. The series of nap-of-the-earth maneuvers was devised primarily to simulate military helicopter operation in a hostile environment where remaining undetected is a necessity. Most of the maneuvers employed are abrupt turns, starts, and stops which require a helicopter with very good maneuverability to perform them effectively. Previous investigations have shown that the cyclic loads of the hingeless rotor can be very high during these abrupt types of maneuvers. Time histories of the rotor-hub bending moments measured during the investigation show that during the abrupt maneuvers a rapid buildup in the cyclic bending moments occurs. This buildup, in most cases, exceeds the assigned endurance limit of the rotor hub to such an extent that the service life of the hub is significantly shortened. These results indicate that any operational hingeless-rotor helicopter utilized for nap-of-the-earth flying must be carefully evaluated with respect to the service life of the rotor system. Author

N68-24662# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A SUMMARY OF RESULTS ON SONIC-BOOM PRESSURE SIGNATURE VARIATIONS ASSOCIATED WITH ATMOSPHERIC CONDITIONS

I. E. Garrick and D. J. Maglieri Washington May 1968 28 p refs

(NASA-TN-D-4588) CFSTI: HC$3.00/MF$0.65 CSCL 01C

This report reviews the most pertinent information obtained in recent years relating to atmospheric effects on the sonic boom and, in particular, includes some results of various flight programs. These atmospheric effects are complex, and a statistical approach appears necessary. The statistics of peak pressures follows approximately a log normal distribution, a result that is indicated by existing theory for pure (sinusoidal) sound. A tabular summary of the flight data gives the standard deviations of pressure peaks relative to nominal calculated values of the mean. Information is included on observed variations of sonic-boom signatures for different types and sizes of airplanes. Measurements indicate that wavelike spatial patterns exist in which peaked and rounded waves may alternate and vary with time. Such variations are shown to be induced by the atmosphere rather than by effects of airplane unsteady motion. The spectral content of some ideal and some measured pressure signatures is exhibited and discussed with reference to peakedness or roundness of the wave. Author

N68-25313# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

INVESTIGATION OF THE EFFECT OF WHEEL BRAKING ON SIDE-FORCE CAPABILITY OF A PNEUMATIC TIRE

Thomas A. Byrdsong Washington June 1968 24 p refs

(NASA-TN-D-4602) CFSTI: HC$3.00/MF$0.65 CSCL 01B

An experimental investigation was made to determine the effects of wheel braking on the side force capability of a pneumatic tire. Data were obtained from tests of a smooth-tread pneumatic tire with an inflation pressure of 30 pounds per square inch at ground speeds of 10, 20, and 30 miles per hour at wheel yaw angles of 4° and 8° on both wet and dry paved surfaces. The results indicate that a considerable amount of side-force capability is available during wheel braking in the slip-ratio range from free rolling to maximum braking force. For additional wheel braking, the side force decreases rapidly to zero at full skid. Author

N68-25817*# Colorado Univ., Boulder.

OPTIMUM MANEUVERS OF HYPERVELOCITY VEHICLES

A. Busemann, N. X. Vinh, and G. F. Kelley Washington, D. C. NASA Jun. 1968 67 p refs

(Grant NGR-06-003-033)

(NASA-CR-1078) CFSTI: HC$3.00/MF$0.65 CSCL 01B

This report presents the analytical solutions of the problem of optimum maneuvering of a glide vehicle flying at hypervelocity regime. The investigation is based on the approximation of Allen and Eggers, namely along the fundamental part of a reentry or ascent trajectory the aerodynamic forces greatly exceed the components of the force of gravity in the directions tangent and normal to the flight path. The problem consists of finding an optimal control law for the lift program such that the final velocity or the final altitude is maximized. As applications, the problem can be viewed as bringing the vehicle to the best condition for interception, or penetration, or making an evasive maneuver. If the range is not constrained, the solutions are obtained in closed forms. If the lift control is bounded, then bounded control is optimal whenever it is reached. The switching sequences for different cases are discussed and it is shown that there are at most two switchings. When the range is also prescribed the problem consists of integrating a second order nonlinear system. Using Poincaré's series expansions technique, an approximate solution is obtained for the case of optimizing the final velocity with a slightly constrained range. Author

N68-26691*# Dynamic Science Corp., Monrovia, Calif.

A STUDY OF AIRCRAFT FIRE HAZARDS RELATED TO NATURAL ELECTRICAL PHENOMENA Final Report, Jun. 1966-Jul. 1967

Frank L. Kester, Melvin Gerstein, and J. A. Plumer (GE, Pittsfield, Mass.) Washington NASA Jun. 1968 128 p refs Prepared jointly with GE, High Voltage Lab., Pittsfield, Mass.
(Contract NASw-1416)
(NASA-CR-1076; SN-9000) CFSTI: HC $3.00/MF $0.65 CSCL 01B

The problems of natural electrical phenomena as a fire hazard to aircraft are evaluated. Assessment of the hazard is made over the range of low level electrical discharges, such as static sparks, to high level discharges, such as lightning strikes to aircraft. In addition, some fundamental work is presented on the problem of flame propagation in aircraft fuel vent systems. This study consists of a laboratory investigation in five parts: (1) a study of the ignition energies and flame propagation rates of kerosene-air and JP-6-air foams, (2) a study of the rate of flame propagation of n-heptane, n-octane, n-nonane, and n-decane in aircraft vent ducts, (3) a study of the damage to aluminum, titanium, and stainless steel aircraft skin materials by lightning strikes, (4) a study of fuel ignition by lightning strikes to aircraft skins, and (5) a study of lightning induced flame propagation in an aircraft vent system. Author

N68-26930*# Consultants in Engineering Science (CONESCO), Watertown, Mass.
PROCEDURES FOR ESTIMATING THE EFFECTS OF DESIGN AND OPERATIONAL CHARACTERISTICS OF JET AIRCRAFT ON GROUND NOISE
Robert Lee, James Farrell, George Henry, and Albert Lowe Washington NASA Jun. 1968 166 p refs
(Contract NAS1-5724)
(NASA-CR-1053) CFSTI: HC $3.00/MF $0.65 CSCL 01B

Procedures have been developed for estimating the effects of design and operational characteristics of jet aircraft on ground noise; this has been done for various engine-cycle parameters, aircraft-design characteristics, and aircraft-flight characteristics; parametric plots have been prepared to show how these different inter-related factors influence noise; and, when possible, assessments have been made of the accuracies and limitations of the graphs, nomographs, and equations that have been developed. One important general conclusion that can be drawn from all this effort is that it is feasible to develop simplified analytic procedures for relating aircraft design and flight characteristics to ground noise, and that such techniques can be extremely useful for providing design guidance and for showing how various flight paths influence ground noise. The report includes the following: Noise prediction procedures for jets and compressors. An analytical investigation of noise as a function of engine-cycle parameters for jet and fan engines. Several simplified calculational methods for determining PNdb including (a) jet and compressor noise PNdb from overall sound-pressure level, (b) PNdb of the combined jet and compressor noise from individual PNdb values, and (c) variation of PNdb with distance for jet, compressor, and jet combined with compressor noise. An analytical study of ground noise as a function of design and flight characteristics. Author

N68-28153*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
A STUDY OF THE OPTIMUM VALUES OF SEVERAL PARAMETERS AFFECTING LONGITUDINAL HANDLING QUALITIES OF VTOL AIRCRAFT
James R. Kelly and John F. Garren, Jr. Washington Jul. 1968 11 p refs
(NASA-TN-D-4624) CFSTI: HC $3.00/MF $0.65 CSCL 01D

Because of the many factors which influence handling qualities, a disparity often exists between the absolute pilot rating results obtained from various investigations. In this paper, longitudinal handling qualities data from three published studies have been analyzed and compared in terms of pilot rating trends associated with changes in each of several important parameters. Optimum values or points of diminishing returns for each of these parameters (pitch-rate damping, angle-of-attack stability, speed stability, and longitudinal control sensitivity) appear to be largely independent of changes in other parameters and operating conditions covered. Author

N68-28277*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
HOT-GAS INGESTION INVESTIGATION OF LARGE-SCALE JET VTOL FIGHTER-TYPE MODELS
H. Clyde Mc Lemore and Charles C. Smith, Jr. Washington Jun. 1968 258 p refs
(NASA-TN-D-4609) CFSTI: HC $3.00/MF $0.65 CSCL 01C

An investigation to study the problem of hot-gas ingestion was conducted in the Langley full-scale tunnel and outdoors on large-scale jet VTOL fighter-type aircraft configurations. The investigation included several rectangular and in-line exhaust-nozzle arrangements, inlet positions, and wing positions for a range of forward and side-wind conditions. The exhaust-gas source was a turbojet engine operating at a nozzle pressure ratio of about 1.8 and a nozzle temperature of 1200°F (649°C). The ingestion of hot-engine exhaust gases into the inlets was found to be very dependent upon the aircraft configuration and upon the wind speed. An in-line arrangement of engine exhaust nozzles resulted in virtually no hot-gas ingestion, whereas a rectangular arrangement of nozzles resulted in an inlet air temperature rise above ambient of 100°F to 200°F for many test conditions. The ingestion of hot exhaust gases was greatest at wind speeds from zero to 20 knots, and there was virtually no hot-gas ingestion than the side inlets, and the low-wing configuration was found to result in lower inlet air temperatures than did the high-wing configuration. Deflecting the jet exhaust 25° rearward with the vectoring nozzles generally eliminated the ingestion of hot exhaust gases. Author

N68-28831*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AIRPLANE SIZE AND STAGING EFFECTS ON SST CRUISE SONIC BOOM
John B. Whitlow, Jr. Washington Jul. 1968 53 p refs
(NASA-TN-D-4677) CFSTI: HC $3.00/MF $0.65 CSCL 01B

An analytical study was made to determine the performance requirements and economic penalities involved in reducing the cruise sonic boom of various sizes of a domestic-range SST. No attempt was made to reduce the climb sonic boom since climb might possibly be scheduled over sparsely populated areas. For airplanes in the 200-passenger category, it was found that cruise at nonoptimum altitudes allows reductions up to 10 per-cent in initial cruise boom at the expense of a 10-percent increase in DOC. By size and weight reductions, cruise boom can be reduced almost 40 percent at the expense of a five-fold increase in DOC. A similar study of a two-stage vehicle with stage separation just prior to cruise revealed that a boom reduction of only about 5 percent is possible with this concept, relative to unstaged airplanes of the same payload capacity. Author

N68-29372*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
SIMULATION STUDIES OF THE SUPERSONIC TRANSPORT IN THE PRESENT DAY AIR TRAFFIC CONTROL SYSTEM
Richard H. Sawyer, Milton D. McLaughlin, and Norman S. Silsby Washington Jul. 1968 78 p refs
(NASA-TN-D-4638) CFSTI: HC $3.00/MF $0.65 CSCL 17G

The problems for the supersonic transport (SST) encountered in operations in a simulated present day air traffic control (ATC) system have been studied in real time by using an SST aircraft flight simulator and ATC simulation facilities. Airline crews operated the SST flight simulator, and experienced air traffic controllers operated

the ATC simulation facilities. Design study configurations of the SST were used in the tests. The test program consisted of departures and arrivals under weather conditions which required operation by FAA instrument flight rules in the New York and San Francisco terminal areas. The investigation showed that on established departure and arrival routes the SST was required in many instances to make substantial changes in heading at low supersonic speeds. For departures, such turns were detrimental to performance; straight-line route segments from 120 to 170 nautical miles long for SST supersonic acceleration were considered to be highly desirable. On the basis of fuel allowances, terminal area maneuvering in the New York area consumed on the average up to 40 percent of the en route contingency fuel in departures and up to 38.6 percent in arrivals. Crew workload associated with ATC communications and navigation was not, in general, enough higher than that for subsonic jet transport operations to elicit adverse comments from the pilots. Author

N68-29406*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

NOISE REDUCTION BY MEANS OF INLET-GUIDE-VANE CHOKING IN AN AXIAL-FLOW COMPRESSOR

David Chestnutt Washington Jul. 1968 32 p refs

(NASA-TN-D-4682) CFSTI: HC$3.00/MF$0.65 CSCL 10A

Studies have been made to evaluate noise-reduction benefits obtainable by alteration of the inlet guide vanes of a specially designed 25-pound/second (11.32-kilogram/second) three-stage transonic axial-flow research air compressor. Particular attention has been given to the use of inlet guide vanes to choke the flow aerodynamically for the purpose of preventing noise radiation out of the inlet. Choking was obtained in the inlet guide vanes either by increasing the thickness of each inlet guide vane or by turning the inlet guide vanes to reduce the air passage area and increase the airflow. When the vane thickness was increased, there were no compressor-efficiency losses. When the vanes were turned, there was an average compressor-efficiency loss of 8 percent. The results indicate that inlet guide vanes with variable thickness hold the most promise for maximum noise reductions without compromising compressor performance. However, for both methods of obtaining choked flow, there were pressure-ratio losses of 7 to 8 percent. The corresponding noise reductions obtained in both choked-flow modes were 25 to 30 decibels in the overall sound pressure level and 36 decibels in the first-rotor-blade passage-frequency sound pressure level. Author

N68-29887*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SOUND MEASUREMENTS ON A FULL-SCALE JET-ENGINE INLET-NOISE-SUPPRESSOR COWLING

L. Jack Smith, Loren W. Acker, and Charles E. Feiler Washington Jul. 1968 27 p refs

(NASA-TN-D-4639) CFSTI: HC$3.00/MF$0.65 CSCL 21E

Several prototype suppressors were ground tested on a jet engine. Broadband resonant absorbers were used as the acoustic absorption treatment. Inlet geometries included both acoustically treated struts and a circumferential splitter ring. Results of calculations on far field noise data showed a maximum total sound power reduction of 10.2 decibels and simulated flyover noise reductions up to 10.5 perceived noise decibels. Strut geometries were best for sideline noise reduction, but the splitter configuration, with the most treated surface areas, achieved the greatest sound power reduction. A mathematical model of sound power attenuation correlated with the data. Author

N68-31956*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.

EXPERIMENTAL VERIFICATION OF SCALE FACTORS FOR PARAWING OPENING CHARACTERISTICS

David L. Eichblatt, Robert H. Moore, and Richard L. Barton Washington Aug. 1968 30 p refs

(NASA-TN-D-4665) CFSTI: HC$3.00/MF$0.65 CSCL 01C

The verification of an analytical scaling technique by experimental drop tests under controlled conditions is presented in which the opening characteristics of a full-scale flexible parawing are predicted from the results of model testing. The scaling method is derived from a comparison of similar forces (in the equation of motion) on a scale model with a keel length of 4 feet and a full scale of 8 feet. Initial velocities of 17 to 40 feet per second were used in the test program. Test results within the scope of the program indicate that the models can be used to predict full-scale deployment characteristics. Author

N68-33669*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EFFECT OF SPEED BRAKES ON THE SUPERSONIC AERODYNAMIC CHARACTERISTICS OF A VARIABLE SWEEP TACTICAL FIGHTER MODEL AT MACH NUMBERS FROM 1.60 TO 2.50

Celia S. Richardson Washington Sep. 1968 35 p refs

(NASA-TN-D-4773) CFSTI: HC$3.00/MF$0.65 CSCL 01B

An investigation has been made in a wind tunnel to determine the effect of various speed-brake configurations on the aerodynamic characteristics of a current multimission tactical fighter model. The speed-brake configurations, which included upgapped and gapped brakes with variations in area, location, planform, and deflection angle, were tested at Mach numbers from 1.60 to 2.50 for a wing-leading-edge sweep angle of 72.5°. Tests were made through an angle-of-attack range from about $-4°$ to 28° and at angles of sideslip from about $-6°$ to 11°. The test Reynolds number was 3.0×10^6 per meter). The results indicated the drag values of a gapped and an ungapped brake configuration were about the same; even though the gapped speed brakes were somewhat smaller than the ungapped brakes. The ungapped speed brakes generally increased the directional stability of the model. The gapped speed brakes generally reduced the directional stability of the model particularly at the higher test Mach numbers. Author

N68-33879*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

FREE-FLIGHT AND WIND-TUNNEL STUDIES OF DEPLOYMENT OF A DYNAMICALLY AND ELASTICALLY SCALED INFLATABLE PARAWING MODEL

Alice T. Ferris and H. Neale Kelly Washington Sep. 1968 44 p refs

(NASA-TN-D-4724) CFSTI: HC$3.00/MF$0.65 CSCL 01A

The deployment characteristics of a 1/8-size dynamically and elastically scaled model of an inflatable parawing suitable for the recovery of an Apollo-type spacecraft were investigated in free flight and in the Langley transonic dynamics tunnel using a model which was mounted to permit limited angular freedom. The deployments were of a passive type; that is, there was no powered reel-in or reel-out of the suspension lines. However, a braking system was used to attenuate the dynamic loads in the suspension lines. The deployment technique was developed in an initial series of wind-tunnel tests. By utilizing the equipment and technique evolved from the wind-tunnel studies, successful free-flight deployments were accomplished and the transient loads associated with the deployments were measured. These results were compared with the results of subsequent wind-tunnel tests. The general behavior of the parawing during deployment in the wind tunnel and during free flight was similar and loads measured in the wind tunnel can be used to give a preliminary indication of those that will be encountered in free-flight deployments. Thus, it was concluded that the wind tunnel can serve as a useful tool in the development of a deployment technique for an inflatable parawing. Author

N68-34907*# National Aeronautics and Space Administration, Washington, D. C.
SECOND CONFERENCE ON SONIC BOOM RESEARCH
Ira R. Schwartz ed. 1968 218 p refs Conf. held at Washington, D.C., 9–10 May 1968; Sponsored by NASA
(NASA-SP-180) CFSTI: HC$3.00/MF$0.65 CSCL 01A

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N68-35177*# Boeing Co., Morton, Pa. Vertol Div.
SUPPLEMENT TO FEASIBILITY OF V/STOL CONCEPTS FOR SHORT-HAUL TRANSPORT AIRCRAFT
Bernard L. Fry Washington NASA Sep. 1968 63 p refs
(Contract NAS2-3142)
(NASA-CR-743(1); D8-0375, V. 3) CFSTI: HC $3.00/MF $0.65 CSCL 01C

Examination of the aircraft designed to the ground rules of the original study showed the considerable influence on aircraft size, and therefore cost, of such parameters as flight profile and fixed equipment assumptions. A revised set of ground rules was developed with respect to range, payload, reserves, flight profile, etc., and tilt wing and lift fan aircraft were designed to these ground rules. More economical aircraft than those designed to the original rules have resulted. One of the tradeoffs made in the original study investigated the effect of advanced propulsion technology. This report investigates the effect of advanced airframe and propulsion technology and shows that weight savings of more than 20 percent and direct operating cost (D.O.C.) reductions of 13 to 25 percent may be possible relative to 1970 aircraft designed to identical ground rules. Author

N68-35595*# Litchford Systems, Northport, N. Y.
ANALYSIS OF CUMULATIVE ERRORS ASSOCIATED WITH CATEGORY 2 AND 3 OPERATIONS WITH REQUIREMENTS FOR ADDITIONAL RESEARCH
G. B. Litchford Washington NASA Sep. 1968 29 p refs
(Contract NASw-1441)
(NASA-CR-1188) CFSTI: HC$3.00/MF$0.65 CSCL 01B

The results are presented of a study and investigation of conventional and unconventional terminal flight paths for CTOL aircraft in connection with low visibility landing problems. The interrelationships of the geometry of possible approach paths, visual and electronic guidance equipments, and numerous aircraft piloting problems are reviewed. Pilot display requirements for optimizing these interrelationships under typical airline operating conditions are described as well as the flight path dispersions expected at the transition from instrument to visual flight guidance. Areas requiring improved simulation, flight validation, or other means of establishing statistically significant data for these critical operations are identified. The ILS standards will be examined to identify errors that affect the transition from instrument to visual flight. Author

N68-36073*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
LANDING LOADS AND ACCELERATIONS OF THE XB-70-1 AIRPLANE
Ronald J. Wilson and James M. McKay Washington Oct. 1968 29 p refs
(NASA-TN-D-4836) CFSTI: HC$3.00/MF$0.65 CSCL 01C

Data are presented on landing contact conditions for the first 48 landings of the XB-70-1 airplane. Landing weights varied from 419,800 pounds to 274,600 pounds. Vertical velocities at touchdown ranged from 5.26 feet/second to 1.49 feet/second. Maximum indicated airspeed was 195.0 knots, with a minimum of 167.3 knots. Landing contact conditions of the XB-70-1 are compared with those of a modern turbojet transport. The mean vertical velocity at touchdown for the XB-70-1 was 3.21 feet/second, which was 1.59 feet/second higher than that reported for the turbojet transport. A mean indicated airspeed of 180.5 knots was 47.7 knots greater than that reported for the transport. The maximum XB-70-1 roll angle (3.0) and rolling velocity (3.28 deg/sec) at touchdown were less than the values (4.3° and 8.7 deg/sec, respectively) for the transport. The measured main gear maximum vertical reaction generally compared favorably with predicted values. The nose gear initial maximum vertical reactions were generally less than the predicted values. The mean acceleration measured at the pilot's station was 1.39g due to main gear impact and 1.54g due to nose gear impact. Author

N68-36074*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPARATIVE STUDY OF FUSELAGE TANKS FOR LIQUID METHANE FUELED SUPERSONIC AIRCRAFT
Rene E. Chambellan and William A. Bevevino Washington Oct. 1968 18 p refs
(NASA-TN-D-4837) CFSTI: HC$3.00/MF$0.65 CSCL 01C

Three designs of flight-weight nonintegral tanks, capable of gage pressures of 15 or 30 psi (10.8 or 20.7 N/cm^2), were studied. Two void spaces representative of a forward and an aft fuselage segment were selected. Ratios of tank weight to contained fuel weight range from 0.0110 to 0.0482 and volumetric efficiencies range from 75 to 95.4 percent. Tanks studied are thin walled pressure vessels of titanium or nonmetallic fabric constrained to an envelope by structural elements internal to the tank. Author

N68-37066*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EFFECTS OF VARIATIONS IN NOSE AND WINDSHIELD GEOMETRY ON SUPERSONIC AERODYNAMIC CHARACTERISTICS OF A VARIABLE-SWEEP TACTICAL FIGHTER MODEL
Celia S. Richardson Washington Oct. 1968 55 p refs
(NASA-TM-X-1664) CFSTI: HC$3.00/MF$0.65 CSCL 01C

An investigation was made in the low Mach number test section of the Langley Unitary Plan wind tunnel to determine the effects of various nose and windshield shapes on the aerodynamic characteristics of a current multimission tactical fighter model. Tests were performed for a wing leading edge sweep of 72.5° at Mach numbers of 1.6, 2.16, and 2.50, at angles of attack from about −2° to 20°, and at angles of sideslip of about 0° and 4°. The Reynolds number per foot was 3.0×10^6. The data indicate that each of the forebody modifications, which resulted in forebodies somewhat longer than the basic forebody, generally caused a slight increase in minimum drag and a reduction in directional stability. Author

N68-37075*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EFFECTS OF REDUCED AIRSPEED FOR LANDING APPROACH ON FLYING QUALITIES OF A LARGE JET TRANSPORT EQUIPPED WITH POWERED LIFT
Harold L. Crane, Robert W. Sommer, and Frederick M. Healy Washington Oct. 1968 91 p refs
(NASA-TN-D-4804) CFSTI: HC$3.00/MF$0.65 CSCL 01B

A flight research program was conducted to determine the effects of reduced landing approach speeds on the flying qualities of a typical large jet transport for simulated instrument approaches. The reduced approach speeds were made possible by a powered lift system which blew air over the upper surface of the wing flaps. The effects of reduced approach speeds on flying qualities and flying-qualities requirements are discussed. It was found that a 25 percent reduction in landing approach speed would not necessarily result in new requirements for satisfactory flying qualities. However, such items as pitch response and trim characteristics, Dutch roll damping, and lateral directional coupling are likely to be more difficult to maintain at satisfactory levels. Author

N68-37932*# Southampton Univ. (England).
HELICOPTER NOISE–A BLADE SLAP. PART 1: REVIEW AND THEORETICAL STUDY
John W. Leverton Washington NASA Oct. 1968 58 p refs
(Grant NGR-52-025-002)
(NASA-CR-1221) CFSTI: HC$3.00/MF$0.65 CSCL 01C

This report reviews previous work on the topic of blade slap and the various mechanisms for its generation. It is concluded that blade/tip vortex interaction is the most likely noise producing mechanism. A theoretical approach to the problem leading to the development of a Blade Slap Factor (BSF), which will give an indication of the severity of blade slap likely on any helicopter, is also included. A comparison between some subjective assessments of the blade slap noise and the BSF is also given. Author

N68-37941*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
WIND TUNNEL INVESTIGATION OF AIRFRAME INSTALLATION EFFECTS ON UNDERWING ENGINE NACELLES AT MACH NUMBERS FROM 0.56 TO 1.46
Bernard J. Blaha and Daniel C. Mikkelson Washington Nov. 1968 83 p refs
(NASA-TM-X-1683) CFSTI: HC$3.00/MF$0.65 CSCL 01C

A 1/20 scale model of the F-106B with simulated underwing engine nacelles was tested in the 8- by 6-foot supersonic wind tunnel. Pressures and boattail drag coefficients were obtained on cone-cylinder and bulged nacelles with 15° conical boattail afterbodies and jet boundary simulators. Data were obtained with and without inlet airflow through the nacelles at attack angles from 0° to 8°. Effects of nacelle strut geometry, local elevon geometry, and elevon deflection were also investigated. The installed boattail pressure drag coefficient was lower than isolated nacelle values at all Mach numbers, and transonic drag rise was delayed to Mach 0.975. Author

03

AUXILIARY SYSTEMS

Includes fuel cells, energy conversion cells, and solar cells; auxiliary gas turbines; hydraulic, pneumatic and electrical systems; actuators; and inverters. For related information see also: 09 Electronic Equipment; 22 Nuclear Engineering; and 28 Propulsion Systems.

N68-10103*# *National Aeronautics and Space Administration.* Lewis Research Center, Cleveland, Ohio.

AUTOMATED DATA COLLECTION SYSTEM APPLIED TO HALL EFFECT AND RESISTIVITY MEASUREMENTS

Ralph D. Thomas Washington NASA Nov. 1967 26 p refs

(NASA-TM-X-1464) CFSTI: HC$3.00/MF$0.65 CSCL 14B

A description of the instrumentation and theory of operation of a fully programmable automated Hall effect and resistivity apparatus is presented. The apparatus has the capability of controlling all operational conditions over a wide range of temperatures and logging data in the form of both typewritten copy and computer-compatible punched paper tape. Application of the system for measuring both thin film and bulk samples of cadmium sulfide and bulk samples of n-type and p-type silicon in the temperature region between 4.2° and 400°K is discussed. Also discussed are a simple yet highly reliable technique for obtaining ohmic contacts to the samples, the systematic procedure followed for each measurement run, the data program and computer recording format, and samples of the computer results. Extension of the system to include measurement of materials of high resistivity was achieved by operating a high-input-impedance electrometer between the sample leads and the input scanner. A sample holder was designed to accept either thin-film samples on substrates up to 1-inch (2.54 cm) square or bridge-shaped bulk samples. A complete Dewar system was assembled for controlling the temperature and sample environment at temperatures between 4.2° and 400°K. The system accuracy and specifically the accuracy of the reduced Hall effect and resistivity measurements are discussed. Calibration procedures for the thermocouples and gaussmeter are outlined. Author

N68-11920*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL PERFORMANCE EVALUATION OF A 6.02-INCH (15.29-CM) RADIAL-INFLOW TURBINE WITH AN EXIT DIFFUSER

Samuel M. Futral, Jr. and Donald E. Holeski Washington Dec. 1967 17 p refs

(NASA-TM-X-1480) CFSTI: HC$3.00/MF$0.65 CSCL 10A

The evaluation used argon as the working fluid and covered a range of speeds and pressure ratios. Turbine inlet conditions were fixed at values corresponding to design Reynolds number for design equivalent speed and design pressure ratio operation. Results of the investigation indicated that, at design equivalent speed and pressure ratio, the turbine static efficiencies before and after diffusion were 0.825 and 0.865, respectively. The results also indicated a decrease in total efficiency of approximately 2 percent across the diffuser with the leaving loss accounting for less than 1 percentage point in the efficiency. The ratio of diffuser static pressure recovery to the diffuser inlet impact pressure was approximately 0.6. This recovery is about 71 percent of the isentropic incompressible value for the same area ratio. Author

N68-14630* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PARAMETRIC ANALYSIS OF RADIOISOTOPE-THERMOELECTRIC GENERATORS

James J. Ward, William J. Bifano, and Larry S. Blair Washington Oct. 1967 22 p ref

(NASA-TM-X-1453) CFSTI: $3.00 CSCL 10B

A parametric analysis of a radioisotope-thermoelectric power generator is presented. A cylindrical heat-source geometry was assumed with either lead telluride or silicon-germanium thermoelectric elements located around the lateral surface of the fuel block. The heat source was treated parametrically by using the effective-volume power density of the heat source as a variable. Generator efficiency and specific weight were determined for fuel-block length-to-diameter ratios from 0.5 to 10.0, effective-volume power densities from 0.5 to 10.0 watts per cubic centimeter (W/cc), thermoelectric element hot-junction temperatures of 811°K for lead telluride and 1089° and 1255°K for silicon-germanium, and generator electrical output powers from 100 to 1000 watts. The results indicate that a substantial specific weight advantage is gained by employing silicon-germanium thermoelectric elements rather than lead telluride. In all cases, however, minimum specific weight is achieved at the lowest output power level, that is, 100 watts electric (W_e). For silicon-germanium generators having an output power of 100 W_e, the minimum specific weights are 120 and 88 lb/kW_e (54.5 and 40 kg/kW_e) for hot-junction temperatures of 1089° and 1255°K, respectively, with corresponding generator efficiencies of 4.1 and 5.8 percent. Author

N68-14639*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE EVALUATION OF A TWO STAGE AXIAL-FLOW TURBINE FOR TWO VALUES OF TIP CLEARANCE

Milton G. Kofskey and William J. Nusbaum Washington Jan. 1968 20 p refs

(NASA-TN-D-4388) CFSTI: HC$3.00/MF$0.65 CSCL 10A

An experimental investigation was made of a two-stage turbine designed to drive an alternator for a 10-kilowatt-shaft-output space power system. Performance results were obtained for the turbine operating with the rotor top clearance of 0.031 inch (0.079 cm) recommended for preliminary hot operation of the turbine. These results are compared with the results obtained with the design tip clearance of 0.013 inch (0.033 cm). Tests were made with cold argon as the working fluid over a speed range from 0 to 120 percent of design equivalent speed and at pressure ratios ranging from 1.08 to 1.55. The results of the investigation indicated that the static and total efficiencies were 0.785 and 0.792, respectively, for a tip clearance of 0.031 inch (0.079 cm). These values represent a 4-percentage-point decrease in turbine efficiency when the tip clearance is increased. The results based on

two tip clearances indicated that the subject turbine, which was designed with high rotor reaction, was very sensitive to changes in tip clearance. There was a 3.7-percent decrease in turbine specific work for an increase in tip clearance of 1.0 percent of passage height. This decrease is substantially greater than the 1.75-percent decrease in turbine work obtained for a reference turbine of impulse design. Author

N68-15943*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYTICAL DETERMINATION OF RADIAL INFLOW TURBINE DESIGN GEOMETRY FOR MAXIMUM EFFICIENCY

Harold E. Rohlik Washington Feb. 1968 32 p refs

(NASA-TN-D-4384) CFSTI: HC$3.00/MF$0.65 CSCL 10A

Radial turbine performance was examined analytically in order to determine optimum design geometry for various applications as characterized by specific speed. Five specific losses were calculated for various combinations of stator-exit flow angle, outlet- to inlet-diameter ratio, and the ratio of stator blade height to rotor-exit diameter. The losses considered were stator loss, rotor loss, tip-clearance loss, windage, and exit kinetic energy. Resulting static efficiencies ranged from 0.23 to 0.87 for a specific-speed range of 15 to 173 (0.12 to 1.34). Turbine pressure ratio had no appreciable effect on optimum geometry except in the case of stator blade height. Curves of blade-jet speed ratio, stator-exit flow angle, tip-diameter ratio, and the ratio of stator blade height to rotor-inlet diameter are presented for maximum static efficiency over a wide range of specific speed. These curves permit the systematic selection of optimum turbine size and shape for a variety of turbine applications. An exit diffuser of 0.6 effectiveness was examined for its effect on overall performance. The gain in static efficiency was appreciable except at very high specific speeds where a lower diffuser effectiveness or a different type of turbine would be required. Author

N68-16228*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE IN AIR OF 4-INCH-(10.16-CM-) MEAN-DIAMETER SINGLE STAGE AXIAL-FLOW TURBINE FOR REYNOLDS NUMBERS FROM 4,900 TO 188,000

Hugh A Klassen and Robert Y Wong Washington Feb. 1968 25 p refs

(NASA-TN-D-4383) CFSTI: HC$3.00/MF$0.65 CSCL 10A

A 4-inch mean-diameter turbine was investigated in air over a range of absolute inlet total pressures from 1.0 to 35.0 psia which corresponds to a Reynolds number range of 4900 to 188 000. Results were compared with those obtained for a reference 4-inch mean-diameter turbine with higher peak suction surface velocities on the stator and rotor and with higher rotor surface diffusion. Peak efficiency for the subject turbine increased from 0.40 at the lowest Reynolds number to 0.63 at the highest. The turbine had higher peak efficiencies than the reference turbine over the entire Reynolds number range. Stator- and rotor-outlet flow separation reported for the reference turbine was absent in the subject turbine except for the lowest Reynolds number of 4900, where the rotor-relative-outlet flow angle was 14° greater than design. Rotor losses were smaller than those used in the turbine design. The stator over-expansion caused by these low losses resulted in negative rotor reaction. Stator, rotor, and exit losses were computed for a blade-jet speed ratio of 0.32 and an overall static-to static-pressure ratio of 2.5. Author

N68-16321*# Douglas Aircraft Co., Inc., Newport Beach, Calif. Astropower Lab.

INORGANIC SEPARATOR FOR A HIGH TEMPERATURE SILVER–ZINC BATTERY

F. C. Arrance, R. Greve, and A. Rosa Washington NASA Feb. 1968 177 p refs

(Contract NAS3-7639)

(NASA-CR-965; SM-48461-F) CFSTI: HC $3.00/MF $0.65 CSCL 10C

The design, development and testing of a multiplate five amperehour cell are described. The fabrication of the various cell components in accordance with the cell design is discussed, and the testing and evaluation of each is described with emphasis on electrode configuration and performance. Graphs are given to illustrate results of cycling tests performed on the various cells at 30 ma/cm^2 at 25° and 100°C. Among the results from the evaluation and performance of the zinc cells constructed with inorganic separators are: (1) The 5-Ah silver–zinc cells of this type are capable of long cycle life at both 25° and 100°C. (2) The cells can be operated using KOH concentrations ranging from 30% to 45% without substantially effecting operating characteristics or cell life. (3) The inorganic separator proved its effectiveness in preventing electrode species migration, its inertness to reaction with the silver electrode, and its applicability to practical high energy density cell designs. B.S.D.

N68-16439*# General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.

TWO-STAGE POTASSIUM TEST TURBINE. VOLUME 2: FLUID DYNAMIC DESIGN AND PERFORMANCE

R. J. Rossbach and G. C. Wesling Washington NASA Feb. 1968 240 p refs

(Contract NAS5-1143)

(NASA-CR-922) CFSTI: HC$3.00/MF$0.65 CSCL 10A

The design, fabrication and test of a two-stage turbine suitable for operation in wet potassium vapor at temperatures of 1400 to 1600°F are reported. The test turbine consisted of stages three and four of a five-stage 500 KW turbine and had a design flow capacity of 2.8 pounds per second at 1600°F turbine inlet temperature. One principal objective of the program was to establish accurate fluid flow design methods for potassium turbines operating in the wet vapor region. The fluid flow design methods were verified when performance data measured during tests with potassium vapor agreed within five percent with values calculated prior to the tests. Author

N68-16469*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AERODYNAMIC EVALUATION OF TWO-STAGE AXIAL FLOW TURBINE DESIGNED FOR BRAYTON-CYCLE SPACE POWER SYSTEM

Milton G. Kofskey and William J. Nusbaum Washington Feb. 1968 30 p refs

(NASA-TN-D-4382) CFSTI: HC$3.00/MF$0.65 CSCL 10B

An experimental investigation was conducted of a two-stage turbine designed to drive an alternator for a 10-kilowatt-shaft-ouput space power system. First-stage and two-stage performance results are described for operation at approximately design Reynolds number at equivalent design speed and pressure ratio with argon as the working fluid. Tests were made at speeds ranging from 1 to 120 percent of equivalent design speed and at pressure ratios from 1.02 to 1.65. The results of the investigation indicated that, for two-stage operation, the static and total efficiencies, based on turbine-inlet and rotor-exit conditions, were 0.825 and 0.845, respectively, which compare favorably with design. The equivalent mass flow, however, was 4 percent lower than design and was attributed to the flow areas in the blade rows being smaller than design. At this point the first- and second-stage total efficiencies were 0.864 and 0.805 or approximately 2 points higher and 4 points lower than design, respectively. Two-stage performance based on turbine-inlet and collector-exit tions indicated static and total efficiencies of 0.826 and 0.835, respectively. These results, which indicate a drop in total efficiency within the collector of approximately 1 point with no change in static efficiency, compare closely with design. Author

N68-16631*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PARAMETRIC MASS ANALYSIS AND COMPARISON OF TWO TYPES OF REACTANT COOLING-AND-STORAGE UNITS FOR A LUNAR-BASED HYDROGEN-OXYGEN REGENERATIVE FUEL-CELL SYSTEM
Norman H. Hagedorn Washington Feb. 1968 34 p refs
(NASA-TN-D-4386) CFSTI: HC $3.00/MF $0.65 CSCL 13A

This study was to determine the effect of prestorage reactant cooling on the mass of a lunar-based hydrogen-oxygen regenerative fuel cell system. Consideration was given to cooling by radiators and by refrigerator–radiator combinations. Parametric mass analyses were performed for components of each cooling-and-storage unit and for the residual reactant in each tank. The combined radiative-plus-refrigerative unit has a minimum mass when the reactant is cooled to subcritical temperatures. The mass of the purely radiative unit minimizes when the reactant is cooled to within 0.5°K of the radiator sink temperature. All cooling which occurs above these optimum temperatures decreases, but does not minimize, the mass of these units. Decreasing the final storage pressure leads to considerable mass increases when the reactants are stored at supercritical temperatures. There exists an optimum allowable heat leak into the storage tanks which minimizes the total mass of the unit. For the combined unit there exists an optimum heat-rejection temperature which minimizes the sum of the masses of the solar cells and the radiator required by the refrigerator. Author

N68-17075*# General Electric Co., Cincinnati, Ohio.
TWO-STAGE POTASSIUM TEST TURBINE. VOLUME 2: MECHANICAL DESIGN AND DEVELOPMENT
H. E. Nichols and R. W. Fink Washington NASA Feb. 1968 227 p refs
(Contract NAS5-1143)
(NASA-CR-923) CFSTI: HC $3.00/MF $0.65 CSCL 10A

This report is one of a series describing the design and development of a two-stage, Rankine cycle turbine for operation with potassium vapor. This volume presents the turbine mechanical design and describes a three-phase development test program comprising stem and air testing, potassium vapor performance testing, and a 2000-hour endurance test with turbine inlet potassium vapor at 1500°F. As part of the endurance testing, four each of TZM and TZC molybdenum blades were inserted in the second stage to observe any effects of corrosion and/or erosion. The average weight changes of the rotor blades during the endurance test were: Stage 1 (U-700), −0.304%; Stage 2 (U-700), −0.019%; Stage 2 (TYM), −0.105%; and Stage 2 (TYC), −0.102%. The testing demonstrated minimal deterioration of the turbine parts in 2100 hours of vapor operation and the feasibility of long-time operation of a potassium turbine of the design described herein. Author

N68-17110*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REDUCTION OF APPARENT-POWER REQUIREMENT OF PHASE-CONTROLLED PARASITICALLY LOADED TURBO-ALTERNATOR BY MULTIPLE PARASITIC LOADS
Leonard J. Gilbert Washington Feb. 1968 35 p refs
(NASA-TN-D-4302) CFSTI: HC $3.00/MF $0.65 CSCL 10B

Alternator output is improved when a phase-controlled parasitically loaded turbo-alternator has multiple sequentially actuated parasitic loads. Phase-controlled currents produce some unwanted effects. Included among these effects is an increase in the apparent-power (volt–ampere) requirement of the alternator. Phase control also produces strong harmonic components in the alternator current. The effects derive from the nonsinusoidal and reactive character of the parasitic load. The results of the analysis give the alternator apparent power and the toal harmonic content of the alternator current as a function of parasitic load. One means of reducing the unwanted effects is to subdivide the parasitic load. The analysis shows this reduction as a function of the number of divisions of the parasitic load. For the model of the circuit analysis, an undivided parasitic load produces a total harmonic content of 32 percent in the alternator current when used with a basic 0.8 lagging power factor load. But when the parasitic load is divided into two loads, the total harmonic content is reduced to 18 percent. With the same basic 0.8 lagging power factor load, the apparent power with an undivided parasitic load is 7.6 percent greater than the apparent power without a parasitic load. However, when the parasitic load is divided, this difference is only 3 percent. Additional division of the original parasitic load reduces the undesirable effects further. The amount of improvement at each division decreases appreciably with increasing number of loads, lessening the advantage obtained from load division. Author

N68-18044*# General Electric Co., Cincinnati, Ohio.
TWO-STAGE POTASSIUM TEST TURBINE. VOLUME 3: TEST FACILITIES
S. E. Eckard Washington NASA Feb. 1968 199 p refs
(Contract NAS5-1143)
(NASA-CR-924, V. 3) CFSTI: HC $3.00/MF $0.65 CSCL 10A

A detailed description of the two phase potassium test facility is presented. Pertinent information on operating procedures and problems is disclosed. The potassium containment piping and component hardware in the test facility were fabricated of Type 316 stainless steel. The facility was designed to produce potassium vapor up to 1600°F at 3.5 lb/sec flowrate. Maximum obtainable vapor temperature was 1587°F. The test facility was designed for Rankine cycle testing of a two-stage potassium vapor turbine. More than 2000 hours of turbine testing were completed at 1500°F turbine inlet temperature. Also thermodynamic properties of potassium vapor were experimentally investigated by flowing potassium vapor through a large convergent–divergent nozzle prior to turbine testing. Author

N68-18501*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL PERFORMANCE EVALUATION OF AN 8.5 INCH (21.59 CM) MEAN-DIAMETER AXIAL FLOW TURBINE AT REYNOLDS NUMBERS FROM 18,000 TO 177,000
William J. Nusbaum and Milton G. Kofskey Washington Mar. 1968 21 p refs
(NASA-TN-D-4432) CFSTI: HC $3.00/MF $0.65 CSCL 10A

An experimental investigation of an 8.5-inch- (21.59-cm-) mean-diameter, two-stage, axial-flow turbine was conducted to determine the effect of a change in Reynolds number on the performance of a turbine of this type and size. The investigation was conducted with cold argon over a range of inlet pressures from about 1.0 to 9.0 psia (0.68 to 6.2 N/cm^2 abs) with corresponding Reynolds numbers from 18,000 to 177,000. At each value of turbine-inlet pressure, data were taken at design equivalent speed and various pressure ratios. Results of the investigation indicated that at design equivalent speed and pressure ratio an increase in Reynolds number resulted in a 5.8 percent increase in mass flow over the range of Reynolds number covered. The total efficiency at design equivalent speed and pressure ratio increased from 0.82 to 0.88 with an increase in Reynolds number over the same range. The corresponding static efficiency increased from 0.80 to 0.86. The variation in loss with change in Reynolds number agreed well with a theoretical variation, wherein 0.7 of the loss was attributed to viscous losses and the remaining 0.3 was attributed to other losses which are independent of Reynolds number. Author

N68-18702*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DYNAMIC CHARACTERISTICS OF PARASITIC LOADING SPEED CONTROLLER FOR 10 KILOWATT BRAYTON CYCLE TURBOALTERNATOR

Raymond L. E. Fischer and Darryl J. Droba Washington Mar. 1968 18 p refs
(NASA-TM-X-1456) CFSTI: HC$3.00/MF$0.65 CSCL 10B

An investigation was conducted to determine the operating characteristics of a static parasitic-loading speed controller, including the transient and off-design characteristics, when operating with an air driven turboalternator. The speed controller was designed to be used with the turboalternator in a 400 hertz Brayton cycle power conversion system. The speed controller begins to deliver power to the parasitic load when the turboalternator output frequency increases above the rated frequency of 400 hertz, and it delivers maximum power to the load when the frequency reaches 406 hertz. With this controller, the system speed was maintained within 2 percent for voltage variations from 140 to 92 volts and step load changes of 10 kilowatts, with an alternator output of 10.5 kilowatts. Author

N68-18998*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYSIS OF THE MAXIMUM PERFORMANCE OF A PARABOLOIDAL SOLAR COLLECTION SYSTEM FOR SPACE POWER

Gabriel N. Kaykaty Washington Mar. 1968 19 p refs
(NASA-TN-D-4415) CFSTI: HC$3.00/MF$0.65 CSCL 10B

An analytical study was performed to investigate the effects and interactions of the concentrator surface errors and rim angle, collection system orientation error, and cavity receiver operating temperature on the maximum thermal efficiency of a paraboloid collection system operating in the vicinity of the earth. The ranges investigated were: standard deviation of surface error (0 to 18 min), orientation error (0 to 30 min), receiver temperature (2000° to 4000°R or 1110° to 2200°K), and concentrator rim angle (45 to 60 deg). Results indicate that the surface error, orientation error, and receiver operating temperature each decidedly affect the collection efficiency and that these effects are interdependent. It is shown that surface and orientation error became increasingly important with increasing receiver operating temperature. A variation in rim angle, on the other hand, produces only a slight variation in collection efficiency and does not materially modify the effects of the other three parameters. This information can be applied to the more comprehensive design optimization of a solar power system with regard to such factors as weight, size, and manufacturing simplicity. Author

N68-20276*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYTICAL INVESTIGATION OF SUPERSONIC TURBOMACHINERY BLADING. 2: ANALYSIS OF IMPULSE TURBINE-BLADE SECTIONS

Louis J. Goldman Washington Apr. 1968 23 p refs
(NASA-TN-D-4422) CFSTI: HC$3.00/MF$0.65 CSCL 10A

The geometric characteristics of supersonic impulse turbine-blade sections were investigated. The blade sections were designed to produce vortex flow conditions within the blade passage. The effects of the lower- and upper-surface Mach numbers M_l and M_u, inlet flow angle β_i, and specific-heat ratio γ on the geometric characteristics were studied over an inlet Mach number range of 1.5 to 5.0. Blade design limitations imposed by consideration of supersonic starting and flow separation problems as well as restriction of the axial velocity to subsonic values were also investigated over the same Mach number range. The results indicated that the lower-surface Mach number level M_l and the inlet flow angle β_i had a significant effect on blade shapes, whereas the upper-surface Mach number M_u did not. For similar surface Mach numbers the effect of specific-heat ratio γ on blade shape was small. Increasing M_l or decreasing β_i resulted in thinner blades. The blade solidities σ were affected significantly by all the design parameters. Increasing M_l resulted in an increase in σ, while increasing either M_u or β_i caused σ to decrease. For similar surface Mach numbers, increasing γ tends to increase σ. Although the design limitation considered herein places severe restrictions on the freedom on choice of the design parameters, it was still possible to obtain blades of reasonable shape and solidities that meet these restrictions. Author

N68-20344*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DISCHARGE CHARACTERISTICS OF SOME COPPER OXIDE–MAGNESIUM THERMAL CELLS

Lawrence H. Thaller Washington Apr. 1968 23 p refs
(NASA-TN-D-4306) CFSTI: HC$3.00/MF$0.65 CSCL 10A

Primary thermal cells were discharged at 450°C for periods ranging from 24 to 290 hours. These cells employed magnesium (99.8 percent) as the anode material. The cathode material was the wire form of cupric oxide, which is about 80-mole-percent cupric oxide with the remainder cuprous oxide. The electrolytes consisted of 59-mole-percent lithium chloride with the remaining 41-mole-percent mixtures of potassium chloride and cesium chloride ranging from pure potassium chloride to pure cesium chloride. The average capacity of the cells was 15 ampere-hours (5.4×10^4C). The service life was limited by self-discharge arising from internal chemical reactions and short circuits. In this work, several features of cell design were altered in order to reduce self-discharge. A woven glass fabric separator was successful in eliminating the internal short circuits. Self-discharge from internal chemical reaction was reduced by increasing the electrode spacing and by adding CsCl to the electrolyte. The former increased the distance that electrode materials had to diffuse before reaction, and the latter reduced the diffusion coefficient. With these improvements, the rate of self-discharge was reduced from 200 milliamperes to less than 1 milliampere with a corresponding increase in cell resistance from 0.2 to 2.0 ohms. Service lives up to 12 days were achieved. Author

N68-20363*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INVESTIGATION OF THE USE OF THE LUNAR SURFACE LAYER TO STORE ENERGY FOR GENERATING POWER DURING THE LUNAR NIGHT

Gerald J. Barna and Roy L. Johnson Washington Apr. 1968 19 p
(NASA-TM-X-1560) CFSTI: HC$3.00/MF$0.65 CSCL 10A

A solar concentrator and a surface heat exchanger with a coating having a high ratio of solar absorptivity to thermal emissivity were used to increase the thermal input to the storage bed during the lunar day. A Rankine cycle system was selected as the conversion device; the boiling temperature of the cycle varied from 560° to 760°R. To cover a range of possibilities, dry sand in a vacuum, pumicite, basalt lava, and basalt rock were considered. For a powerplant conversion efficiency of 0.135, the required specific storage bed area for basalt rock was approximately 37.2 m^2/kW_e for a boiling temperature of 560°R, more than 2 times as large for basalt lava, more than 6 times as large for pumicite, and about 40 times as large for dry sand. Raising the cycle boiling temperature was studied for basalt rock and basalt lava. Throughout the study assumptions favorable to the thermal energy storage device were used. It was concluded that the possibility of developing an attractive thermal energy storage device using this concept does not appear promising. K.W.

N68-20432*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A 23.4 SQUARE-FOOT (2.17-SQ-M) CADMIUM SULFIDE THIN-FILM SOLAR CELL ARRAY

Henry W. Brandhort, Jr. and Adolph E. Spakowski Washington Apr. 1968 11 p refs
(NASA-TM-X-1519) CFSTI: HC$3.00/MF$0.65 CSCL 10A

A large film solar cell array was built to explore the construction problems associated with the assembly of flexible,

large-area solar cells. The array contains 378 cells, is 7 feet long and 3.35 feet wide, and weighs 1.76 pounds. The array is extended vertically from a storage drum by self-extending booms. In air mass 1 sunlight at 25°C the array output was 43.8 watts per pound of cells. The overall array had an efficiency of 3.55 percent and a cell packing factor of 0.94. Efficiencies of cells used in the array ranged betweed 3.0 and 5.5 percent, and no cell selection was made during assembly. Cell series connections had a resistance of less than 0.5 milliohm and a tensile strength to rupture of 70 pounds. The demonstration model has been extended and retracted over 500 times with no damage to either cells or connections. Author

N68-21562*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CRITICAL ELECTRICAL ASPECTS OF ALTERNATING-CURRENT POWER SOURCE FOR CENTAUR SPACE VEHICLE

Maurice F. Baddour and John P. Quitter Washington Apr. 1968 36 p

(NASA-TM-X-1569) CFSTI: HC$3.00/MF$0.65 CSCL 10B

A solid-state inverter is used on Centaur to supply high-quality three-phase electric power to the guidance, autopilot, and propellant utilization systems. (Centaur is a high-energy, cryogenic-fueled second-stage vehicle.) The results of a test program to evaluate the design and performance of this inverter are described. The scope of the program is concerned primarily with measurements on internal parts of the inverter while it was subjected to extreme service conditions. Detailed data are presented on electrical and thermal design margins. Special attention is directed toward transient susceptibility and the effect of source impedance variations. Significant wave shapes are shown, and their implications are examined. Test failures and critical weaknesses in the system are analyzed, and design improvements are proposed. These improvements were incorporated into the inverter and verified by test. Subsequent flight performance has been excellent, and the inverter has provided three-phase electric power of high quality at 400 hertz to the Atlas-Centaur launch vehicle on 14 flights. Author

N68-21651*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A BREADBOARD FLUERIC-CONTROLLED PNEUMATIC STEPPING MOTOR SYSTEM

William S. Griffin Washington Apr. 1968 67 p refs

(NASA-TN-D-4495) CFSTI: HC$3.00/MF$0.65 CSCL 13G

This report describes flueric circuitry used to drive a novel pneumatic stepping motor. The design and breadboard implementation of the circuitry are presented along with some of the techniques used for interconnection of digital fluid jet amplifiers. The experimental performance of a breadboard flueric-drive-circuitry–stepping-motor actuator system is evaluated. Finally, a comparison is made between the resultant pneumatic stepping-motor system and the more conventional pneumatic piston-in-cylinder actuator. The principal conclusions of the work are: (1) The flueric-drive-circuitry–stepping-motor combination constitutes a reliable, fast, open-loop digital stepping actuator system which has high resolution and output stiffness. The breadboard flueric-drive-circuitry–stepping-motor system could be stepped at 173 steps per second in either direction and cyclicly reversed, without missing steps, at 115 steps per second. The step size of the shaft output motion was 0.25° and a maximum static output torque of 70 inch-pounds force (788.9 cm-N) was obtained. (2) The flueric-drive-circuitry–stepping-motor actuator system consumes more flow than a conventional electropneumatic piston-in-cylinder actuator designed to do the same job. Author

N68-21766*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ELECTRICAL PERFORMANCE OF A RHENIUM-NIOBIUM CYLINDRICAL THERMIONIC CONVERTER

Richard M. Williams and William J. Bifano Washington Apr. 1968 23 p refs

(NASA-TN-D-4533) CSCL 10A

The electrical performance of a cylindrical rhenium-niobium thermionic converter was measured by a pulse technique for the following temperatures: emitter, 1873° to 2073°K; collector, 850° to 1050°K; and cesium reservoir, 590° to 670°K. The peak output power densities at 1873°, 1973°, and 2073°K were 7.0, 9.4, and 11.4 W/cm^2 at 0.4, 0.5, and 0.6 V, respectively. The corresponding collector temperatures were about 900°, 940°, and 950°K, and the cesium reservoir temperatures were 595°, 606°, and 611°K. The Rason–Warner correlation was used to estimate a 5.0±0.1 V work function for the vapor-deposited rhenium emitter. Author

N68-21835*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESIGN AND PERFORMANCE OF FLUERIC ANALOG-TO-PULSE-FREQUENCY-CONVERTER

Miles O. Dustin Washington Apr. 1968 29 p refs

(NASA-TN-D-4497) CFSTI: HC$3.00/MF$0.65 CSCL 13G

A flueric circuit which converts an analog pressure signal to pulse frequency is described, and design considerations are discussed. The performance characteristics of a breadboard model are also included. The breadboard model was constructed to commercial flueric amplifiers and one specially developed amplifier. The circuit uses a three-amplifier, flueric oscillator having a pulsed output whose frequency is a function of input pressure level. The frequency of the oscillator varies continuously from 0 to 180 pulses per second when the input pressure changes from 5.2 psig (36×10^3 N/m^2 gage) to 3.1 psig (21×10^3 N/m^2 gage). The complete converter system will operate from 0 to 160 pulses per second when the input pressure to the converter is varied over a range of 2 psi (13.8×10^3 N/m^2). The converter system has flat saturation characteristics. The oscillator circuit will recover from a step change in input pressure within one output pulse. The flueric amplifiers use supply pressures of 20 psig (138×10^3 N/m^2 gage) or less. The analog-to-pulse-frequency converter will be used to drive a pneumatic stepping actuator system developed for positioning nuclear reactor control drums. Author

N68-22257*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL INVESTIGATION OF REACTOR-LOOP TRANSIENTS DURING STARTUP OF A SIMULATED SNAP-8 SYSTEM

Pierre A. Thollot, Henry B. Block, and Kent S. Jefferies Washington May 1968 46 p refs

(NASA-TN-D-4546) CFSTI: HC$3.00/MF$0.65 CSCL 10B

Experimental investigations of primary-loop transients during the startup of a Rankine-cycle space-power system were conducted in the SNAP-8 Simulator Facility at Lewis. Of particular significance to these studies was the fact that both a realistic reactor simulator and a flight-weight mercury boiler were used in the primary loop. Furthermore, the system tested used the same liquid metals and operated at similar temperatures, pressures, and flow rates as those of the SNAP-8 system. During startup, the electric heater power input was automatically controlled so that the transient behavior of a real reactor could be duplicated. With the exception of this automic power control, all other variables were manually controlled to predefined values. In order to evaluate the relative merits of the wide variety of startup modes studied, a method of judging the results of each run was derived based on the reactor simulator exit temperature excursion. A comparison of this criterion with individual nuclear-system constraints showed excellent agreement. Author

N68-22258*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Hampton, Va.

THE GEOMETRIC PROPERTIES OF AN EXPANDABLE WHIRLING-MEMBRANE SOLAR-ENERGY CONCENTRATOR

John M. Jerke and Atwood R. Heath, Jr. Washington May 1968 36 p refs

(NASA-TN-D-4532) CFSTI: HC$3.00/MF$0.65 CSCL 10A

The whirling-membrane concept of solar-concentrator fabrication has been proposed for use with spacecraft-power-conversion devices because of its compact-packaging potential. Three membranes of 0.01-millimeter-thick aluminized plastic were constructed and attached to metal hubs for which the ratios of the hub radius to the membrane radius were 0.20, 0.35, and 0.50. The resulting models that had design focal lengths of 132.1 centimeters and design diameters of 3.05 meters were rotated at 71 radians per second in a vacuum chamber at pressures below 133 newtons per meter^2. The accuracy with which each membrane achieved the design paraboloidal shape was measured by an optical-ray-trace technique. The membrane with the metal hub of largest diameter gave the best concentration of energy. For this model, the focal length was 130.5 centimeters or 1 percent less than the design value. A geometric efficiency of 1.00 was obtained at a concentration ratio of 23. Membrane surface mean errors varied from -0.6° to 0.4° in the radial direction and were essentially zero in the circumferential direction. The random error has a standard deviation of 0.5° in the radial direction over most of the membrane and 0.25° in the circumferential direction. Location of supporting cables relative to the metal hub was found to be an important factor in the design of a whirling-membrane concentrator. Author

N68-22842*# Bendix Corp., Davenport, Iowa.
DEVELOPMENT OF A LIQUID SHROUD CRYOGENIC SUPERCRITICAL PRESSURE STORAGE SYSTEM
Washington NASA May 1968 66 p refs
(Contract NAS9-4634)
(NASA-CR-1048; Rept.-3734A-67) CFSTI: HC $3.00/MF $0.65 CSCL 13A

The concept of insulating a cryogenic fluid by the vaporization of a secondary cryogenic refrigerant is not new. This technique has been used for several years in ground equipment and laboratory type liquid helium dewars. However, little effort has previously been expended in applying this technique to flight-type equipment. Fuel cell reactants supply systems, environmental control systems, and propellant pressurization systems to be utilized aboard future spacecraft will all require improved state-of-the-art advances in the handling and storage of cryogenic fluids. The concept of shroud cooling of a cryogenic storage system is discussed in this report to determine the potential weight savings and improved thermal performance for certain applications. In addition, vapor cooling of a discrete radiation shield for more effective insulation is discussed. The cryogenic shroud system fabricated and tested in this program is described. The feasibility of this cryogenic storage system for specific flight applications has been successfully demonstrated by this program. Author

N68-23476*# General Electric Co., Schenectady, N. Y.
CHARACTERISTICS OF A VARIABLE SPACED PLANAR THERMIONIC CONVERTER WITH A TUNGSTEN EMITTER AND A NIOBIUM COLLECTOR
V. C. Wilson and J. Lawrence Washington NASA May 1968 105 p refs
(Contract NAS3-8511)
(NASA-CR-1033) CFSTI: HC $3.00/MF $0.65 CSCL 10A

A parallel plane, variable spaced, thermionic converter was built with a polycrystalline tungsten emitter and a polycrystalline niobium collector. Current-voltage characteristics were obtained for a range of emitter temperatures from 1673 to 2153°K; collector temperatures from 873 to 1173°K; cesium reservoir temperatures from 583 to 683°K, and spacings from 1.0 to 20.0 mils. Over fifty families of curves consisting of over 190 load lines were obtained. Description of the converter processing procedure, test facility and experimental techniques is included. The output characteristics are compared with those of three converters with nickel collectors. Author

N68-24461*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CAVITATING PERFORMANCE OF TWO LOW-AREA-RATIO WATER JET PUMPS HAVING THROAT LENGTHS OF 7.25 DIAMETERS
Nelson L. Sanger Washington May 1968 39 p refs
(NASA-TN-D-4592) CFSTI: HC $3.00/MF $0.65 CSCL 10B

Cavitation performance of two jet pumps was evaluated in a closed-loop facility using room-temperature, deaerated water. Objectives of the investigation were to study the cavitation performance of jet pumps having low ratios of nozzle to throat area and to examine methods of cavitation prediction in jet pumps. Experimental performance was obtained with two nozzles operated separately in one test section. Each nozzle was operated at three spacings of the nozzle exit from the throat entrance. At each nozzle spacing, tests were conducted at four values of secondary-to primary-flow ratio, while secondary (pumped fluid) inlet pressure was varied. Extensive amounts of cavitation were observed before performance was affected. However, when the head ratio deteriorated, it did so quite sharply. For the test section considered in this investigation, a nozzle spacing of approximately one throat diameter best satisfied the two major performance requirements of high efficiency and cavitation resistance. The design of the secondary inlet region was important to jet pump cavitation performance. Smooth hydrodynamic streamlining of this region and a thin nozzle wall at the nozzle exit would reduce cavitation susceptibility. Author

N68-24596*# Pratt and Whitney Aircraft, East Hartford, Conn.
RESEARCH AND DEVELOPMENT OF HIGH-PERFORMANCE AXIAL-FLOW TURBOMACHINERY. VOLUME 1: DESIGN OF TURBINE-COMPRESSOR
P. Bolan, R. Cohen, and W. K. Gilroy Washington NASA May 1968 157 p refs
(Contract NAS3-4179)
(NASA-CR-800) CSCL 10A

An evaluation of candidate Brayton-cycle turbomachinery configurations was conducted. As part of this program, a turbine-compressor incorporating a single-stage axial-flow turbine driving a six-stage axial-flow compressor supported on gas bearings was designed. The gas bearing rotor support system was successfully tested in a gas bearing dynamic simulator. A backup gas bearing system was designed and various experimental investigations were conducted to verify certain areas of the turbine-compressor design in addition to the gas bearing testing. Author

N68-24597*# Pratt and Whitney Aircraft, Philadelphia, Pa.
RESEARCH AND DEVELOPMENT OF HIGH-PERFORMANCE AXIAL-FLOW TURBOMACHINERY. VOLUME 3: DESIGN OF BACKUP GAS BEARINGS
J. T. Mc Cabe, W. Shapiro, and T. Y. Chu Washington NASA May 1968 265 p refs
(Contract NAS3-4179)
(NASA-CR-802) CFSTI: HC $3.00/MF $0.65 CSCL 10A

An evaluation of candidate Brayton-cycle turbomachinery configurations was conducted. As part of this program, a turbine-compressor incorporating a single-stage axial-flow turbine driving a six-stage axial-flow compressor supported on gas bearings. A backup gas bearing system was designed. The design activities included steady-state analysis and time transient rotor support system studies. A satisfactory backup gas bearing system was designed. Author

N68-24757*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INJECTION START OF A BRAYTON CYCLE TURBOCOMPRESSOR OPERATING ON GAS BEARINGS IN A CLOSED LOOP
Robert Y. Wong, Robert C. Evans, Donald J. Spackman, and Charles H. Winzig Washington May 1968 30 p refs
(NASA-TM-X-1590) CFSTI: HC $3.00/MF $0.65 CSCL 10B

A Brayton cycle turbocompressor was experimentally investigated to determine whether the gas bearings could withstand the transients associated with a space start using gas injection. Of the two injection methods studied, constant flow injection and bottle injections, the constant flow injection method imposed a lower thrust load on the turbocompressor during injection. It was also observed that the turbocompressor unit was able to withstand the transients during start, shutdown, and accidental compressor surge. A compressor bypass valve proved to be capable of effecting emergency shutdown without causing severe vibrations. Author

N68-25059*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THERMAL PERFORMANCE OF A RHENIUM NIOBIUM CYLINDRICAL THERMIONIC CONVERTER

R. M. Williams and W. J. Bifano Washington May 1968 26 p refs

(NASA-TN-D-4582) CFSTI: HC$3.00/MF$0.65 CSCL 10A

Efficiency and steady state performance were measured for a cylindrical thermionic converter having a rhenium emitter and a niobium collector. Measurements were made at the cesium-reservoir temperatures at which peak output power was obtained from emitter temperatures in the range from 1873° to 2073°K and collector temperatures in the range from 850° to 1050°K. Increasing the emitter temperature from 1873° to 2073°K resulted in increasing the maximum electrode efficiency from 0.127 to 0.144. The output power at maximum efficiency increased from 5.7 to 9.2 W/cm^2. For fixed emitter temperatures, the emitter-to-collector heat flux increased linearly with current at the rate of 2.10 W/A. Author

N68-25304*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.

TRANSIENT THERMODYNAMIC ANALYSIS OF A FUEL-CELL SYSTEM

William Emile Simon Washington, D. C. Jun. 1968 89 p refs

(NASA-TN-D-4601) CFSTI: HC$3.00/MF$0.65 CSCL 10A

This report presents a transient thermodynamic analysis of a fuel-cell system exclusive of cryogenic supply system and external heat dissipation system. The results of a simplified analysis and of a more general analysis are compared, and the results of the more general analysis are compared with performance test data. The analysis is oriented toward a particular application, but the methods employed are sufficiently general to allow application of these concepts to most fluid-loop systems involving heat and mass transfer. Author

N68-25829*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYSIS AND SELECTION OF DESIGN CONDITIONS FOR A RADIOISOTOPE BRAYTON-CYCLE SPACE POWERPLANT

John L. Klann, Leonard Soffer, Gerald J. Barna, Gabriel N. Kaykaty, Paul T. Kerwin et al Darl D. Bien Washington Jun. 1968 83 p refs

(NASA-TN-D-4600) CFSTI: $3.00/MF$0.65 CSCL 18E

Selections were made for a conceptual plutonium 238 module for electric powers in the range from 2 to 10 kilowatts. Based on the selections, component and system efficiency and weight were estimated for powers of 2, 6, and 10 kilowatts. Author

N68-28101*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EVALUATION OF ALTERNATING-CURRENT LINE-VOLTAGE REGULATORS IN AUXILIARY ELECTRIC POWER SYSTEMS

Richard R. Secunde and James E. Vrancik Washington Jul. 1968 19 p refs

(NASA-TN-D-4627) CFSTI: HC$3.00/MF$0.65 CSCL 09E

The operation of ferroresonant and feedback alternating-current line-voltage regulators in a 15-kilowatt auxiliary power system was experimentally evaluated. Input current harmonics, transient response, input–output voltage harmonic isolation, and efficiency were measured and are discussed. Author

N68-28280*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYSIS OF RADIATOR CHARACTERISTICS OF A SINGLE-LOOP 100-KILOWATT BRAYTON SPACE POWER SYSTEM USING A PURE GAS AND A GAS-SOLID SUSPENSION

Robert Pfeffer (City Coll. of the City of New York), Salvatore Rossetti (City Coll. of the City of New York), and Seymour Lieblein Washington Jul. 1968 68 p refs

(NASA-TN-D-4659) CFSTI: HC$3.00/MF$0.65 CSCL 22B

Results are presented for an exploratory comparative analysis of radiator geometric characteristics based on a simplified radiator model with either a pure gas or a graphite-gas suspension working fluid. Radiator variables investigated were gas-flow Reynolds number, pressure-drop fraction, and suspension-particle loading ratio. For the pure gases, type of gas and Reynolds number had a pronounced effect on tube and panel geometry, but Reynolds number and pressure drop fraction had a relatively small effect on planform area for fixed overall cycle loss pressure ratio. Only moderate reductions in radiator planform area (10 to 17 percent) were indicated with the use of graphite-gas suspensions. Author

N68-28310*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A RADIATOR CONCEPT BASED ON CAPILLARY RETENTION OF LIQUID

Alex Vary Washington Jul. 1968 45 p refs

(NASA-TN-D-4370) CFSTI: HC$3.00/MF$0.65 CSCL 13A

A preliminary study was made to define problem areas and potential advantages of a radiator for extraterrestrial applications in which a heat exchange liquid is circulated through a capillary medium. An evaluation of surface energy, heat transfer, hydraulic, geometric, and meteoroid penetration factors in a capillary radiator operating under extraterrestrial conditions is presented to indicate feasibility in a potential application. Author

N68-28420*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.

CRYOGENIC STORAGE SYSTEMS FOR EARTH-ORBITAL AND MARS-FLYBY MISSIONS

Robert K. Allgeier, Thomas L. Davies, and Robert R. Rice Washington Jul. 1968 42 p refs

(NASA-TN-D-4619) CFSTI: HC$3.00/MF$0.65 CSCL 22B

A study program was undertaken to assess cryogenic gas requirements and storage methods for four design reference missions with respect to present thermal performance. Developed data indicate that anticipated improvements in static insulation techniques will not suffice to meet long-term cryogenic gas storage requirements unless vessel environmental temperatures are lowered, and the data indicate that there is need for further research on refrigeration techniques. Parametric curves and data are presented to make possible the rapid determination of cryogenic expendable requirements, Dewar sizes, and thermal protection schemes for application similar to the design reference systems. Author

N68-28870*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AERODYNAMIC PERFORMANCE OF A 4.59-INCH MODIFIED RADIAL-INFLOW TURBINE FOR A SINGLE-SHAFT BRAYTON CYCLE SPACE POWER SYSTEM

Charles A. Wasserbauer and Milton G. Kofskey Washington Jul. 1968 19 p refs

(NASA-TM-X-1615) CFSTI: HC$3.00/MF$0.65 CSCL 10B

The turbine was modified to include a stator with 60 percent design throat area to be consistent with the single shaft system requirements. Tests were conducted with argon at an inlet temperature of 560°R and an inlet pressure of 6.0 psia. Performance results are presented in terms of equivalent specific work, torque, mass flow, and efficiency for a range of speeds from 0 to 110 percent of design. Author

N68-29460*# General Electric Co., Cincinnati, Ohio. Space Power and Propulsion Section.

DEVELOPMENT OF ELECTRICAL SWITCHGEAR FOR SPACE NUCLEAR ELECTRICAL SYSTEMS

A. H. Powell, ed. Washington NASA Jul 1968 119 p (Contract NAS3-6467)

(NASA-CR-1026; R67SD3012) CFSTI: HC $3.00/MF $0.65 CSCL 10B

High capacity circuit breakers and contactors are needed for future large spacecraft systems with 500 to 1000 KWe power supplies. Based on the latest experience on utility and industrial systems, a vacuum interrupter appears to be the simplest means of obtaining suitable performance in a space environment. The feasibility of power interruption in a vacuum capsule in a space environment of 1000°F ambient temperature had been previously investigated, and with this background, preflight prototype single pole breakers and contactors have now been designed, built, and extensively tested. The breaker, rated 1000 volts, 600 amperes, 2000 cps, for main system protection, and the contactor, rated 10,000 volts, 10 amperes, for propulsion engine switching, have been mechanically and electrically tested. Overall performance has been determined in a preliminary way, and successful completion of 1000-hour endurance test in the 1000°F and 10^{-6} (or lower) torr pressure has given confirmation of the feasibility of the vacuum switchgear for large space systems. Author

N68-29960*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL EVALUATION OF A VOLTAGE REGULATOR-EXCITER FOR A 15 KILOVOLT-AMPERE BRAYTON CYCLE ALTERNATOR

Gary Bollenbacher, Richard A. Edkin, and Dennis A. Perz Washington Aug. 1968 31 p refs

(NASA-TN-D-4697) CFSTI: HC $3.00/MF $0.65 CSCL 10A

A voltage regulator–exciter for a 15 kVA, 120/208 volts, 400 hertz alternator was experimentally evaluated. Emphasis was placed on the effect of the voltage regulator–exciter on the alternator performance. Specific items tested include the voltage regulator–exciter output capacity, its regulating capability, its effect on alternator waveshape, and its performance during transient and startup conditions. Author

N68-30002*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE CHARACTERISTICS OF 15 kVA HOMOPOLAR INDUCTOR ALTERNATOR FOR 400 Hz BRAYTON-CYCLE SPACE-POWER SYSTEM

Richard A. Edkin, Martin E. Valgora, and Dennis A. Perz Washington Aug. 1968 40 p refs

(NASA-TN-D-4698) CFSTI: HC $3.00/MF $0.65 CSCL 10A

The measured performance of a 15 kVA homopolar inductor is presented and compared with design goals. Test results include alternator saturation, voltage unbalance, harmonic analysis, short circuits, machine reactances, and time constants. The following overall performance was obtained: maximum continuous output, 22.5 kVA; peak efficiency, 0.918 at 11.25 kVA; and efficiency at rated 15 kVA output, 0.915. Author

N68-30241*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COLD-AIR INVESTIGATION OF EFFECTS OF PARTIAL ADMISSION ON PERFORMANCE OF 3.75-INCH MEAN-DIAMETER SINGLE STAGE AXIAL-FLOW TURBINE

Hugh A. Klassen Aug. 1968 22 p ref

(NASA-TN-D-4700; E-4407) CFSTI: HC $3.00/MF $0.65 CSCL 21E

Total to static efficiency is described as a function of percentage of admission and blade-jet speed ratio. At design blade-jet speed ratio, efficiency decreased from 0.68 to 0.56 as percentage of admission was reduced from 100 to 11.76. Partial admission efficiency losses are divided into rotor pumping and windage losses and all other losses. Author

N68-30506*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF A VARIABLE STATOR AREA ON PERFORMANCE OF A SINGLE-STAGE TURBINE SUITABLE FOR AIR COOLING. 2: STATOR DETAILED LOSSES WITH 130 PERCENT DESIGN AREA

Thomas P. Moffitt, Herman W. Prust, Jr., and Bernard Bider Washington Aug. 1968 21 p refs

(NASA-TM-X-1635) CFSTI: HC $3.00/MF $0.65 CSCL 21E

The turbine is being investigated at stator area settings of 70, 100, and 130 percent of design. The experimental and analytically predicted results are presented for the stator having open (130 percent) area setting and compares these results with similar results obtained for the design (100 percent) area setting. The final results are presented in terms of kinetic energy loss coefficients as a function of velocity level. The experimental losses were close to those predicted analytically and indicate a stator efficiency of about 96 percent. Author

N68-30751*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRELIMINARY ANALYSIS OF A TITANIUM ALLOY HONEYCOMB SOLAR ABSORBER HAVING BLACKENED WALLS

William J. Bifano Washington Aug. 1968 27 p refs

(NASA-TN-D-4727) CFSTI: HC $3.00/MF $0.65 CSCL 18N

A titanium alloy hexagonal honeycomb with blackened walls is considered as an absorber of collimated solar solar energy. Circular cylindrical geometry is assumed for the analysis as an approximation of the hexoganal cell structure. The apparent hemispherical emittance of such an absorber positioned over a black surface is calculated. Results are presented for cell length-to-diameter ratios of from 1 to 7 and cell diameters of 0.25, 0.5, and 1.0 in. (0.635, 1.27, and 2.54 cm, respectively). The collimated incident solar flux is assumed sufficient to attain base surface temperatures of 1860° and 2060° R (1033 and 1144 K). The corresponding weight per unit area of such an absorber is also calculated. Author

N68-33062*# AiResearch Mfg. Co., Los Angeles, Calif.

RECUPERATOR FOR SOLAR BRAYTON CYCLE SYSTEM

A. F. Anderson Washington NASA Aug. 1968 222 p refs (Contract NAS3-2793)

(NASA-CR-1150) CFSTI: HC $3.00/MF $0.65 CSCL 10B

Results are presented of analytical and test work conducted on a recuperator to be utilized in a closed Brayton cycle space power system that uses solar energy as a heat source and argon as the working fluid. The initial phase of the work was a parametric design study to determine the optimum recuperator operating conditions for the Brayton cycle. The study was followed by analysis and testing for the final design configuration. The final phase of this program included fabrication and testing of a recuperator. Author

N68-34234*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF AMOUNT OF ELECTROLYTE, DRAIN RATE AND ELECTRODE GEOMETRY ON PERFORMANCE OF COPPER OXIDE–MAGNESIUM THERMAL CELLS

Lawrence H. Thaller Washington Sep. 1968 15 p refs

(NASA-TN-D-4790) CFSTI: HC$3.00/MF$0.65 CSCL 10C

Studies continued on the performance of $Mg/LiCl–KCl/Cu_2O–CuO$ thermal cells operating at 450°C. The measure of performance used is the parameter X, the depth of discharge at which the approximate 0.25-V drop in open circuit voltage occurs. This parameter was evaluated as a function of three factors which influence mass transport, namely, the amount of electrolyte, the rate of discharge, and the electrode shape and spacing. The amount of electrolyte per unit of cell capacity had little effect on X. In tests on horizontal- and vertical-type cells, X was inversely related to current density, with a stronger dependence on current density for cells with poorer mass transport characteristics. An increase in current density and decrease in operating temperature promoted premature failure (low cathode utilization). Author

N68-35467*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THERMAL RADIATIVE AND ELECTRICAL PROPERTIES OF A CADMIUM SULFIDE SOLAR CELL AT LOW SOLAR INTENSITIES AND TEMPERATURES

John R. Jack and Ernie W. Spisz Washington Oct. 1968 18 p refs

(NASA-TN-D-4818) CFSTI: HC$3.00/MF$0.65 CSCL 10A

A typical thin film cadmium sulfide solar cell was investigated in a solar space environment simulator facility. The solar radiation intensity was varied from 0.028 to 1.07 solar constants. The associated solar cell temperature ranged from 155° to 325°K. The results showed that the absorptance–emittance ratio was approximately constant at 0.43 over the temperature range of 200° to 325°K. Below 200°K the absorptance–emittance ratio increased rapidly to 0.70 at a temperature of 155°K. Author

N68-35536*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF VARIABLE STATOR AREA ON PERFORMANCE OF A SINGLE-STAGE TURBINE SUITABLE FOR AIR COOLING. 3: TURBINE PERFORMANCE WITH 130-PERCENT DESIGN STATOR AREA

Harold J. Schum, Thomas P. Moffitt, and Frank P. Behning Washington Oct. 1968 24 p refs

(NASA-TM-X-1663) CFSTI: HC$3.00/MF$0.65 CSCL 21E

The performance changes resulting from adjusting the stator area of an experimental 30-inch (0.762-m) single stage turbine, with blading designed to incorporate physical features associated with turbines for high engine temperature application, are being investigated. The performance of the turbine with design stator area has been previously reported. The performance of this same turbine, modified so the stator area was increased to 130% of the design by reorienting the stagger angle of the blades, is presented herein. When results of these two turbine configurations were compared, it was found that when the stator area was increased by 30%, the choking equivalent work output of operating point corresponding to equivalent design speed and an equivalent work output of 17.00 Btu per pound (39,572 J/kg) showed that the efficiency decreased from 0.923 to 0.897 for the subject opened turbine. This decrease in efficiency is primarily attributable to the incidence angle relative to the motor, which was calculated to be changed about 28° from design. Author

N68-37162*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PREDICTION OF WINDAGE POWER LOSS IN ALTERNATORS

James E. Vrancik Washington Oct. 1968 21 p refs

(NASA-TN-D-4849) CFSTI: HC$3.00/MF$0.65 CSCL 10A

The purpose of this report is to develop a method of predicting the windage loss of rotating electrical machines operating in various gases under different pressures and temperatures. An equation was developed for a cylindrical rotor and modified by empirical relations to take into account the effects of the salient poles and shrouds of the homopolar inductor alternator. The effect of the gap length is briefly studied. The windage loss for a shrouded homopolar inductor alternator was calculated by these equations and compared to the experimental results obtained at the NASA Lewis Research Center. The agreement was within ±10 percent for a range of pressure from standard atmospheric to 40 psia (2.75×10^5 N/m^2). Author

N68-37217*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LENGTH OF WINDING ON A TORUS IN TWO IDEAL MODELS

Janis M. Niedra Washington Oct. 1968 16 p

(NASA-TM-X-1674) CFSTI: HC$3.00/MF$0.65 CSCL 09A

An analysis of the relation of the total number of turns on a torus to the length of winding is presented for two models. One model is based on the assumption of circular turns; the other assumes close packed windings. Results are presented for ratios of major to minor radii of the torus of 1.25 to 10 and for fractional filling of the winding window from 0 to 1.0. The curves presented enable the winding length for a particular number of turns to be easily determined. Author

N68-37263*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland Ohio.

EXPERIMENTAL PERFORMANCE OF A 5-INCH (13 cm) AXIAL-FLOW TURBINE OVER A RANGE OF REYNOLDS NUMBER

Samuel M. Futral, Jr. and Donald E. Holeski Washington Oct. 1968 20 p refs

(NASA-TM-X-1679) CFSTI: HC$3.00/MF$0.65 CSCL 10B

The investigation was conducted in argon and over a range of inlet total pressures from 9.5 to 1.3 psia (6.6 to 0.9 N/cm^2 abs). The corresponding Reynolds numbers ranged from 317,000 down to 41,000. Test results showed that efficiencies and equivalent mass flow decreased with decreasing Reynolds number. These decreases in performance were greater than those of a 6.02-in. (15.3-cm) radial-inflow turbine which was designed for the same application. Author

N68-37265*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECTS OF FREEZING ON PRIMARY SILVER OXIDE ZINC CELLS

Richard E. Johnson Washington Oct. 1968 11 p

(NASA-TM-X-1681) CFSTI: HC$3.00/MF$0.65 CSCL 10C

An investigation was conducted to determine the effects of freezing on primary silver oxide–zinc cells. Three freezing rates of 4.77° F/min. (2.66 K/min), 0.81° F/min (0.45 K/min) and 0.19° F/min (0.10 K/min) were used. In addition, some cells underwent a slow (28-day) freeze–thaw cycle to −50° F (227° K). No harmful effects were noted, either to the cell itself or its performance. Author

N68-37935*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPARISON BETWEEN CEMENTED AND SOLDERED COVERGLASS FOR SILICON SOLAR CELLS

Jacob D. Broder Washington Nov. 1968 11 p refs

(NASA-TM-X-1687) CFSTI: HC$3.00/MF$0.65 CSCL 10A

A comparison was made of the spectral response of cemented and soldered cover glass on a current commercial silicon solar cell. Cover glass transmission factors were determined in the range of 0.4 to 0.95 micron with a filter-wheel solar simulator. Soldered and cemented cell short circuit current spectral response was calculated as a function of the effectiveness of the cover-glass radiation protection, for a bombardment dose of 10^{16} 1-MeV electrons per square centimeter. Author

N68-37943*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL PERFORMANCE OF A 5-INCH SINGLE-STAGE AXIAL-FLOW TURBINE DESIGNED FOR A BRAYTON CYCLE SPACE POWER SYSTEM

Donald E. Holeski and Samuel M. Futral, Jr. Washington Nov. 1968 22 p refs

(NASA-TM-X-1666) CFSTI: HC$3.00/MF$0.65 CSCL 10B

The turbine investigated was designed to drive a six stage, axial flow compressor for a 10-kilowatt, two shaft space power system. Tests were made using argon at an inlet pressure of 2.9 psia (2.0 N/cm^2 abs) and an inlet temperature of 582°R (323 K). Test results showed that the turbine efficiency was below the design value. Data indicated the rotor tip sections performed poorly. The exit diffuser performed well. Author

04

BIOSCIENCES

Includes aerospace medicine, exobiology, radiation effects on biological systems; physiological and psychological factors. For related information see also: 05 Biotechnology.

N68-10122*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
APPLICATION OF CELL CULTURE AS A PRIMARY TOXICITY SCREEN OF POSSIBLE SPACECRAFT CONTAMINANTS
Richard B. Hays Washington NASA Nov. 1967 13 p refs
(NASA-TN-D-4251) CFSTI: HC$3.00/MF$0.65 CSCL 06T

Cell culture has been investigated with regard to its applicability as a primary toxicity screen. Forty-nine compounds have been screened by this method. These compounds are all contaminants which may occur in manned spacecraft. The data presented indicate that cell culture can be a useful tool for selecting, from a long list, those compounds most likely to be toxic to a living system. The compounds tested might be ranked, in terms of decreasing toxicity to cells in culture, as follows: unsaturated aldehydes, amines, aldehydes, acids, ketones, and alcohols. Author

N68-11968*# Dudley Observatory, Albany, N. Y.
THE MICROBIOLOGICAL FLORA OF THE GEMINI 9 SPACECRAFT BEFORE AND AFTER FLIGHT
John Hotchin (N. Y. State Dept. of Health), Peter Lorenz, Aletha Markusen (N. Y. State Univ., Albany), and Scott Covert (Albany Med. Coll., N. Y.) Washington NASA Dec. 1967 16 p refs
(Grant NsG-155)
(NASA-CR-972) CFSTI: HC$3.00/MF$0.65 CSCL 06M

Three sites within the Gemini IX space capsule were investigated for microbiological contamination by swabbing before and after the flight. Bacterial or mold growth was observed in three sets of swabs taken before the flight and one set of swabs taken after the flight, and most of the swabs were then found heavily covered with dust. The results were obtained by the completely independent study of the eluted suspensions of the swabs by three research groups and, despite the considerable variation of the detailed results, they show that the inside of the Gemini IX space capsule was contaminated with microbiological materials both before and after the flight. Author

N68-12494*# General Technical Services, Inc., Upper Darby, Pa.
TRANSIENT BEHAVIOR OF ARTERIAL SYSTEMS IN RESPONSE TO FLOW PULSES
E. D. Young Washington NASA Dec. 1967 35 p refs
(Contract NASw-1066)
(NASA-CR-990) CFSTI: HC$3.00/MF$0.65 CSCL 06P

In this paper we hope to show the relation of transient analysis of fluid lines to harmonic analysis thereof, to indicate the practicality of formulating the transmission problem with respect to transients in the time domain and uniformly with respect to frequency or pulse width within the domain of linearity assumptions of Witzig, Iberall, Womersley, etc., to apply this transient analysis to a whole class of systems embracing in principle the normal range of mammalian arterial systems which should help to clarify the meaning of equivalence among various idealized models mentioned, to trace causual relations between familiar wave distortions seen in arterial trees and the basic geometry of the trees, or that of the equivalent system. Author

N68-13432*# Israel Program for Scientific Translations, Ltd., Jerusalem.
BIOCHEMISTRY OF THE NERVOUS SYSTEM
A. V. Palladin 1967 136 p refs Transl. into ENGLISH of the publ. "Voprosy Biokhimii Nervnoi Sistemy" Kiev, Izd. Naukova Dumka, 1965 Publ. for NASA and NSF
(NASA-TT-F-439; TT-67-51375) CFSTI: HC $3.00/MF $0.65 CSCL 06A

Metabolism of the brain in various functional states, problems related to biochemistry of the brain and nervous system, and the use of radioactive isotopes for biochemical studies of the nervous system are discussed in reprints of conference papers. Other papers deal with the nervous system of hibernating animals, activity and localization of various subcellular cerebral functions separable by electrophoresis in agar gels, and the use of neurotropic drugs. M.W.R.

N68-14671* National Aeronautics and Space Administration, Washington, D. C.
AEROSPACE MEDICINE AND BIOLOGY—A CONTINUING BIBLIOGRAPHY WITH INDEXES
Nov. 1967 172 p refs
(NASA-SP-7011(43)) CFSTI: $3.00 CSCL 06S

The abstracts and annotated indexes were selected from those introduced into the NASA Information System during October 1967. The references were previously announced by the Library of Congress, the American Institute of Aeronautics and Astronautics, and NASA. The emphasis is placed on the biological, physiological, psychological, and environmental effects to which man is subjected during and following simulated or actual flight in the earth's atmosphere or in interplanetary space. N.E.N.

N68-14725* National Aeronautics and Space Administration, Washington, D. C.
AEROSPACE MEDICINE AND BIOLOGY—A CONTINUING BIBLIOGRAPHY WITH INDEXES
Oct. 1967 153 p refs
(NASA-SP-7011(42)) CFSTI: $3.00 CSCL 06S

The abstracts and indexes were selected from those introduced into the NASA Information System during September 1967. They appeared previously in the separate journals of the Library of Congress, the American Institute of Aeronautics and Astronautics, and NASA. The emphasis is placed on the biological, physiological, psychological, and environmental effect to which man is subjected during aerospace flight. N.E.N.

N68-15477*# National Aeronautics and Space Administration, Washington, D. C.
PROBLEMS OF SPACE BIOLOGY. VOLUME 5: DYNAMICS OF THE CEREBRAL BLOOD VOLUME UNDER NORMAL CONDITIONS AND GRAVITATIONAL STRESSES
Yu. Ye. Moskalenko Feb. 1968 193 p refs Transl. into ENGLISH of the book "Problemy Kosmicheskoy Biologii. Tom V. Dinamika Krovenapolneniya Golovnogo Mozga.v Norme i pri Gravitatsionnykh Nagruzkakh" Leningrad, Nauka Press, 1967
(NASA-TT-F-492) CFSTI: HC$3.00/MF$0.65 CSCL 06S

The basic mechanisms responsible for compensating changes in the blood volume of the closed cranial cavity are described, based on data obtained by electroplethysmography, which makes it possible to judge the dynamics of the cerebral blood volume directly; and on critical analyses of other experimental material. A detailed assessment is made of some aspects of active and passive compensation of changes during gravitational stresses of more than 1 g, such as are encountered in space flight. Analytical data are also presented on the nature and activity of the basic mechanisms during compensation of periodic fluctuations in the blood volume resulting from cardiac activity, respiratory movements, third-order waves, and vascular reaction of the brain under normal conditions, including longitudinal gravitational accelerations of up to +1 g. To define these mechanisms, the dynamics of the cerebral blood volume as a partly isolated system are examined. M.G.J.

N68-15899*# National Aeronautics and Space Administration, Washington, D. C.
AEROSPACE MEDICINE AND BIOLOGY: A CONTINUING BIBLIOGRAPHY WITH INDEXES
Dec. 1967 133 p refs
(NASA-SP-7011(44)) CFSTI: HC$3.00/MF$0.65 CSCL 06S

Subject coverage concentrates on the biological, physiological, psychological, and environmental effects to which man is subjected during and following simulated or actual flight in the earth's atmosphere or in interplanetary space. Also included are such related topics as sanitary problems, pharmacology, toxicology, safety and survival, life support systems, exobiology, and personnel factors. Each entry consists of a standard citation accompanied by its abstract. Author

N68-16517*# National Aeronautics and Space Administration, Washington, D. C.
AEROSPACE MEDICINE AND BIOLOGY Continuing Bibliography With Indexes, During December 1967
Jan. 1968 130 p refs
(NASA-SP-7011(45) CFSTI: HC$3.00/MF$0.65 CSCL 06S

Subject coverage concentrates on the biological, physiological, psychological, and environmental effects to which man is subjected during and following simulated or actual flight in the earth's atmosphere or in interplanetary space. References describing similar effects on biological organisms of lower order are also included. Such related topics as sanitary problems, pharmacology, toxicology, safety and survival, life support systems, exobiology, and personnel factors receive appropriate attention. Each entry consists of a standard citation accompanied by its abstract. Author

N68-20026*# National Aeronautics and Space Administration, Washington, D. C.
AEROSPACE MEDICINE AND BIOLOGY—A CONTINUING BIBLIOGRAPHY WITH INDEXES
Feb. 1968 175 p refs
(NASA-SP-7011(47)) CFSTI: HC$3.00/MF$0.65 CSCL 06S

Subject coverage concentrates on the biological, physiological, psychological, and environmental effects to which man is subjected during and following simulated or actual flight in the earth's atmosphere or in interplanetary space. References describing similar effects on biological organisms of lower order are also included. Such related topics as sanitary problems, pharmacology, toxicology, safety and survival, life support systems, exobiology, and personnel factors receive appropriate attention. Each entry consists of a standard citation accompanied by its abstract. Author

N68-20027*# National Aeronautics and Space Administration, Washington, D. C. Scientific and Technical Information Div.
AEROSPACE MEDICINE AND BIOLOGY—A CONTINUING BIBLIOGRAPHY WITH INDEXES
Mar. 1968 131 p refs For abstract see N68-20026 10-04
(NASA-SP-7011(48)) CFSTI: HC$3.00/MF$0.65 CSCL 06S

N68-21383*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
REVIEW OF NASA-MSC ELECTROENCEPHALOGRAM AND ELECTROCARDIOGRAM ELECTRODE SYSTEMS INCLUDING APPLICATION TECHNIQUES
J. L. Day Washington Apr. 1968 16 p refs
(NASA-TN-D-4398) CFSTI: HC$3.00/MF$0.65 CSCL 06B

The development and evaluation of a silver/silver chloride/gelatinate matrix electrode with a specially prepared electolytic paste are described. The system was developed to enhance readings of space flight electroencephalogram, electrocardiogram, and respiration monitoring systems. Details of the electrode, electrolytic paste, harness assembly, and integument subsystems are given followed by a step by step presentation of application procedures. These electrodes are more artifact free than conventional electrodes. If the application procedure is followed meticulously, the electrodes will remain in place and provide a high quality signal for long periods. Dermatological and microbiological tests show that the paste and electrodes are nonirritating and cause insignificant microbial proliferation during 14-day periods. R.N.A.

N68-22194*# National Aeronautics and Space Administration, Washington, D. C.
AEROSPACE MEDICINE AND BIOLOGY—A CUMULATIVE INDEX
Jan. 1968 887 p refs Supersedes NASA-SP-7011(45)
(NASA-SP-7011(46); NASA-SP-7011(45)) CFSTI: HC $3.00/MF $0.65 CSCL 06S

This publication is a cumulative index to the past twelve issues (SP-7011(34) through SP-7011(45)) of the National Aeronautics and Space Administration's Continuing Bibliography titled *Aerospace Medicine and Biology*. The bibliography has been compiled through the cooperative efforts of the Aerospace Medicine and Biology Bibliography Project of the Library of Congress (LC), the American Institute of Aeronautics and Astronautics (AIAA), and the National Aeronautics and Space Administration (NASA). Entries prepared by the three contributing organizations are identified as follows: (1) NASA entries by their STAR accession numbers (N67-10000 series); (2) AIAA entries by their IAA accession numbers (A67-10000 series); and (3) LC entries identified by a number in the A67-80000 series. Author

N68-22882*# National Aeronautics and Space Administration, Washington, D. C.
AEROSPACE MEDICINE AND BIOLOGY. A CONTINUING BIBLIOGRAPHY WITH INDEXES
Apr. 1968 144 p
(NASA-SP-7011(49)) CFSTI: HC$3.00/MF$0.65 CSCL 06S

Subject coverage concentrates on the biological, physiological, psychological, and environmental effects to which man is subjected during the following simulated or actual flight in the earth's atmosphere or in interplanetary space. References describing similar effects on biological organisms of lower order are also included. Such related topics sanitary problems, pharmacology, toxicology, safety and survival, life support systems, exobiology, and personnel factors receive appropriate attention. Each entry consists of a standard citation accompanied by its abstract. Author

N68-24272*# Scientific Translation Service, La Canada, Calif.
THE ORIGIN AND INITIAL DEVELOPMENT OF LIFE
A. I. Oparin Washington NASA May 1968 60 p refs Transl. into ENGLISH of the book "Vozniknoveniye i Nachal'noye Razvitiye Zhizni" Moscow, Meditsina, 1966
(Contract NASw-1496)
(NASA-TT-F-488) CFSTI: HC $3.00/MF $0.65 CSCL 06B

A book is presented on the history of the development of life on earth. A brief review of the attempts to solve the origin of life is given along with an objective chronology of the events leading to the origin and initial development of life. The initial stages in the development of carbon compounds is described, and the formation of the primary broth is examined. Details are given on the rise of prebiological systems, and the evolution and rise of primitive organisms with the subsequent evolution of primary organisms is described. B.S.D.

N68-25844*# National Aeronautics and Space Administration, Washington, D. C.
AEROSPACE MEDICINE AND BIOLOGY: A CONTINUING BIBLIOGRAPHY WITH INDEXES
May 1968 132 p refs
(NASA-SP-7011(50)) CFSTI: $3.00/MF $0.65 CSCL 06S

Subject coverage concentrates on the biological, physiological, psychological, and environmental effects to which man is subjected during and following simulated or actual flight in the earth's atmosphere or in interplanetary space. References describing similar effects on biological organisms of lower order are also included. Such related topics as sanitary problems, pharmacology, toxicology, safety and survival, life support systems, exobiology, and personnel factors receive appropriate attention. Each entry consists of a standard citation accompanied by its abstract. *Author*

N68-26207*# National Aeronautics and Space Administration, Washington, D. C.
BIOREGENERATIVE SYSTEMS
1968 152 p refs Proc. of a Conf. held in Washington, D. C., 15–16 Nov. 1966
(NASA-SP-165) GPO: HC $1.50; CFSTI: MF $0.65 CSCL 06M

Topics presented at this conference cover the application of Hydrogenomonas–chemosynthesis and algae-photosynthesis processes in future bioregenerative life support systems for long duration space travel. Advantages and disadvantages of both systems are outined and the possibility of a combined chemosynthetic–photosynthetic system is considered. G.G.

N68-28246*# National Aeronautics and Space Administration, Washington, D. C.
AEROSPACE MEDICINE AND BIOLOGY—A CONTINUING BIBLIOGRAPHY WITH INDEXES, MAY 1968
Jun. 1968 174 p refs
(NASA-SP-7011(51)) CFSTI: HC $3.00/MF $0.65 CSCL 06S

Subject coverage concentrates on the biological, physiological, pyschological, and environmental effects to which man is subjected during and following simulated or actual flight in the earth's atmosphere or in interplanetary space. References describing similar effects on biological organisms of lower order are also included. Such related topics as sanitary problems, pharmacology, toxicology, safety and survival, life support systems, exobiology, and personnel factors receive appropriate attention. Each entry consists of a standard citation accompanied by its abstract. Author

N68-28247*# Litton Systems, Inc., Minneapolis, Minn.
MICROBIOLOGICAL EXPLORATION OF THE STRATOSPHERE. DEVELOPMENT AND FLIGHTS OF THE MARK 2 AND 3 SAMPLING SYSTEMS
Paul D. Pederson, Jr. Washington NASA Jun. 1968 139 p refs
(Contract NAS5-3888)
(NASA-CR-1101; TR-3172) CFSTI: HC $3.00/MF $0.65 CSCL 06M

Research to determine the existence and identity of viable microorganisms in the stratosphere was performed. This report covers all effort expended and includes the description of two sampling systems (Mark II and Mark III) which employ low-pressure drop media for the collection of viable microorganisms at low air densities. A total of seven operationally successful flights were conducted with samples obtained from altitude profiles ranging from 10,000 to 90,000 feet. Emphasis was on contamination control techniques to minimize or eliminate microbial background during all procedures associated with sample acquisition and analysis. Organisms recovered existed in low numbers generally varying inversely with altitude in the range of 10^{-2} to 10^{-4} organisms per ambient ft^3 air. A variety of bacterial and fungal species were isolated. Author

N68-28278*# Esso Research and Engineering Co., Linden, N. J.
STUDY OF METHODS FOR CHEMICAL SYNTHESIS OF EDIBLE FATTY ACIDS AND LIPIDS Final Technical Report
John W. Frankenfeld, ed. Washington NASA Jul. 1968 160 p refs
(Contract NAS2-3708)
(NASA-CR-1105) CFSTI: HC $3.00/MF $0.65 CSCL 06A

A survey and critical evaluation of existing methods for the synthesis of fatty acids and lipids from metabolic wastes under conditions of space travel was completed. An extensive literature search was conducted and the candidate processes were evaluated from the standpoints of chemical feasibility and nutritional value of the products. The only promising route involved synthesis of ethylene from carbon monoxide, polymerization to α-olefins *via* the Ziegler growth reaction, conversion to fatty acids by oxidative ozonolysis and combination with glycerol to form edible glycerides. Four methods for the synthesis of glycerol were discovered. The most promising are base catalyzed trimerization of formaldehyde followed by hydrogenation and hydrogenolysis of higher sugars which may be prepared by controlled polymerization of formaldehyde. The synthesis of glycerol is much less complicated than fatty acid production and hence is a recommended alternate. A series of recommendations for further research and development were drawn up. These are mostly in the area of engineering and nutrition. Author

N68-28829*# Esso Research and Engineering Co., Linden, N. J.
STUDY OF METHODS FOR CHEMICAL SYNTHESIS OF EDIBLE FATTY ACIDS AND LIPIDS: FINAL SUMMARY
John W. Frankenfeld, ed. Washington NASA Jul. 1968 97 p refs
(Contract NAS2-3708)
(NASA-CR-1104) CFSTI: HC $3.00/MF $0.65 CSCL 06A

A survey and critical evaluation of existing methods for the synthesis of fatty acids and lipids from the metabolic wastes under conditions of space travel has been completed. An extensive literature search was conducted and the candidate processes were evaluated from the standpoints of chemical feasibility and nutritional value of the products. The only promising route involved synthesis of ethylene from carbon monoxide, polymerization to α-olefins *via* the Ziegler growth reaction, conversion to fatty acids by oxidative ozonolysis and combination with glycerol to form edible glycerides. A first approximation engineering design was made and some rough estimates of power requirements were drawn up. The system was found to be extremely complex and unreliable. Hence it is not recommended as a method for food preparation on board a space craft. Four methods for the synthesis of glycerol were discovered. The most promising are base catalyzed trimerization of formaldehyde followed by hydrogenation and hydrogenolysis of higher sugars which may be prepared by controlled polymerization of formaldehyde. The synthesis of glycerol is much less complicated than fatty acid production and hence is a recommended alternate. Dissert. Abstr.

N68-29128*# National Aeronautics and Space Administration, Washington, D. C.
THE ROLE OF THE VESTIBULAR ORGANS IN SPACE EXPLORATION
1968 437 p refs 3d Symp., Held at Naval Aerospace Med. Inst., Pensacola, Fla., 24–26 Jan. 1967 Sponsored by NAS-NRC
(NASA-SP-152) GPO: HC$3.25; CFSTI: MF$0.65 CSCL 06S

In the conference papers presented, the problems of studying disorientation under space conditions is discussed in relation to the basic research being conducted on vestibular mechanisms. Attention is focused on circulation of the endolymph, efferent vestibular function and anatomical considerations, blood supply to the labyrinth, tests of otolith and canal function. For individual titles see N68-29128 through N68-29158.

N68-32707*# National Aeronautics and Space Administration, Washington, D. C.
AEROSPACE MEDICINE AND BIOLOGY A Continuing Bibliography with Indexes
Jul. 1968 150 p refs
(NASA-SP-7011(52)) CFSTI: HC$3.00/MF$0.65 CSCL 06S

Subject coverage concentrates on the biological, physiological, psychological, and environmental effects to which man is subjected during and following simulated or actual flight in the earth's atmosphere or in interplanetary space. References describing similar effects on biological organisms of lower order are also included. Such related topics as sanitary problems, pharmacology, toxicology, safety and survival, life support systems, exobiology, and personnel factors receive appropriate attention. Each entry consists of a standard citation accompanied by its abstract. Author

N68-33005*# Stanford Research Inst., Menlo Park, Calif.
A PRELIMINARY STUDY OF THE AWAKENING AND STARTLE EFFECTS OF SIMULATED SONIC BOOMS
Jerome S. Lukas and Karl D. Kryter Washington NASA Sep. 1968 74 p refs
(Contract NAS1-6193)
(NASA-CR-1193) CFSTI: HC$3.00/MF$0.65 CSCL 05E

Results of experiments on the startling and awakening effects of sonic booms are presented. The objectives were to: (1) build and test a device and associated room where one could simulate the effects of sonic booms on a room in a house, and (2) conduct studies of the effects of the simulated indoor booms on people sleeping and performing manual tasks. The tentative findings are based on a study of a small, homogeneous group of subjects. Author

N68-35069*# National Aeronautics and Space Administration, Washington, D. C.
AEROSPACE MEDICINE AND BIOLOGY: A CONTINUING BIBLIOGRAPHY WITH INDEXES
Aug. 1968 154 p refs
(NASA-SP-7011(53)) CFSTI: HC$3.00/MF$0.65 CSCL 06S

Subject coverage concentrates on the biological, physiological, psychological, and environmental effects to which man is subjected during and following simulated or actual flight in the earth's atmosphere or in interplanetary space. References describing similar effects on biological organisms of lower order are also included. Such related topics as sanitary problems, pharmacology, toxicology, safety and survival, life support systems, exobiology, and personnel factors receive appropriate attention. Each entry consists of a standard citation accompanied by its abstract. Author

N68-35103*# Stanford Research Inst., Menlo Park, Calif.
RELATIVE ANNOYANCE AND LOUDNESS JUDGEMENTS OF VARIOUS SIMULATED SONIC BOOM WAVEFORMS
L. J. Shepherd and W. W. Sutherland Washington NASA Sep. 1968 59 p refs
(Contract NAS1-6193)
(NASA-CR-1192; LR-20922) CFSTI: HC $3.00/MF $0.65 CSCL 05E

A series of investigations were initiated in an effort to assess the effect of sonic boom signature modification on human subjective response, using Lockheed's sonic boom simulation facility. Subjective response was found to be influenced by changes in several signature parameter, including rise time, interpeak duration, and the addition of short duration transients to the signature bow wave. Detailed descriptions and the results of this series of experiments are described. Author

05

BIOTECHNOLOGY

Includes life support systems, human engineering; protective clothing and equipment; crew training and evaluation, and piloting. For related information see also: 04 Biosciences.

N68-10381*# Serendipity Associates, Chatsworth, Calif.
A DESCRIPTIVE MODEL FOR DETERMINING OPTIMAL HUMAN PERFORMANCE IN SYSTEMS, VOLUME 4 Final Summary Report
Washington NASA Nov. 1967 51 p
(Contract NAS2-2955) CSCL 05H
(NASA-CR-879) CFSTI: HC $3.00/MF $0.65

This study was conducted to provide tools to aid in management decisions germane to the development of complex aerospace systems to the end that man be used in an optimal way. The study consists of five parts packaged in three reports and each part is focused on a particular area of concern to enable the necessary decision-making, planning, and execution effort to be conducted. The reports are concerned with a simple model of a man–machine development cycle, a simple calculus for discrete systems, system development activities concerned with putting man in an aerospace system, some concepts and guidelines for developing man–machine systems, and an approach for determining the optimal role of man and allocation of functions in an aerospace system. The method by which the study was conducted is described in terms of 12 major tasks. Implications for future work are considered in detail. R.N.A.

N68-10648* Aerospace Products Research Corp., Santa Monica, Calif.
COMPUTER DRIVEN ELECTROLUMINESCENT VERTICAL SCALE INDICATOR
James A. Pellegrino and Jules L. Rosenbaum Washington NASA Nov. 1967 40 p
(Contract NAS7-420)
(NASA-CR-919) CFSTI: $3.00 CSCL 09B

The effort expended in the design, development, and fabrication of two types of solid-state digitally controlled electroluminescent vertical scale indicators is outlined. One type is a single parameter indicator which employs one bargraph, with scale and parameter indication; and the other is a flight director which uses two adjacent bargraphs, with scale and parameter indication. The delivered indicators met all of the following specification requirements: fast dynamic response compatible with the SDS 920 Computer update-time capability of one to twenty milliseconds; automatic lamp brightness regulation; absence of glow, flicker, and cross-coupling in the lighted display; use of high-contrast display techniques; interchangeability and versatility compatibile with an instrument used in laboratory simulations; multicolor display capability; internal information storage; low power consumption, capable of operating at 2.5 watts. The objectives for simulator environments were met with the exception of temperature. Some difficulty was encountered in isolating problems which appeared under dynamic operation of the instruments. Author

N68-11510*# Webb Associates, Yellow Springs, Ohio.
THE PRINCIPLE OF THE SPACE ACTIVITY SUIT
Paul Webb and James F. Annis Washington NASA Dec. 1967 34 p refs
(Contract NAS1-6872)
(NASA-CR-973) CFSTI: HC $3.00/MF $0.65 CSCL 05B

This paper describes in principle a Space Activity Suit (SAS) designed for an active astronaut working in a vacuum for up to four hours. The suit will consist of a powerful elastic net leotard combined with positive pressure breathing via helmet and trunk bladders. Under the terms of the present contract, an elastic sleeve-and-glove was constructed to demonstrate the principle of the full SAS suit. Subjects wore the garment in an arm chamber which produced negative pressures up to 200 mm Hg (8 in Hg). Exposures to near-vacuum conditions were accomplished in an altitude chamber where the total pressure was 155 mm Hg and the arm chamber pressure was 5 to 8 mm Hg. The near-vacuum exposure for 20 minutes produced no evidence of gaseous swelling; arterial and venous circulation was adequate; mobility and finger dexterity were excellent; increase in arm volume from accumulation of tissue fluid was approximately 5%. The successful demonstration of principle indicates that a full SAS can be developed. As an alternative to gas-filled pressure suits, its advantages would be: improved mobility, flexibility, and dexterity at small metabolic cost; simplicity in approach; low risk to the astronaut if the netting is torn; and physiological temperature regulation without power or cooling machinery. Author

N68-13609*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
A PILOTED FIXED-BASE SIMULATOR STUDY OF LOW-SPEED FLIGHT CHARACTERISTICS OF AN ARROW-WING SUPERSONIC TRANSPORT DESIGN
William D. Grantham and Perry L. Deal Jan. 1968 39 p refs
(NASA-TN-D-4277) CFSTI: HC $3.00/MF $0.65 CSCL 01B

A piloted fixed-base simulator study has been made to determine the low-speed flight characteristics of an arrow-wing supersonic transport configuration. The transport-type cockpit was equipped with normal flight controls and a flight instrument display representative of those found in current transport aircraft. The results indicated that although the longitudinal short-period damping ratio was at a good level (0.84), the pitch damping appeared to be low to the pilot because of the low frequency of the short-period oscillation. This low pitch damping and the sluggish pitch response made the longitudinal handling qualities of the basic configuration unsatisfactory. When the static stability, the damping in pitch, the elevator effectiveness, and the elevator to column gearing were increased by a sufficient amount. The lateral-directional handling qualities of the basic configuration were said to be unacceptable because of the poor roll control characteristics and the uncontrollable Dutch roll. When the effective dihedral was decreased by a sufficient amount, and the damping in roll and yawing moment due to roll were increased by a sufficient amount, the Cooper rating was improved to 2.5. Author

N68-13999* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CARDIAC R-WAVE DETECTOR
Vernon D. Gebben Washington Jan. 1968 13 p refs
(NASA-TM-X-1489) CFSTI: $3.00 CSCL 06B

A method of detecting the R-wave of the electrocardiac signal was developed for controlling the timing cycle of heart-assist pumps. Dependable separation of the R-wave from high-level electrical interferences was obtained from a circuit that contains high

common-mode rejection, a band-pass filter, an amplitude detector, and a pulse-width discriminator. An experimental circuit was tested using copper surface electrodes located on the right arm and left leg. All false signals except those generated by vigorous motion or extreme muscle tensions were rejected by the circuit. Author

N68-14262*# Serendipity Associates, Chatsworth, Calif.
A DESCRIPTIVE MODEL FOR DETERMINING OPTIMAL HUMAN PERFORMANCE IN SYSTEMS, VOLUME 1
Washington NASA Jan. 1968 166 p refs
(Contract NAS2-2955)
(NASA-CR-876) CFSTI: HC$3.00/MF$0.65 CSCL 05H

CONTENTS:

1. A SIMPLE MODEL OF A MAN-MACHINE DEVELOPMENT CYCLE, PART A J. J. Wulff and J. N. Leonard 129 p refs (See N68-14263 05-05)

2. A SIMPLE CALCULUS FOR DISCRETE SYSTEMS, PART B J. J. Wulff, A. F. Pixley (Harvey Mudd Coll.), and J. N. Leonard 31 p refs (See N68-14264 05-19)

N68-15120*# Serendipity Associates, Chatsworth, Calif.
A DESCRIPTIVE MODEL FOR DETERMINING OPTIMAL HUMAN PERFORMANCE IN SYSTEMS. VOLUME 2: PART A: SYSTEM DEVELOPMENT ACTIVITIES CONCERNED WITH PUTTING MAN IN AN AEROSPACE SYSTEM. PART B: DEVELOPMENT OF MAN–MACHINE SYSTEMS: SOME CONCEPTS AND GUIDELINES
Washington, D. C. NASA Jan. 1968 380 p refs
(Contract NAS2-2955)
(NASA-CR-877, V. 2) CFSTI: HC$3.00/MF$0.65 CSCL 05H

The design and control of each of the identified man-related activities in an aerospace system model are described. Consideration is given to planning and controlling each activity in the system development cycle which pertains to the production of man-related end products such as trained personnel, job aids, and human-engineered interfaces. Each man-related activity is discussed in the context of the overall development cycle objectives which are dependencies upon other activities, demands of other activities, activities interactions, and the process of conducting the activity. The identified man-related activities are described in terms of activity groups. Selected terms are given for the common vernacular of the biotechnology and system engineering community. Tools for synthesizing aerospace systems are included with emphasis on the design and development of the man-related features of man–machine systems. B.S.D.

N68-15306*# Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md.
EXTENDED DURATION, RECOVERABLE PRIMATE SATELLITE
Washington NASA Jan. 1968 147 p
(NASA Order R-21-009-014)
(NASA-CR-926) CFSTI: HC$3.00/MF$0.65 CSCL 06K

The results are presented of a brief engineering study of a proposed six-month orbital physiological experiment generally referred to as the Primate Orbital Experiment. In this proposed Apollo application experiment, two live squirrel monkeys would be placed into a low earth orbit, then recovered alive approximately six months later, for examination on the ground. This study includes all spacecraft systems, life support, and instrumentation for an experiment package which could be transported into orbit by an Apollo spacecraft and function autonomously until picked up six months later through rendezvous with a second Apollo spacecraft. Presented are approaches to possible ways of integrating the animal-carrying satellite with Apollo during launch, and feasible life support and instrumentation techniques to maintain the animals alive in orbit for six months. Techniques for retrieval are suggested. Author

N68-15901*# National Aeronautics and Space Administration, Washington, D. C.
THIRD ANNUAL NASA UNIVERSITY CONFERENCE ON MANUAL CONTROL
1967 435 p refs Conf. held Univ. of Southern Calif., Los Angeles, 1–3 Mar. 1967
(NASA-SP-144) CFSTI: HC$3.00/MF$0.65 CSCL 05H

In the conference proceedings presented, emphasis is placed on display devices, function models, decision processes, computer processing of manual control records, controlled elements, physiological modeling, and advanced modeling techniques. For individual titles, see N68-15902 through N68-15935.

N68-16594*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EVALUATION OF A CLOSED-CIRCUIT TELEVISION DISPLAY IN LANDING OPERATIONS WITH A HELICOPTER
William Gracey, Robert W. Sommer, and Don F. Tibbs Washington Feb. 1968 20 p refs
(NASA-TN-D-4313) CFSTI: HC$3.00/MF$0.65 CSCL 05H

An instrument display consisting of a television monitor; vertical-type torquemeter was evaluated in simulated IFR (Instrument Flight Rules) approaches with a helicopter. The evaluation was made with three lenses having focal lengths of 12.5, 25, and 50 mm. The restricted-view tests with binocular vision showed that a view as small as 22.6° horizontal and 18.5° vertical has a detrimental effect on the control of longitudinal position at touchdown. The tests with monocular vision showed that the control difficulties increase with the loss of depth perception. The tests of the television display showed that the difficulties in controlling attitude and position increased as the helicopter approached the ground. The determination of position and position-rate information was made difficult because of the restricted views of the lenses, the image magnification and the low resolution and lack of depth perception of the televised scene. The tests demonstrated that, with the television display augmented by height information, the pilots were able to execute low-speed, steep approaches with an angular view as small as 22.6° by 18.5° and an image magnification as small as about 0.35. Author

N68-18014*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
ANALYSIS OF HUMAN RESPONSE IN COMBINED CONTROL TASKS
Hugh P. Bergeron, James J. Adams, and George J. Hurt, Jr. Washington Mar. 1968 55 p refs
(NASA-TN-D-4356) CFSTI: HC $3.00/MF $0.65 CSCL 05H

The simulation consisted of a primary control task to which were added secondary or side tasks. A trajectory control problem was used as the primary control task for the pilot. The trajectory task was a fixed-base simulation of a lunar letdown. The task-loading effects on the letdown were found to be predominant during the final hover and translation phase. All multitask tests were made by using either the lunar-letdown simulation or the multiloop representation as the primary control task. The secondary or side tasks consisted of: (1) a system-failures task integral to a typical space vehicle, and (2) a well-defined motor response task. The study generated a quantitative index of the information processing characteristics of a full (multitask) simulation. A method for determining the information processing requirements of a trajectory control task was devised to provide the quantity related to this index. By combining this quantity with the information processing measurements of the side tasks, the total workload for various combinations of tasks was determined. A quantitative analytical model was also generated for the multiloop control in a multitask simulation. A duty-cycle shaping technique developed in this study was used to generate the model. Author

N68-18870*# National Aeronautics and Space Administration, Washington, D. C.
TELEOPERATORS AND HUMAN AUGMENTATION. AN AEC–NASA TECHNOLOGY SURVEY
Edwin G. Johnson and William R. Corliss Dec. 1967 273 p
(NASA-SP-5047) GPO: HC$1.00; CFSTI: MF$0.65 CSCL 05H

This book surveys general purpose, dexterous, cybernetic machines developed in the last 25 years, emphasizing the principal subsystems of contemporary designs of such teleoperators. The purpose of the work is to present the concepts and techniques of teleoperators now used in nuclear and aerospace work for possible adaptation in exploring the seas, increasing industrial productivity, and aiding physically handicapped persons. Covered are: (1) present and potential teleoperator applications; (2) subsystems and man–machine integration; (3) design principles of structure, control, actuator, and sensor subsystems; and (4) teleoperator terminal devices. A glossary and an extensive bibliography are included. K.W.

N68-19165*# Serendipity Associates, Chatsworth, Calif.
A DESCRIPTIVE MODEL FOR DETERMINING OPTIMAL HUMAN PERFORMANCE IN SYSTEMS. VOLUME 3: AN APPROACH FOR DETERMINING THE OPTIMAL ROLE OF MAN AND ALLOCATION OF FUNCTIONS IN AN AEROSPACE SYSTEM
Harold E. Price and Barbara J. Tabachnick Washington NASA Mar. 1968 1204 p refs
(Contract NAS2-2955)
(NASA-CR-878) CFSTI: HC$3.00/MF$0.65 CSCL 05H

Conventions, sequence of activities, and research needs are considered in an effort to determine the role of man in space and the allocation of functions to men and machines in aerospace systems. The 11 conventions discussed include the local and remote segment, optimal manned design, man-rated performance, core performance, and roles of men in systems. Types and components of human performance, personnel support systems, man–machine comparisons, personnel products package, and automation are the other conventions implicit in a descriptive model for determining optimal human performance in aerospace systems. Activities are considered in terms of determining both the optimal role of man and the optimal allocation of function; and detailed data are appended on man–machine performance and crew support requirements. M.W.R.

N68-20339*# Environmental Research Associates, Randallstown, Md.
A STUDY OF THE PERFORMANCE OF AN ASTRONAUT DURING INGRESS AND EGRESS MANEUVERS THROUGH AIRLOCKS AND PASSAGEWAYS
Harry L. Loats, Jr. and William J. Bruchey, Jr. Washington NASA Apr. 1968 163 p refs
(Contract NAS1-4059)
(NASA-CR-971) CFSTI: HC$3.00/MF$0.65 CSCL 05H

The performance characteristics of a pressure-suited astronaut during ingress–egress through various geometry airlocks were studied by water immersion techniques. The buoyancy force induced by water displacement of a totally immersed subject was used to counteract all or part of his adjusted total weight to provide the desired simulated gravity level. The subject performed real-time maneuvers as determined from functional analysis of representative extravehicular and intravehicular tasks. The purpose of this phase of the contract was to generate additional data on refined experiments initiated under previous contractual phases and to expand the experiment scope to include rescue, replenishment and general maneuvers exterior to the airlock. The effect of the variation of airlock dimension and shape on the capabilities to perform manual ingress–egress was evaluated by comparative time-task analysis. Author

N68-20354*# National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.
EFFECTS OF PRESSURE SUITS AND BACKPACK LOADS ON MAN'S SELF-LOCOMOTION IN EARTH AND SIMULATED LUNAR GRAVITY
Amos A. Spady, Jr. and Randall L. Harris Washington Apr. 1968 46 p refs
(NASA-TN-D-4464) CFSTI: HC$3.00/MF$0.65 CSCL 05E

Studies were conducted to evaluate the effect of a state-of-the-art full pressure suit on man's self-locomotion capabilities in earth and simulated lunar gravity. Separate tests, with subjects wearing lightweight coveralls, were also conducted in simulated lunar gravity to determine the effect on locomotion of carrying backpack loads of up to 500 earth pounds. The simulated lunar tests were conducted on a modified version of the reduced-gravity walking simulator. Tests in earth gravity were performed on a portion of asphaltic concrete road of length equal to that provided by the modified lunar-gravity simulator. The gait characteristics of the subjects were determined by having the subjects walk and run at various speeds. The results obtained with the pressure suit indicated that pressurizing the suit to 3.7 psig did not appreciably affect the subject's self-locomotive gait characteristics in lunar gravity. The results of the load-carrying tests indicated that a subject, dressed in lightweight coveralls, could carry a backpack loaded with 500 earth pounds while walking, loping, and sprinting in lunar gravity. Author

N68-20357*# National Aeronautics and Space Administration, Washington, D. C.
AN INTRODUCTION TO THE ASSURANCE OF HUMAN PERFORMANCE IN SPACE SYSTEMS
1968 42 p refs Prepared by Martin Co.
(NASA-SP-6506) CFSTI: HC$3.00/MF$0.65 CSCL 05H

To assess the role that man plays as a potential source of error in space technology, studies were conducted to determine what human performance assurance effort is appropriate for various projects and to show how this effort relates to various phases in the development cycle. A method for classifying programs and systems according to mission complexity and significance is developed, and human engineering and serviceability functions appropriate for specific development phases of the programs are categorized and described. Man–machine capabilities are summarized as an aid in determining the relative superiority of each. An example is presented in which the techniques are applied to a hypothetical micrometeoroid deep space satellite, a concept based on studies of an unmanned satellite program of medium-to-small cost and complexity. The reliability program provision for space system contractors, concerning prevention of human error, is included. M.G.J.

N68-21537*# National Aeronautics and Space Administration, Flight Research Center, Edwards, Calif.
FM HANDLING AND ANALOG-TO-DIGITAL CONVERSION OF BIOMEDICAL DATA FROM A 1,000-FLIGHT STUDY
Richard Carpenter and James Roman Washington Apr. 1968 12 p refs
(NASA-TN-D-4488) CFSTI: HC$3.00/MF$0.65 CSCL 06B

To collect, process, and analyze FM-recorded biomedical data from 1,000 flights in high performance aircraft and test vehicles, it was necessary to devise a handling facility that would prepare these data in a standard format for high speed computer processing. The handling system designed maintains the very high signal to noise ratio inherent in the original data acquisition equipment, provides pushbutton control for converting the medical information into a standard format for digital processing at either four or eight times faster than the original record speed, and provides an effective number of quality control checkpoints. The system is described in detail, and system design considerations are discussed in relation to preventing data degradation in both FM handling and digital conversion. Approximately 1,400 hours of

flight data have been processed by this system in less than 600 hours without loss of data integrity. This system is suitable for preparing biomedical data in standard format for digital processing, since the system design can easily be changed to accommodate nonstandard input formats. Author

N68-21538*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

RECORDING AND SIGNAL-CONDITIONING TECHNIQUES AND EQUIPMENT USED IN A 1,000-FLIGHT BIOMEDICAL STUDY

Richard Carpenter and James Roman Washington Apr. 1968 17 p refs

(NASA-TN-D-4487) CFSTI: HC $3.00/MF $0.65 CSCL 06B

The NASA Flight Research Center recently concluded a biomedical monitoring program involving 1,000 flights in high performance aircraft by students of the USAF Aerospace Research Pilot School and by NASA aerospace research pilots. To permit accurate and reliable data acquisition of electrocardiogram (ECG), respiration rate, and normal acceleration, it was necessary to design and develop a means of reliably recording and transcribing flight medical data in a format compatible with computer reduction. Signal conditioners and interconnecting harnesses were designed and fabricated, and guidelines were established for the construction of a five channel analog tape recorder to record these data while the recorder is being carried on the pilot with minimum interference or discomfort. The equipment operated reliably and enabled satisfactory data acquisition of biomedical information both in extended biomedical instrumentation studies and in remote site medical monitoring. Author

N68-21859*# California Univ., San Francisco. Medical Center.

RELATIVE ROLES OF GRAVITATIONAL AND INERTIAL WORK IN THE ENERGY COST OF HUMAN LOCOMOTION

H. J. Ralston and L. Lukin Washington NASA Apr. 1968 18 p refs

(Grant NsG-722)

(NASA-CR-1042) CFSTI: HC $3.00/MF $0.65 CSCL 06S

The metabolic cost of walking was measured during walking on the treadmill at various slopes—positive, level and negative—and before and after loading of the principal body segments. An equation derived from these studies relates metabolic demand to speed of walking under 1/6 g conditions, and is shown to be in acceptable agreement with the data obtained by other investigators for moderate speeds of walking under simulated 1/6 g conditions. The effects of load upon the metabolic cost of walking are shown to be critically dependent upon the segment of the body loaded. Loading of the extremities causes a much greater increase in the metabolic cost of walking than loading of the trunk, due to the greater magnitude of inertial (kinetic energy) work compared with gravitational work. The probable metabolic effects of restraint of free body motion, combined with difficult terrain, are briefly discussed. Author

N68-22448*# Rensselaer Polytechnic Inst., Troy, N. Y.

FREQUENCY CODED THRESHOLD LOGIC UNIT FOR PATTERN RECOGNITION APPLICATION

Rob Roy and David Hinks Washington NASA May 1968 72 p refs

(Grant NGR-33-018-014)

(NASA-CR-1035) CFSTI: HC $3.00/MF $0.65 CSCL 06B

The principles on which the central nervous system functions are investigated, and their application to pattern recognition problems are discussed. The concepts are then developed in the form of a frequency coded threshold logic element which will employ the advantageous techniques of information transmission exhibited by the sensory nervous system, and improve the performance of the pattern recognition system. The design develops a discriminant function that is a linear combination of weighted frequencies and computed simply as a pulse count; the operating characteristics of the system are delineated. The concept of frequency coding is used to provide a method in which modern digital techniques may be applied to incorporate speed and reliability into the design. The hardware requirements of the proposed design are given in detail and require only moderate expenditure of equipment. B.S.D.

N68-24756*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.

FLAMMABLE AND TOXIC MATERIALS IN THE OXYGEN ATMOSPHERE OF MANNED SPACECRAFT

John H. Kimzey Washington May 1968 30 p refs

(NASA-TN-D-3415) CFSTI: HC $3.00/MF $0.65 CSCL 05E

A preliminary study of the considerations necessary in selecting materials for use in an oxygen-rich atmosphere revealed that a major design effort must be directed toward reducing the toxic and flammable contaminants of the atmosphere. The effect of zero gravity in preventing convection is one aspect of research that deserves considerable effort since heat transfer and flammability are two major fields directly affected. Other research is needed in human tolerances, static electricity, removal of low-molecular-weight gas, fire extinguishment, overall characteristics of materials exposed for long periods in pure oxygen, and in the development of adequate test procedures. Author

N68-25060*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

A PIEZOELECTRIC TRANSDUCER FOR MEASURING CARDIAC AND GROSS MOTOR ACTIVITY OF SMALL ORGANISMS

Vernon L. Rogallo, Robert S. Jenkins, and Gordon J. Deboo Washington May 1968 11 p refs

(NASA-TN-D-4590) CFSTI: HC $3.00/MF $0.65 CSCL 06B

The transducer system incorporates both mechanical and electrical noise rejection features. The mechanical feature is achieved by a dual arrangement, essentially two transducers, one of which senses the organism activity and noise while the second senses only the noise. Subtraction of the output of the individual transducers results in a cancellation of the environmental noise. The electrical noise rejection is achieved by low-noise preamplifiers with differential input to reject 60 Hz. A low-noise-RC-active filter is used to eliminate frequencies outside the bandwidth of interest. It was found that the rejection features provided sufficient discrimination against environmental noise to allow the transducer to be used in a normal laboratory environment. The instrument is sufficiently sensitive to measure heart rates in insects, reptiles, mammals, and developing chick embryos as young as 3 days. Author

N68-26690*# Systems Technology, Inc., Hawthorne, Calif.

PILOT DYNAMIC RESPONSE TO SUDDEN FLIGHT CONTROL SYSTEM FAILURES AND IMPLICATIONS FOR DESIGN

David H. Weir and Walter A. Johnson Washington NASA Jun. 1968 152 p refs

(Contract NAS2-3607)

(NASA-CR-1087; TR-165-1) CFSTI: HC $3.00/MF $0.65 CSCL 05H

The dynamic response of the human pilot is studied during sudden changes in the effective controlled element dynamics caused by flight control system failure. Experimental results from single-loop and multiple-loop fixed-base studies are presented. A hypothesis of graceful degradation is shown to be valid which states that the pilot's transition response and performance are improved if the difference in controlled element dynamics at failure is reduced. The design implications of this principle are detailed. A model for the pilot's dynamic response is presented which accounts for his behavior during the several phases of transition. Author

N68-26701*# Webb Associates, Yellow Springs, Ohio.
AUTOMATIC CONTROL OF WATER COOLING IN SPACE SUITS
Paul Webb, James F. Annis, and Samuel J. Troutman Washington NASA Jun. 1968 91 p refs
(Contract NASw-1529)
(NASA-CR-1085) CFSTI: HC $3.00/MF $0.65 CSCL 06K

Accurate and timely control of the powerful cooling available in a water cooled garment (WCG) is important during periods when work varies widely, as in extravehicular activity, and with it the need for cooling. The relationship between metabolic rate (MR) and the suit inlet water temperature (T_{wi}) can be expressed as an ordinary differential equation: $\tau T_{wi} = -T_{wi} + B_4(MR_0-MR)$. An experimental Q controller was used to automatically control heat removal (Q) from men wearing a new WCG while working on a treadmill. The input to the controller was a continuous oxygen consumption signal. The cooling water was recirculated through a closed loop where the man was the heat source and a controllable thermoelectric cooler was the heat sink. After initial experiments where variation in the controller gain and time constant were explored, automatic control was evaluated in two subjects doing four different patterns of work, including brief periods of intermittent work. Physiological responses were good, and control was smooth and accurate. Author

N68-28319*# IIT Research Inst., Chicago, Ill.
PRELIMINARY STUDY OF ADVANCED LIFE-SUPPORT TECHNOLOGY FOR A MARS SURFACE MODULE
R. E. Mitchell and M. Burns Washington NASA Jun. 1968 189 p refs
(Contract NASr-65(15))
(NASA-CR-1083) CFSTI: HC $3.00/MF $0.65 CSCL 06K

This study represents an initial step in the direction of subsystem definition for extended manned missions on Mars and is centered primarily around a review of the current literature and state-of-the-art techniques. A mission profile of four men for six months is analyzed. From this baseline assumption, a Mars surface module configuration is projected, and subsystems in life support, power, and environmental control most candidate for the proposed mission are assessed. Author

N68-28833*# Garrett Corp., Los Angeles, Calif.
THE EFFECTS OF LUNAR GRAVITY ON METABOLIC RATES
W. G. Robertson and E. C. Wortz Washington NASA Jul. 1968 91 p refs
(Contract NAS9-6494)
(NASA-CR-1102; Rept.-67-2174) CFSTI: HC $3.00/MF $0.65 CSCL 06S

Experiments were conducted to determine the effects of simulated lunar gravity on the metabolic cost of work in both the A-5-L and the RX-2 full pressure suits. Lunar gravity simulation was accomplished using a modified Hewes and Spady inclined-plane simulator and a 6-degree-of-freedom (DOF) suspension simulator. Six subjects wearing the A-5-L and RX-2 pressure suits were instrumented for determining metabolic rates; data were collected for walking and upper-torso exercises during ventilated and pressurized modes of operation for each suit. Results show that the metabolic rates for walking are lower in the 1/6-g environment than in the 1-g environment. There were no significant differences in the energy costs of walking between the RX-2 and the A-5-L pressure suits at 1/6 g with the suits pressurized. Pressurization results in a slight but significant increase in metabolic rate in the RX-2. Pressurization of the A-5-L results in a significant increase in metabolic rate in all exercise modes in each simulator. There were no significant differences between suits while performing upper-torso tasks in the pressurized mode during 1/6-g simulation. Author

N68-28847*# Decision Science, Inc., San Diego, Calif.
MODELING THE HUMAN OPERATOR WITH FINITE-STATE MACHINES
L. J. Fogel and Roger A. Moore Washington NASA Jul. 1968 236 p refs
(Contract NAS1-6739)
(NASA-CR-1112) CFSTI: HC $3.00/MF $0.65 CSCL 05H

The prospect of using finite-state machines to represent arbitrary analog transducers and the human operator in his performance of flight control is considered in this experimental investigation, together with the use of evolutionary programming as a means for finding such representations. A series of tasks of increasing difficulty which demonstrate this capability are presented, ranging from the characterization of relatively simple linear analog "pilots", through more complex nonlinear analog "pilots", and on to the human pilot acting both in a simulator and in flight. The findings of the investigation demonstrate that finite-state machines do offer a suitable means for representing the human operator in terms of his stimulus-response behavior with respect to non-convergent tracking tasks. In addition, alternative hypotheses concerning the logic of pilot behavior were examined in order to reveal their relative worth on the basis of the available empirical evidence. Additional tasks are outlined which may well be addressed through the use of the technique described in this report. Author

N68-30602*# Bolt, Beranek, and Newman, Inc., Van Nuys, Calif.
THE NOISINESS OF TONES PLUS NOISE
Karl S. Pearsons, Richard D. Horonjeff, and Dwight E. Bishop Washington NASA Aug. 1968 89 p refs
(Contract NAS1-6364)
(NASA-CR-1117; Rept.-1520) CFSTI: HC $3.00/MF $0.65 CSCL 06P

A series of judgment tests were conducted to investigate subjective judgments of single, modulated and multiple tones plus noise. The subjects were asked to judge which of two sounds, tones plus noise or noise alone, was noisier (or in some cases louder). Stimuli included both broadband and octave band noises together with single tones at 250, 500, 1000, 2000, and 4000 Hz. Amplitude and frequency modulated tones of 500 and 2000 Hz were also employed. Multiple tone stimuli included 2 and 5 tone complexes with overall frequency spacings of 1/10, 1/3, 1, 4/3 and 2 octaves. Analysis of the judgment results were made using calculated perceived noise level and pure tone correction procedures. Author

N68-31480*# Biotechnology, Inc., Arlington, Va.
EFFECT OF HEAT STRESS AND PROLONGED ACTIVITY ON PERCEPTUAL-MOTOR PERFORMANCE
Raymond E. Reilly and James F. Parker, Jr. Washington NASA Aug. 1968 58 p refs
(Contract NASw-1329)
(NASA-CR-1153) CSCL 06S

This study was concerned with the assessment of the effects of two stress conditions on 16 basic dimensions of perceptual-motor performance. Subjects were tested under conditions of heat stress (86°F effective temperature for a period of six hours) and prolonged activity (24-hour continuous activity, with two 2-hour rest periods). In general, perceptual-motor performance levels were well maintained under these stress conditions and there was essentially no change in performance effectiveness during the 24-hour period of prolonged activity. Under heat stress, oral temperature and pulse rate increased significantly, lending support to the inference of increased arousal. Under prolonged activity, no change was noted in oral temperature, pulse rate, or blood pressure. This was consistent with the general lack of change in the performance measures indicating this level of stress was well tolerated. The findings of this investigation demonstrate the usefulness of the integrated measurement system as a device for the study of human performance. Author

N68-31911*# Massachusetts Inst. of Tech., Cambridge.
A THEORY AND MODEL OF HUMAN LEARNING BEHAVIOR IN A MANUAL CONTROL TASK
Albert Ernest Preyss Washington NASA Aug. 1968 138 p refs
(Grant NsG-577)
(NASA-CR-1124) CFSTI: HC $3.00/MF $0.65 CSCL 05H

A theory is presented for the explanation of human learning behavior in a manual control task. In the performance of a psychomotor task, a human operator responds to sensory stimuli with limb movements. This psycho-physiological phenomenon is conceptualized herein as a single channel information processing system. A sensor, a decision center and an effector are the serially connected components of the system. In the decision center responses are selected from a set of possible alternatives. Stored in memory are apriori estimates of the probability that a specific response should be inforced at the moment of decision. Response selection is determined by a rule which takes the priors into account. Learning is effected by a revision of the priors based on the weighting of certain evidence. The model of human learning behavior is a computer program obtained from a translation of the theory into machine language. Model behavior is compared with subject behavior measured in a motor skill experiment performed at M. I. T.'s Man Vehicle Laboratory. Author

N68-32100*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
A SIMPLE LABORATORY METHOD FOR REDUCTION OF RHYTHM AND RATE IN LARGE-SCALE MONITORING OF ELECTROCARDIOGRAM
James Roman, Fred M. Larmie (Northrop Corp., Edwards, Calif.), and Tulio R. Figarola (Lovelace Found., Edwards, Calif.) Washington Aug. 1968 15 p refs Prepared in cooperation with Northrop Corp. and Lovelace Found. Field Teams at Edwards, Calif.
(NASA-TN-D-4751) CFSTI: HC $3.00/MF $0.65 CSCL 06B

A laboratory system for rapid reduction of large amounts of continuously recorded ECG information has been developed. The system consists of 60-times-real-time playback device which generates one pulse for each cardiac cycle, appropriate signal conditioning and logic circuitry, and a counting and printing system. Practical means for culling out noisy information, at 60 times real time, are provided. In addition, modifications to the commercially available parts of the system have been made that significantly increase the reliability of diagnosis of ectopic events by the average investigator. Author

N68-33009*# Boeing Co., Philadelphia, Pa.
SUBJECTIVE RESPONSE TO SYNTHESIZED FLIGHT NOISE SIGNATURES OF SEVERAL TYPES OF V/STOL AIRCRAFT
Ernest G. Hinterkeuser and Harry Sternfeld, Jr. Washington NASA Aug. 1968 98 p refs
(Contract NAS1-7083)
(NASA-CR-1118; D8-0907A) CFSTI: HC $3.00/MF $0.65 CSCL 05E

The acoustical signatures of various types of V/STOL aircraft sized for 60 passengers and a 500 mile range were analytically predicted, and tape recordings synthesizing these sounds were prepared. Test subjects listened to these sounds and compared their annoyance with that of a jet airplane. Perceived noise levels were calculated, and the levels which produced equal annoyance to the jet were determined. Each aircraft was analyzed to determine the distance it must maintain from observers in order not to exceed the annoyance of the jet airplane during terminal and flight operations. A second analysis was made to identify the noise reduction required for each aircraft in order to operate at specified distances at a specified level of annoyance. The aircraft studied were helicopters, fan lift, jet lift, and tilt wing VTOL and a turbofan STOL. Author

N68-33304*# Bolt, Beranek, and Newman, Inc., Cambridge, Mass.
THE HUMAN AS AN OPTIMAL CONTROLLER AND INFORMATION PROCESSOR
Sheldon Baron and David L. Kleinman Washington Sep. 1968 76 p refs
(Contract NAS12-104)
(NASA-CR-1151; Rept.-1571) CFSTI: HC $3.00/MF $0.65 CSCL 05H

A mathematical model of the human operator in multivariable control tasks is developed by considering the human as a control and information-processing system. The model contains elements for describing the operator's inherent physiological limitations as well as his instrument-monitoring, data-reconstruction, and control behavior. Special emphasis is placed on the instrument-monitoring aspects of the model. The human's limitations are modelled by combining them into an equivalent perceptual time delay and an equivalent observation noise. The main assumption underlying the subsequent theoretical investigations is that the well-trained, well-motivated operator behaves in a near optimal manner, subject to the constraints imposed by the above limitations. Thus, the operator's control behavior is assumed to be that of an ideal feedback controller. The human's data-reconstruction process is chosen so as to obtain a "best" estimate of the state of the controlled element based on information obtained from "sampling" the various instruments. Author

N68-35102*# Lafayette Clinic, Detroit, Mich.
SYSTEM AND PROCESS DEVELOPMENT FOR SELECTION OF HIGH STRESS TOLERANCE PERSONNEL
Albert F. Ax Washington NASA Sep. 1968 84 p refs
(Contract NAS2-1031)
(NASA-CR-1122) CFSTI: HC $3.00/MF $0.65 CSCL 06B

A system was developed for digital computer processing of psychophysiological data. It employs oscilloscope and oscillograph display, analog magnetic tape storage, A/D conversion, digital tape storage and a large digital computer (IBM 7094). The computing programs developed select all points of interest and compute their type, time of occurence, amplitude and curvature. Two substantive studies were completed. The classical conditioning of autonomic responses in schizophrenia and healthy subjects demonstrated a marked impairment in the performance of autonomic conditioning by schizophrenic patients. A pilot study of non-schizophrenic low motivation subjects revealed a disability for autonomic conditioning similar to that found in chronic schizophrenia. These findings suggest that autonomic conditioning may serve as an index for the diagnosis of both schizophrenia and low motivation and permit the speculation that a low aptitude for autonomic learning may be a contributing factor to both schizophrenia and low social motivation. Finally a study of physiological concomitants of psychological differentiation suggests that the degree of autonomic response differentiation may be correlated with the cognitive style of perceptual discrimination. Author

N68-35109*# Stanford Research Inst., Menlo Park, Calif.
RESEARCH STUDY OF A FUNDUS TRACKER FOR EXPERIMENTS IN STABILIZED VISION
D. H. Kelly and H. D. Crane Washington NASA Sep. 1968 49 p refs
(Contract NAS2-3995)
(NASA-CR-1121) CFSTI: HC $3.00/MF $0.65 CSCL 06B

An image stabilization method is discussed that involves the tracking of retinal blood vessels amd other structures of the back of the eye—i.e., a fundus tracker. The method involves projecting a scanning pattern onto the retina, and detecting the translational and rotational movements of the reflected pattern by means of a certain type of high-speed correlation processing of the video signal. A particularly simple, circular scan method for this purpose is implemented by inverting a standard fundus camera in order to project the scan pattern onto the retina. The correlation processing is presently simulated on a digital computer at slow speed. This

simulation program will be used for overall evaluation of the tracking system as well as to help in design of the required high-speed correlation equipment. This fundus tracker technique may provide greater precision of tracking than is provided by contact-lens techniques, as well as the potential for greater convenience of use. Author

N68-36457*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

USE OF AN ELECTROLUMINESCENT DISPLAY IN MANUAL TRACKING AND IN A READING TASK

Frank Neuman and John D. Foster Washington Oct. 1968 22 p refs

(NASA-TN-D-4841) CFSTI: HC$3.00/MF$0.65 CSCL 05H

The purpose of this research was to determine whether performance differences existed between electromechanical and electroluminescent (EL) displays in a closed loop manual tracking task and in reading accuracy tests. Both displays had vertical scales, which are considered acceptable for spacecraft use. Studies were made with two EL displays, a single-scale, and a double-scale bargraph display. Pursuit tracking of sine and random waves and readability tests were conducted. The double scale instrument was used in the tracking tasks and the single scale instrument in the readability tests. The discreteness of the EL instrument's 128 vertical scale segments (12.6/cm) did not appear to cause any problems in either task. In the tracking tasks, the electroluminescent instruments were comparable to the electromechanical instruments in the region of their flat frequency response. In the readability tests, in which the environmental illumination was changed, readability of the EL instruments reduced rapidly with increasing environmental illumination above 550 lumens/m^2. However, at the low ambient light conditions expected in a spacecraft environment, less than 1 lumen/m^2, the readability was adequate. Author

N68-36461*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A SYNTHESIS OF HUMAN RESPONSE IN CLOSED-LOOP TRACKING TASKS

James J. Adams and Hugh P. Bergeron Washington Oct. 1968 35 p refs

(NASA-TN-D-4842) CFSTI: HC$3.00/MF$0.65 CSCL 05H

Experiments have been conducted to determine the variability in a human subject's control stick response to the stimulus of displayed displacement and of rate of change of displacement to aid in the implementation of the time variations to be included in a linear model of the human subject. Additional tracking tests were made to obtain a definition of the characteristics of the random signal to be added to the model. These two factors, the time variations and the random signal, were then added to the linear model, and the resulting composite model was placed in analog representations of single loop and multiloop systems. The results demonstrate that this composite model reproduces the dynamic characteristics of the time histories and mean square system error which more closely match the response obtained with the human subject than does the linear model. Author

N68-37819*# Lockheed Missiles and Space Co., Sunnyvale, Calif.

DISCRIMINATION OF INCREASES IN THE BRIGHTNESS OF A FLASHING BEACON

R. S. Lincoln, S. Seidenstein and C. V. Juliano Washington NASA Oct. 1968 47 p 8 refs

(Contract NAS1-6801)

(NASA-CR-1220) CFSTI: HC$3.00/MF$0.65 CSCL 05E

The effects, on pilot judgments, of four variables were studied: beacon flash rate, beacon on time, beacon intensity, and rate of vehicle closure. The 25 subjects viewed a point source beacon, represented by a xenon arc lamp, through a lens that provided a virtual image of the beacon at a point near infinity. Flash rate and on time were controlled by motor driven cams, while closure rate was controlled with a servomotor that rotated a circular neutral filter, the density of which increased linearly. Initial brightness was varied with a second circular filter. In a counter-balanced experimental design each subject was exposed to combinations of all four variables, each at five levels. On certain trials, a steady rather than a flashing beacon was employed. The principal measure of performance was the time required to discriminate a change in beacon brightness, measured from the initiation of a trial to its termination by the subject when he was absolutely sure that the brightness of the beacon had increased. The results indicated that the thresholds for brightness increase were positively related to the rate at which the brightness of the beacon increased. Author

06

CHEMISTRY

Includes chemical analysis and identification (e.g., spectroscopy). For applications see: 17 Materials, Metallic; 18 Materials, Nonmetallic; and 27 Propellants.

N68-10497*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
APPLICATION OF LIQUID-LAYER SOLID-SAMPLE SPARK TECHNIQUE TO SPECTROCHEMICAL SPARK SOURCE
Ramon M. Barnes Washington Nov. 1967 15 p refs
(NASA-TM-X-1429) CFSTI: HC$3.00/MF$0.65 CSCL 07D

Improved analytical results were obtained when a thin layer of water or aqueous solution was aspirated onto the surface of a flat metal sample during spark analysis. Studies with liquid layers applied to aluminum alloy standards demonstrated that increased sampling and line emission produced increased analytical curve slopes and count precision for the determination of impurities. Spark exposure times were reduced by one-half to one-fifth. The solvent from a solution layer was used to replace the aluminum internal standard in both the spark analysis of aluminum alloys and the d-c arc analysis of the sample electrode material vapor deposited on the counter electrode. In spark analysis when a liquid layer was applied, interfering emission from atmospheric elements and from the counter electrode material was minimized, and the physical appearance of the spark crater showed no oxide formation. Inductance of the spark circuit and aspiration rate influences were investigated. Application of this method to the analysis of refractory and superalloys is indicated by the results of the analysis. Author

N68-11512*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STABILIZATION OF DC ARCS IN STATIC ARGON ATMOSPHERES FOR USE IN SPECTROCHEMICAL ANALYSIS
William A. Gordon Washington Dec. 1967 26 p refs
(NASA-TN-D-4236) CFSTI: HC$3.00/MF$0.65 CSCL 07D

The use of metal cathodes in an argon atmosphere was investigated and found to be highly effective in achieving a positionally stable arc column. Visual and spectral evaluations of refractory metal cathodes, including graphite, thoriated tungsten, rhenium, tantalum, molybdenum, niobium, and platinum, were made to ascertain the most suitable cathode material for this application. From these studies a combination tantalum-graphite cathode was developed. This special cathode produced arcs characterized by a diffuse cathode emission, which resulted in a stable arc column. A simple model of the arc column, based on the mechanisms of cathodic gas streaming and thermionic emission, was used to explain experimental observations relevant to stability of arcs in argon. The emission spectrum of stabilized arcs was evaluated for use in spectrochemical analysis. It was found that, under the specified conditions, the excitation characteristics of the stabilized arc were essentially the same as when conventional graphite cathodes were used. It was therefore possible to integrate the special cathode into analytical procedures by substituting for graphite cathodes. Moreover, each special cathode was used for 100 to 200 analyses with no intervening treatment. Author

N68-11621*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THE COMPUTATION OF THE PARTIAL VOLUMES OF THE COMPONENTS IN SOLUTION
Joseph S. Rosen (Computer Sci. Corp., Huntsville, Ala.) Washington Dec. 1967 10 p refs
(NASA-TN-D-4199) CFSTI: HC$3.00/MF$0.65 CSCL 07D

Described is a method for calculating partial volumes of the components in solution. The method is applicable to both aqueous and nonaqueous solutions of both electrolytes and nonelectrolytes. S.C.W.

N68-14093*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SYNTHESIS OF ULTRAHIGH MOLECULAR-WEIGHT POLY(ETHYLENE TERREPHTHALATE)
Li-Chen Hsu Washington Jan. 1968 13 p refs
(NASA-TN-D-4335) CFSTI: HC$3.00/MF$0.65 CSCL 11I

This study was conducted to synthesize poly(ethylene terephthalate) or PET of number-average molecular weight of the order of 120,000. PET of number-average molecular weight of the order of 120,000 was prepared with a gas chromatograph apparatus through solid-state polymerization technology. PET particles were packed in the column, heated to a temperature somewhat below the melting temperature, and flushed with a carrier gas until the desired molecular weight was reached. Parameters studied were the catalyst, the particle size, the molecular weight of the starting material, the reaction temperature and time, and the flow rate and nature of the carrier gas. The results showed that ester interchange catalysts such as tetraisopropyl titanate, zinc acetate–antimony trioxide, and cobaltous acetate are capable of increasing the molecular weight of PET. Small particle size and high molecular weight of the starting material are essential for obtaining products of ultrahigh molecular weight. The polymerization of PET in the solid state starts around 175°C (448°K); the molecular weight of the final product increased with increasing temperature for the period of time studied. Molecular weights are also increased by increasing the carrier gas flow rate to a certain practicable value, which varies with other polymerization conditions. Author

N68-18219*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
LATTICE STRUCTURES IN SOLUTIONS
Joseph S. Rosen Washington Mar. 1968 17 p refs
(NASA-TN-D-4297) CFSTI: HC$3.00/MF$0.65 CSCL 07D

The concept of an irregular and random arrangement of ions in solution is rejected. The interionic distances of the crystal lattice structure, assumed to be retained in solution, are maintained by the equilibrium between cohesive and repulsive forces on the ions in solution. This concept of a lattice structure in solution may have an important relation to the theory of an ionic atmosphere in electrolytic solutions. Calculations are presented for various concentrations of the alkali halides; for concentrations when no water is present, the interionic distances for the alkali halides agree with results obtained by other methods. Author

N68-19434*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RADIATION-INDUCED REDUCTION OF DIVALENT COPPER SALTS IN SOLUTIONS
Warren H. Philipp and Stanley J. Marsik Washington Mar. 1968 17 p refs
(NASA-TN-D-4451) CFSTI: HC$3.00/MF$0.65 CSCL 07C

Aqueous solutions of divalent copper salts containing soluble organic compounds were irradiated with 2-million-volt electrons. In

the presence of oxidizable organic compounds (e.g., methanol, glycerine, and formaldehyde), the divalent copper ion is reduced on irradiation. From solutions of either copper(II) sulfate or copper(II) perchlorate, free copper forms, G(Cu) (atoms per 100 eV or 1.6×10^{-17} J) = 2.2. A study involving concentration parameters in the copper(II)-sulfate-methanol-water system showed that two reaction mechanisms are operative. In general, when the water is the major constituent, the initial and rate-controlling reaction is the decomposition of water by radiation to form hydrogen atoms and hydroxyl radicals. The methanol is rapidly oxidized by the hydroxyl radicals and thereby leaves an excess of reducing hydrogen radicals in the system. At high methanol concentrations, the initial process is the direct interaction of the radiation with the methanol molecules, which results in the removal of hydrogen atoms from the carbon atoms. In both mechanisms, these hydrogen atoms then reduce the divalent copper. Author

N68-21430*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

METHOD AND RESULTS OF STUDYING VAPOR DEPOSITION NUCLEATION PROCESSES BY IN SITU ELECTRON MICROSCOPY

Helmut Poppa Washington Apr. 1968 30 p refs

(NASA-TN-D-4506) CFSTI: HC $3.00/MF $0.65 CSCL 07D

The kinetics of nucleation in some simple substrate-overgrowth systems have been measured quantitatively by improved in situ electron microscopy techniques. The nucleation of bismuth and silver on evaporated carbon and the nucleation of bismuth on evaporated SiO substrates were studied as a function of substrate temperature and impinging flux. The results were analyzed in terms of the phenomenological theory of nucleation and in terms of Walton's atomistic model of condensation from the vapor phase. Both theoretical concepts led to specific conclusions concerning such nucleation parameters as the number of atoms in the critical nucleus n^* and the free energy of desorption ΔG_{des} The substrate temperature and impingement flux dependence of the maximum number of particles deposited on the substrate surface were determined and tentatively interpreted on the basis of nucleation limited surface migration. Some nucleation induction time observations were made and were related to the clustering kinetics of adatoms, the growth process of individual nuclei, and the instrument limitations of the detection method. Author

N68-29959*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

PROPERTIES OF SELECTED RADIOISOTOPES. A BIBLIOGRAPHY, PART 1: UNCLASSIFIED LITERATURE

Dale Harris, comp. and Joseph Epstein, comp. Washington 1968 189 p refs

(NASA-SP-7031) CFSTI: HC $3.00/MF $0.65 CSCL 18H

Increasing interest in the application of substantial quantities of radioisotopes for propulsion, energy conversion, and various other thermal concepts emphasizes a need for accurate information describing the nuclear, chemical, and physical properties of these isotopes. This document presents, in a single reference, an annotated bibliography and sets of properties for nine of the more attractive isotopes available for use in power production. These isotopes are: Strontium-90; Cesium-134; Cesium-137; Cesium-144; Promethium-147; Polonium-210; Plutonium-238; Curium-242; and Curium-244. Author

N68-30044*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ON THE INFLUENCE OF NONUNIFORM MAGNETIC FIELDS ON FERROMAGNETIC COLLOIDAL SOLS

S. Stephen Papell and Otto C. Faber, Jr. Washington Aug. 1968 27 p refs

(NASA-TN-D-4676) CFSTI: HC $3.00/MF $0.65 CSCL 07D

Description of a laboratory method for preparing magnetic sols, composed of ferromagnetic submicrometer particles as a stable colloidal dispersion in *n*-heptane, is presented. A fluid of this nature was subjected to nonuniform magnetic fields in a vertically mounted solenoid type electromagnet. Fluid accelerations of up to 7.2 g's were experienced by the magnetic sol without affecting the stability of the colloid system. Body force measurements were made on fluids containing a range of particle concentrations by weight from 1.58 to 13.41 percent that were subjected to magnetic inductions of from 0 to 2.75 teslas in magnetic gradients up to 22.3 teslas per meter. The relations between magnetic induction, magnetic gradient, particle concentration, and body force were examined, and the data are presented herein. An analysis was made from basic considerations that resulted in a general equation that effectively describes the trends in the data. Author

N68-30582*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LOW-ENERGY ELECTRON DIFFRACTION STUDY OF OXYGEN ADSORPTION ON MOLYBDENUM (111) SURFACE

John Ferrante and Gilbert C. Barton Washington Aug. 1968 19 p refs

(NASA-TN-D-4735) CFSTI: HC $3.00/MF $0.65 CSCL 07D

Low energy electron diffraction was used to study oxygen absorption on, and thermal stability of, the Mo (111) surface. The crystal was subjected to oxygen exposures ranging from 0 to 10^{-4} torr-sec. The oxygen exposures resulted in four new surface structures, a chemisorbed structure and three others identified as chemical faceting into (112) planes. The latter required heating the crystal to 700°C to form completely. Differences from oxygen adsorption on W (111) were observed. Oxidation of the surface at room temperature was demonstrated. The surface was found to be thermally stable when heated for several minutes at 2100°C. Author

N68-31948*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A SERVOCONTROLLER FOR PROGRAMMING SAMPLE VAPORIZATION IN DIRECT CURRENT ARC SPECTROCHEMICAL ANALYSIS

William A. Gordon Washington Aug. 1968 32 p refs

(NASA-TN-D-4769) CFSTI: HC $3.00/MF $0.65 CSCL 07D

A method was developed for controlling atomic emission and sample vaporization in dc arc spectrochemical analysis. Automatic adjustments in arc current were made to cause the rate of atomic emission to follow a prescribed program. With a stabilized arc in argon the vaporization of silver chloride was repeatable to about 1 percent. The control system consisted of a spectrometer with multiplier-phototube detector, a curve-following programmer, a controller, a dc current supply, and an argon arc chamber. The control system was used with a stabilized arc in argon and also with a wandering arc in air. Author

07

COMMUNICATIONS

Includes communications equipment and techniques; noise; radio and communications blackout; modulation telemetry; tracking radar and optical observation; and wave propagation. For basic research see: 23 Physics, General; and 21 Navigation.

N68-11475*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A GENERAL METHOD FOR DESIGNING CIRCULAR ARRAY ANTENNAS TO OBTAIN QUASI-OMNIDIRECTIONAL PATTERNS

C. R. Cockrell and W. F. Croswell Washington Dec. 1967 21 p refs

(NASA-TN-D-4254) CFSTI: HC$3.00/MF$0.65 CSCL 09F

A criterion is established for determining the number of sources needed around the periphery of a spacecraft to obtain small far-field pattern fluctuations; that is quasi-omnidirectional antenna patterns. The criterion assumes that the source pattern is expressible as a finite Fourier cosine series and that the circumference in wavelengths of the body is greater than or equal to 10. The number of sources obtained by using this criterion will always be adequate; however, if the representation of the source pattern is known, an optimum number of sources can be obtained. The criterion is not valid when the source pattern is isotropic. Two curves are given which relate the number of sources and the circumference of the body in wavelengths for 0.5 dB or less and 2.0 dB or less fluctuation. Author

N68-17542*# Israel Program for Scientific Translations, Ltd., Jerusalem.

MEASUREMENT OF PULSE DISTORTION IN DIGITAL INFORMATION TRANSMISSION

K. A. Brusilovskii 1968 96 p refs Transl. into ENGLISH of the publ. "Izmereniya Iskazhenii Impul'sov v Sistemakh Peredachi Diskretnoi Informatsii" Moscow, Izd. Nauka, 1965 p 1-92 Published for NASA and NSF

(NASA-TT-F-434; TT-67-51370) CFSTI: HC $3.00/MF $0.65 CSCL 09D

Theoretical analyses of various problems connected with digital data channel measurements are presented, along with the statistical features of noise distortion and error distribution in communication channels. Evaluation criteria are developed for the noiseproof features of communication channels and for elements in the statistical treatment of signals, noises, distortions, and errors in digital data transmission systems handling uniformly coded binary data. A mathematical model is formulated for error analysis in such systems. The fundamental properties and generation of test signals are described, and design criteria are given for noncontact, solid-state, switching element transistor and ferrite measuring instruments. Questions relating to the optimum design of a digital indicator register and a transistorized output relay are discussed. A bibliography of related works is included. E.J.S.

N68-18123*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

THE APERTURE ADMITTANCE OF A GROUND-PLANE-MOUNTED WAVEGUIDE ILLUMINATING A PERFECTLY CONDUCTING SHEET

J. Earl Jones and C. T. Swift Washington Mar. 1968 52 p refs

(NASA-TN-D-4366) CFSTI: HC$3.00/MF$0.65 CSCL 09F

The Fourier transform technique is applied to derive an expression for the aperture admittance of a ground-plane-mounted, transverse electric and magnetic (TEM) mode-excited parallel-plate waveguide illuminating a perfectly conducting sheet. Based on the aperture admittance expression, an equivalent circuit is developed. It is shown that there is a 1:1 correspondence between elements of the equivalent circuit and higher order modes which exist in the parallel-plate waveguide formed by the ground plane and the reflecting sheet. For the special case where the configuration is treated as a microwave circuit tee junction, the waveguide widths which give the best impedance match are seen to be 0.04 wavelength for the feed guide and 0.03 wavelength for the second guide. Numerical computations of the reflection coefficient, derived from the aperture admittance, are compared with both the experimental and theoretical results of a similar problem which is solved by application of the geometrical theory of diffraction. Finally, for various aperture widths, a Smith chart is employed to show that as the distance between the aperture and the reflecting sheet is increased, the admittance locus tends to coalesce about the admittance value for an infinite half-space. Author

N68-18178*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

PERFORMANCE OF SEVERAL CONVOLUTIONAL AND BLOCK CODES WITH THRESHOLD DECODING

Frank Neuman and Dale R. Lumb Washington Mar. 1968 74 p refs

(NASA-TN-D-4402) CFSTI: HC$3.00/MF$0.65 CSCL 09D

The performance of several codes applicable to space communications telemetry links was evaluated. The study was limited to high rate and relatively short constraint length codes, specifically the (15,7) and (73,45) block codes and the (24,12) and (44,22) convolutional codes. Two types of threshold decoding schemes were applied, namely, majority decoding and the more powerful but complex a posteriori probability (APP) decoding. The gaussian data channel and the decoders were simulated on a general purpose computer. The results show that APP decoding has approximately a 1.5 dB advantage over majority decoding. The most powerful code studied, (73,45) with APP decoding, gives a 2.1 dB improvement over a seventh bit parity check code. Also, new error deletion schemes were designed and tested for the codes studied. Because of their constant computation rate, these codes are candidates for high data rate channels. For the low data rates required for deep space missions such as Pioneer, however, the code performances reported here form a basis of comparison with the more powerful sequential decoding of convolutional codes, a variable computation rate decoding technique. Author

N68-18247*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

THEORETICAL AND PRACTICAL RESOLUTION LIMITS FOR PROCESSING PULSE FREQUENCY MODULATION TELEMETRY

Thomas J. Karras and Paul Heffner Washington Mar. 1968 29 p refs
(NASA-TN-D-4180) CFSTI: HC $3.00/MF $0.65 CSCL 09F

The importance of knowing the meaning, methods of computation, and proper use of the equivalent noise bandwidth (ENBW) of a system is presented. From this, a normalized relation for expressing the signal energy per bit of information and the noise power density of the noise in the signal will be developed and compared to the most common S_{rms}/N_{rms} measurement. A universal Pulse Frequency Modulation (PFM) telemetry data processing line incorporates two processing subsystems, a low resolution processor and a high resolution processor. The low resolution processor resolves the data measurement to 1 percent of the data spectrum, while the high resolution processor resolves the data measurement within 0.02 percent to 1 percent. The resolution given by the high resolution processor is a direct function of the input signal-to-noise ratio. The theoretical and actual performance of both modes of processing are described. Reference is made to three presently transmitting PFM satellites. Author

N68-18542*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
WAVEFORM DISTORTION IN A MAXIMUM-LIKELIHOOD DARLINGTON DETECTOR FOR M-ARY PFM SIGNALS
Paul J. Heffernan Washington Mar. 1968 36 p refs
(NASA-TN-D-4294) CFSTI: HC $3.00/MF $0.65 CSCL 09F

This paper describes a proposed pulse frequency modulation digital communication system for satellite applications. The heart of the proposed system is a maximum-likelihood detector of the spectrum-analysis type discussed by Darlington. It is shown that the proposed technique is in principle an ideal M-ary system. A general description is followed by an analysis of anticipated departures from the theoretic system—in particular, waveform distortion due to finite bandwidth, slope mismatch, and phase and amplitude ripple. General results are derived, from which permissible tolerances for departures from the theoretical system may be computed. Author

N68-18616*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
A QUASI-OMNIDIRECTIONAL SLOT ARRAY ANTENNA FOR SPACECRAFT USE AT MICROWAVE FREQUENCIES
W. F. Croswell, C. M. Knop, and D. M. Hatcher Washington Mar. 1968 60 p refs
(NASA-TN-D-4362) CFSTI: HC $3.00/MF $0.65 CSCL 09F

The theory, design, and development of a resonant array of circumferential shunt slots cut in the broad wall of a ring waveguide, which is recessed into a circular metallic cylinder and dielectric coated in the recessed region, are presented. This antenna is suitable for narrow bandwidth space-vehicle applications, since it is essentially flush mounted, provides nearly omnidirectional coverage in the plane perpendicular to the vehicle axis, and provides a broad pattern in the planes which are parallel to and pass through this axis. The theory used for the design of the array is based upon the approximate synthesis method of Knudsen and Chu, in conjunction with the work of Wait for slots on dielectric-coated cylinders. The tolerance problems encountered in the development of the array and their solutions are discussed. Author

N68-18703*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.
ATTENUATION AND DISPERSION OF LONGITUDINAL WAVES IN VISCOUS, PARTLY IONIZED GASES
David Kahn Washington Mar. 1968 9 p refs
(NASA-TM-X-1458) CFSTI: HC $3.00/MF $0.65 CSCL 20I

The propagation of longitudinal waves in three fluid, partly ionized gases is studied as a function of the collision and plasma-to-wave-frequency ratios. A collisional approach is taken with the full Boltzmann equations (together with Maxwell's equations) serving as the starting point, the intention being to describe wave dispersion and absorption in the collisional regime, and to include the viscous and heat conduction effects on the wave propagation from the beginning as an integral part of the theory. Author

N68-19624*# National Aeronautics and Space Administration, Washington, D. C.
CONSTRUCTING INEXPENSIVE AUTOMATIC PICTURE-TRANSMISSION GROUND STATIONS
Charles H. Vermillion 1968 68 p refs
(NASA-SP-5079) CFSTI: HC $3.00/MF $0.65 CSCL 17B

This report describes how one can procure or build the antenna, FM receiver, and other components for an Automatic Picture Transmission (APT) ground station. Detailed drawings and parts lists are included. Installation, alignment, and operation of the APT ground station are also described. APT ground stations are inexpensive and reliable. They can be built from surplus parts for under $500 or procured for as low as $5000. With them, scientists, local weather stations, amateurs, and others can receive satellite-taken photographs of the Earth as APT-equipped satellites pass overhead. It is currently planned that APT systems compatible with the ground station will be flown on Nimbus and ESSA satellites at least until 1972. It is probable that similar or advanced APT systems will be available after 1972, although these programs are still in a tentative planning stage. Author

N68-20333*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
THE INPUT ADMITTANCE OF A RECTANGULAR APERTURE ANTENNA LOADED WITH A DIELECTRIC PLUG
Calvin T. Swift and Douglas M. Hatcher Washington Apr. 1968 27 p refs
(NASA-TN-D-4430) CFSTI: HC $3.00/MF $0.65 CSCL 09F

A waveguide-fed rectangular aperture antenna, loaded with a dielectric plug, is considered as a variational problem. The formulation results in an aperture-admittance expression which contains the self and mutual admittances of the transverse electric waveguide modes TE_{01} and TE_{03}. The theoretical results show that a gross distortion of the aperture field and a significant decrease in the aperture admittance occurs when the plug becomes a resonant cavity for the TE_{03} mode. The input admittance is compared with microwave measurements for the condition in which the external half-space is air. The theory is generally in good agreement with experiment over the entire waveguide band, including the frequency interval around resonance. It is noted that the plug can be used to tune out the susceptance and improve the match of the antenna. Author

N68-22019*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
OPTICAL AND MICROWAVE COMMUNICATIONS: A COMPARISON
F. Kalil Washington May 1968 46 p refs
(NASA-TN-D-3984) CFSTI: HC $3.00/MF $0.65 CSCL 17B

Some preliminary comparisons are made of microwave, millimeter, and optical communication systems for space communication from a spacecraft at Mars distances. An attempt is made to be realistic with regard to technology. Some discussion of thermal, quantum, and sky noise is included, as well as some discussion and analyses of microwave, millimeter wave, and optical technology; acquisition and tracking; and some mission analysis. Based on the considerations herein, it appears likely that in the radio spectrum, the S-Band is the better place to operate. However, it also appears likely that optical communication systems have the greater potential for higher data rates—up to about 10^8 bps at Mars distances. Author

N68-22746*# Ohio State Univ., Columbus.
THE TEM RADIATION PATTERN OF A THIN-WALLED PARALLEL-PLATE WAVEGUIDE ANALYZED BY A SURFACE INTEGRATION TECHNIQUE
D. C. F. Wu Washington NASA May 1968 52 p refs
(Grant NsG-488)
(NASA-CR-1052; Rept.-1691-23) CFSTI: HC $3.00/MF $0.65 CSCL 09F

The radiation pattern of a TEM mode thin-walled parallel-plate waveguide is analyzed by a surface integration technique in conjunction with wedge diffraction theory. The surface integral is obtained by the Green's second identity. The fields on the surface are calculated by plane wave diffraction and first order interactions between two edges of the guide. The surface integration technique provides an improvement in the accuracy of the pattern as compared to the wedge diffraction method. Author

N68-24845*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
AN INTEGRATED-CIRCUIT DIRECT-COUPLED AMPLIFIER FOR SPACECRAFT USE
Guss E. Wenzel Washington May 1968 72 p refs
(NASA-TN-D-4584) CFSTI: HC $3.00/MF $0.65 CSCL 09F

The integrated-circuit direct-coupled differential-amplifier design is based on a previous phase of development and has advanced the state-of-the-art of direct-coupled amplifiers to the extent that the stability and drift characteristics are equal to, or superior to, the conventional high performance chopper direct current amplifier. The circuit diagrams and the physical layout of the various components are presented. The amplifier performance, when powered from a typical flight battery, is described by various tables and plots of test data. Author

N68-25852*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.
CODING SCHEMES FOR RUN-LENGTH INFORMATION BASED ON POISSON DISTRIBUTION
W. W. Happ Washington Jun. 1968 19 p refs
(NASA-TN-D-4572) CFSTI: HC $3.00/MF $0.65 CSCL 09D

The Shannon-Fano-Huffman Redundancy Reduction Procedure is extended to one-parameter and two-parameter Poisson distribution resulting from run-length information streams. Figures-of-merit are established to compare Huffman coding to fixed-word-length binary coding on the basis of (1) average number of coding digits per message, (2) signal-to-noise ratio in analog-to-digital conversion due to bit errors, and (3) design criteria primarily of interest to the system designer and not readily amenable to quantitative analysis. To ascertain whether or not Huffman coding leads to a unique and optimum code, other equally good optimum solutions were obtained. Optimization and uniqueness criteria are examined and applications to data compression are discussed. Author

N68-25918*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
AN OMNIDIRECTIONAL FLUSH-MOUNTED MICROWAVE ANTENNA WITH A SIMPLE FEED FOR USE ON SPACECRAFT
C. R. Cockrell and W. F. Croswell Washington Jun. 1968 28 p refs
(NASA-TN-D-4555) CFSTI: HC $3.00/MF $0.65 CSCL 09F

The qualitative theory, design, and development of a parallel-plate waveguide-fed antenna, suitable for flush-mounted broad-band spacecraft applications are presented. The antenna makes use of wedge-like metal posts placed uniformly about the periphery of the feed plates to provide both structural strength and practical interconnection routes for cables without disrupting the antenna impedance and patterns. Measurements taken on the antenna which is mounted on spheroids up to 50 wavelengths in circumference are presented, equatorial patterns are omnidirectional within ±0.25 dB, and polar patterns have beam widths similar to a half-wave dipole. Author

N68-26621*# Andrew Corp., Chicago, Ill.
THE DIELECTRIC CLAD AXIAL SLOT ANTENNA
C. M. Knop, J. J. Meier, and O. K. Kim Washington NASA Jun. 1968 201 p refs
(Contract NAS1-6242)
(NASA-CR-1057) CFSTI: HC $3.00/MF $0.65 CSCL 09F

The input admittance of a rectangular waveguide whose opening forms an axial slot on a metal cylinder of outer radius, a, which is coated with a concentric layer of homogeneous dielectric of outer radius, b, and of relative dielectric constant, ϵ_r, is analyzed. The analysis is accomplished by relating this input admittance to the external admittance by equating the complex power flow on each side of the slot. The external admittance is found by expanding the fields in the exterior of the cylinder in the form of a Fourier mode expansion following Wait, and casting the expression for the integration of Poynting's vector over the physical space of the slot into one over mode space via Parseval's theorem. The slot width is made small enough so that the higher order modes produced at the slot in the waveguide due to the slot-cylinder transition are negligible. Additionally, the guide is dielectric loaded, so as to realize sufficiently high attenuation at the slot location of the higher order modes produced at the excitation point for a given length of guide. Author

N68-27063*# Martin Co., Orlando, Fla.
PROPAGATION OF MILLIMETER AND SUBMILLIMETER WAVES
V. E. Derr Washington NASA Aug. 1967 225 p refs
(Contract NAS12-10)
(NASA-CR-863; OR-8549) CFSTI: HC $3.00/MF $0.65 CSCL 17B

The instrumentation development for absorption measurements is discussed. Calculations and a search for O_2 submillimeter transitions are described. Spectroscopic investigations of the Stark effect in water have been used to confirm level assignment and to determine a new value of the dipole moment of water by a more accurate dc voltage method. A chemical analog of water, D_2O, has been observed near 300 GHz. A discussion of orientation relaxation theory is presented, as well as a consideration of quadrupole interaction in CO_2. A computer program that is suitable for computation of low J value transitions in asymmetric top molecules has been developed for the Kivelson–Wilson theory of centrifugal effects. Based on all available data from 100 to 1000 to be met by antenna systems that are concerned with earth lunar missions which include lunar rendezvous, lunar landing, and earth rendezvous; and other promising antenna techniques whose development can be expected to provide enhanced performance and flexibility in over-all mission design. Author

N68-28135*# Hughes Aircraft Co., Culver City, Calif.
STUDY OF ADVANCED ANTENNA TECHNIQUES FOR RENDEZVOUS RADAR
B. J. Forman, S. N. Vodopia, and W. H. Kummer Washington NASA May 1967 52 p refs
(Contract NAS1-2621)
(NASA-CR-764) CFSTI: HC $3.00/MF $0.65 CSCL 17I

A study of advanced antenna techniques for rendezvous and lunar landing radar systems is reported. The study was made in order to better define the antenna requirements for future manned spacecraft missions and to demonstrate the extent to which these requirements can be met within the present state-of-the-art. Recommendations have been made for antenna techniques that show promise in extending antenna technology. One such technique, which employs diode-irises to accomplish electronic-beam scanning, has been investigated and shown to be feasible. Technical material

presented discusses results of the investigation on electronic scanning using diode-irises. The design and complete electrical performance of an X-band 10-element slot array is given. Included is a summary of a previous report which details the requirements GHz, the absorption spectrum of water is computed by two methods with different form factors, in order to present a comparison. Author

N68-28272*# Systems Technology, Inc., Hawthorne, Calif.
AN EXPERIMENTAL INVESTIGATION OF COMPENSATORY AND PURSUIT TRACKING DISPLAYS WITH RATE AND ACCELERATION CONTROL DYNAMICS AND A DISTURBANCE INPUT
R. W. Allen and H. R. Jex Washington NASA Jun. 1968 77 p refs
(Contract NAS2-3746)
(NASA-CR-1082; TR-170-1) CFSTI: HC $3.00/MF $0.65 CSCL 17G

Four instrument-rated pilots were trained and tested with a series of different tracking displays and controlled element dynamics to validate some anomalous previous experiments and to provide a sounder data base for a theory of manual control displays. Quasi-random (sum of 9 sinusoids) inputs were used. Compensatory (C) and pursuit (P) display modes were investigated along with a hybrid pursuit-plus-disturbance (P+D) display mode. For P+D the command input was displayed conventionally, while a separate, uncorrelated disturbance input was applied to the controlled element. Rate control and acceleration control dynamics were investigated. The training data show that all pilots learned quickly to perform about equally well with all displays when controlling rate dynamics. With acceleration dynamics they took much longer to learn and the results showed more variability. In the main experiment, the error performance was not sensitive to display mode, while the describing function data showed that differences in the pilot's behavior did occur, with opposing effects leading to the constant net error. Author

N68-29528*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.
M-ARY POISSON DETECTION AND OPTICAL COMMUNICATIONS
Sherman Karp and Robert M. Gagliardi (Univ. of Southern Calif., Los Angeles) Washington Jun. 1968 26 p refs
(NASA-TN-D-4623) CFSTI: HC $3.00/MF $0.65 CSCL 17H

This report presents an investigation of the problem of maximum likelihood detection of one of M Poisson processes in a background of additive Poisson noise. When the observables correspond to counts of emitted photoelectrons, the problem models a discrete version of a coherent M-ary optical communication system using photon counters in the presence of background radiation. Consideration is given to an average distance and a detection probability criterion. The advantages of an M-ary-pulsed intensity set (Poisson intensities wholly concentrated in a single counting interval) are demonstrated. The performance of such intensity sets is exhibited in terms of error probabilities, pulse widths, signal-to-noise ratio, and channel capacity. Behavior as a function of number of intensities M is also discussed. By appropriate conversion these latter results may be used for determining power requirements in an optical pulse position modulation system. Author

N68-31639*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.
RESEARCH ON FIELD-ALIGNED PROPAGATION OF HF RADIOWAVES USING ALOUETTE 2 TOPSIDE SOUNDER DATA AND DIGITAL RAY-TRACING TECHNIQUES
Jayaram Ramasastry, Edward J. Walsh, and John R. Herman (Lowell Technol. Inst. Res. Found.) Washington Aug. 1968 34 p refs Presented at the AGARD meeting, Oslo, 19–23 Aug. 1968
(NASA-TN-D-4748) CFSTI: HC $3.00/MF $0.65 CSCL 17B

The first part of this technical note covers the study of guidance of HF radiowaves along field-aligned paths using the topside sounder data from the Alouette 2 satellite. More than 100,000 Alouette 2 ionograms have been used in this analysis and an unusually high percentage of occurrence of conjugate echoes has been observed in the data of some equatorial stations. Two interesting types of ionograms containing conjugate echo traces are presented. A self-consistent explanation based on the assumption of multiple reflections between conjugate points of the field line passing through the satellite is presented. The second part of the note covers the results of the digital ray tracing study of the guidance of HF radiowaves along field-aligned ionization irregularities in the magnetosphere of the earth. The results reported here on the HF ducting phenomenon is directed primarily towards determining whether such a mechanism may be utilized to study the magnetospheric phenomena and whether it can be useful as a reliable communication link. Author

N68-33042*# Stanford Research Inst., Menlo Park, Calif.
THE EFFECTS OF A PLASMA IN THE NEAR-ZONE FIELD OF AN ANTENNA, 2
W. C. Taylor Washington NASA Sep. 1968 38 p refs
(Contract NAS1-7024)
(NASA-CR-1149) CFSTI: HC $3.00/MF $0.65 CSCL 09F

Measurements are reported on the effects on an antenna of a plasma in the near field. In one phase of the program, admittance measurements were performed with a Teflon-plugged waveguide slot antenna radiating into the flowing ionized gas of an arc-driven shock tube. The electron density was varied above and below the critical density at two different values of shock-tube pressure. The results are compared with theoretical predictions. Measurements were also made in the same shock tube to determine the ionization rise times in normal-shock-heated air and other planetary gas mixtures. The principal results of these measurements were to supply the ionization rise history in air and in a 90-percent N_2/10-percent CO_2 mixture over a wide range of pressures and shock speed. Author

N68-35140*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
ON THE DECREASE OF THE RADAR CROSS SECTION OF THE APOLLO COMMAND MODULE DUE TO REENTRY PLASMA EFFECTS
John W. Marini Washington Sep. 1968 22 p refs
(NASA-TN-D-4784) CFSTI: HC $3.00/MF $0.65 CSCL 17I

A number of mechanisms have been proposed to explain the observed decreases. One of these is the plasma sheath which, at certain combinations of altitude and speed, may act as an absorbant coating. In another, the inhomogeneous plasma sheath may present to the incident radar wave a reflecting surface having, because of its shape, a lower cross section than the original body surface. With the reentry object, radar frequency, and radar look-angle fixed, the regions where these mechanisms are likely to have effect depends primarily on the altitude and speed of the object. The regions of decrease caused by the two mechanisms listed are determined. The case considered is that of a C-band radar observing a large directly approaching object. Neither the possibility of a decrease caused by photoionization nor the effect of the sheath on a radar observing the object at other than a head-on view has yet been treated. Because of the incomplete and tentative nature of the analyses and because of a lack of field data on reentries of the Apollo type, it is premature to say whether the effects constitute a practical tracking problem. Author

N68-35172*# Ohio State Univ., Columbus.
THE REFLECTION COEFFICIENT OF A TEM MODE PARALLEL-PLATE WAVEGUIDE ILLUMINATING A CONDUCTING SHEET: THE LARGE WEDGE ANGLE CASE
W. D. Burnside, L. L. Tsai, and R. C. Rudduck Washington NASA Sep. 1968 46 p refs
(Grant NGR-36-008-048)
(NASA-CR-1174) CFSTI: HC $3.00/MF $0.65 CSCL 20N

The reflection coefficient of a large wedge angle parallel plate waveguide operating in the TEM mode and illuminating a perfectly conducting sheet is analyzed by wedge diffraction techniques. The interactions between the waveguide aperture and the reflector are represented by bouncing cylindrical waves. The scattering of these cylindrical waves by the guide aperture produces four subsequent component cylindrical waves, which in turn reflect back onto the guide. These component cylindrical waves are determined through analysis and are represented by equivalent line sources which then couple power into the guide. The continuation of this reiteration process then includes the contribution of the higher order interactions (or bounces). Good agreement is obtained between the calculated results and measurements. The calculated results also agree with those obtained by the plane wave approach in the region of mutual validity for both analyses. Author

N68-35174*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.
THE DESIGN OF A PULSE POSITION MODULATED (PPM) OPTICAL COMMUNICATION SYSTEM
Sherman Karp and Robert M. Gagliardi (Univ. of Southern Calif., Los Angeles) Washington Oct. 1968 25 p refs
(NASA-TN-D-4814) CFSTI: HC $3.00/MF $0.65 CSCL 17B

In recent literature the advantages of an idealized narrow width pulse position modulated (PPM) optical communication system, using coherent sources and direct photo-detection, have been shown. In this report, the practical design of such an operating PPM link is considered. System performance, in terms of error probabilities and information rates, are derived in terms of key parameters, such as power levels, number of PPM signals, pulse width, and bandwidths. Both background radiation and receiver thermal noise are included. Design procedures utilizing these data are outlined. Whenever possible, optimal design values and parameter trade-offs, in terms of maximizing information rate or minimizing transmitter power, are shown. The effect on performance of photomultipliers and their inherent statistics is also presented. Although the basic analysis is derived in terms of photon counts, the necessary system optics equations are introduced to allow for overall optical hardware design. The primary underlying assumption is that synchronization is maintained at all times between transmitter and receiver. Author

N68-35522*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.
PROBLEMS AND PROGRAMS ON THE USE OF SUBMILLIMETER WAVES IN SPACE
Max R. Nagel Washington 1968 49 p refs
(NASA-SP-182) CFSTI: HC $3.00/MF $0.65 CSCL 09F

The development and the present status of the technology associated with the use of submillimeter waves in field and space applications are described. A compilation of tables, graphs, and other data on the performance of modern submillimeter components is given, along with a list of the most recent literature on the subject. Some of the more significant achievements and the potential of submillimeter waves in the atmospheric and astronomical disciplines and in spaceflight-related operations, are discussed. A review of related programs currently sponsored by the National Aeronautics and Space Administration is given and high priority research needs that may lead to a more effective utilization of submillimeter radiation in space are pointed out. Author

N68-35524*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
HIGHER-ORDER-MODE EFFECTS ON THE APERTURE ADMITTANCE OF A RECTANGULAR WAVEGUIDE COVERED WITH DIELECTRIC AND PLASMA SLABS
C. R. Cockrell Washington Oct. 1968 44 p refs
(NASA-TN-D-4774) CFSTI: HC $3.00/MF $0.65 CSCL 09F

Variational expressions of the admittance of a rectangular aperture covered with homogeneous material are derived. The electric field inside the waveguide is assumed to be a dominant mode plus the first higher order symmetrical mode. Admittance expressions are also given for semi-infinite media. Admittance calculations for polystyrene slabs are given. These calculations are shown to agree closely with results in the literature. Also given are calculations for lossy plasma slabs with electron densities both above and below the critical density. For plasma slabs approximately equal to or greater than $1/3\ \lambda_0$, the medium can be considered semi-infinite, particularly for overdense plasmas. For changing slab thickness, the field of the higher order mode has a greater effect on the admittance in the dielectric slab than in the plasma slab. However, this effect is small; hence, only the dominant mode field is needed for computing aperture admittance. Author

N68-35537*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
ELECTROMAGNETIC PROPERTIES OF A CIRCULAR APERTURE IN A DIELECTRIC-COVERED OR UNCOVERED GROUND PLANE
M. C. Bailey, S. N. Samaddar (Raytheon Co., Alexandria, Va.), and Calvin T. Swift Washington Oct. 1968 30 p refs
(NASA-TN-D-4752) CFSTI: HC $3.00/MF $0.65 CSCL 09F

The problem of an aperture fed by a circular waveguide excited in the dominant transverse electric mode (TE_{11}) is considered. The input admittance in the aperture reference plane for the case of a homogeneous lossy dielectric cover of finite thickness and the radiation patterns for the case of no cover are computed from integral transforms, for which a TE_{11} mode variation of the electric field is assumed at the aperture. Computations for the uncoated antenna show that the patterns and aperture admittance are similar to those of a square aperture with a field distribution given by the TE_{01} rectangular mode. It is noted that the uncoated aperture is well matched above midband of the circular waveguide in contrast to the open-end rectangular waveguide. This inherent property would be advantageous for possible use of the open-end circular waveguide as an antenna. Author

N68-36105*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.
ERROR PROBABILITIES FOR MAXIMUM LIKELIHOOD DETECTION OF M-ARY POISSON PROCESSES IN POISSON NOISE
Sherman Karp, Martin G. Hurwitz, and Robert M. Gagliardi (Univ. of Southern Calif., Los Angeles) Washington Oct. 1968 48 p refs
(NASA-TN-D-4721) CFSTI: HC $3.00/MF $0.65 CSCL 09D

Some of the recent results in the detection of a Poisson distributed signal in Poisson noise are considered. Curves for error probabilities are presented for the case of detecting one of M equiprobable signals over a broad range of parameter values. Implicit in these results for system applications is the use of photon counting receivers. Attention is given to the optical communication and radar problems for this receiver structure and significant parameters are translated into those used in the report. A complete description of the computational procedures used for making the error probability calculations is given. Author

N68-36333*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

SELF-SYNCHRONIZING BI-ORTHOGONAL CODED PCM TELEMETRY SYSTEM

Warner Miller, Ronald Muller, Thomas Taylor, and John Yagelowich

Washington Oct. 1968 29 p refs

(NASA-TR-R-292) CFSTI: HC $3.00/MF $0.65 CSCL 09F

Details are given on the complete design, theory, and experimental statistics of a self-synchronizing, biorthogonal coded PCM telemetry system for space communications. By selecting a proper code set, word synchronization is acquired without using a parallel channel and is maintained at a signal-to-noise ratio below 4 db. With the code's property of comma freedom, work synchronization can be achieved with a circuit requiring only a few logic modules. With the use of this circuit, signal detection can be performed in real time without the use of a computer. The measured probability of word error corresponds to a signal-to-noise ratio that is within 1 db of theoretical predictions; this is 3 db better than is obtained with the standard PCM systems now used on spacecraft. Author

08

COMPUTERS

Includes computer operation and programming; and data processing. For basic research see: 19 Mathematics.

N68-13897*# Philco Corp., Houston, Tex.
COMPUTER ASSISTED INSTRUCTION. FEASIBILITY STUDY
Richard L. Balogh and Don L. Purdum Washington NASA Jan. 1968 445 p refs
(Contract NAS9-1261)
(NASA-CR-917; PHO-TR-307) CFSTI: HC $3.00/MF $0.65 CSCL 09B

Results of a study to assess the potential of using advanced concepts for training flight controllers are presented. Existing computer systems are reviewed and analyzed, and their applicability to flight controller training is deterimed. The functional requirements for an optimum computer assisted system are developed. Costs incurred by programmed instruction are evaluated, and a study is made to determine if this is a cost-effective method of training NASA flight controllers. C.T.C.

N68-15798*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NUMERICAL PROCEDURES FOR CALCULATING REAL FLUID PROPERTIES OF NORMAL AND PARAHYDROGEN
Fredric N. Goldberg and Angela M. Haferd Washington Feb. 1968 62 p refs
(NASA-TN-D-4341) CFSTI: HC $3.00/MF $0.65 CSCL 20M

The library of single function calls can be used efficiently without initial estimates. When physical conditions are known, engineering estimates of density may be included for additional speed in calculation. The procedures are designed to calculate a specified function of one or two input parameters. Independent variables consist of the combinations temperature-density, pressure-density, temperature-pressure, enthalpy-pressure, or entropy-pressure. Ideal and saturation properties may also be calculated as functions of either temperature or pressure. The program is written in separate modules that can be modified easily in the future to include new data. These modules can be used as a subset of functions when computer space is not available for the entire library in complex programs. The discussion includes techniques used, resolution of inherent physical and mathematical problems, and consistency of results based on National Bureau of Standards data. Computer time and storage estimates are given with a manual of instructions for the programmer. A listing of the program is included as used in the library of functions at the Lewis Research Center. Author

N68-17154*# Little (Arthur D.), Inc., Cambridge, Mass.
APPLICATION OF STATISTICAL ASSOCIATION TECHNIQUES FOR THE NASA DOCUMENT COLLECTION
Paul E. Jones, Robert M. Curtice, Vincent E. Giuliano, and Murray E. Sherry Washington NASA Feb. 1968 111 p refs
(Contract NASw-1051)
(NASA-CR-1020) CFSTI: HC $3.00/MF $0.65 CSCL 05B

Computer programs for batched associative search of the NASA coordinate-indexed document collection have been prepared and tested. Cooccurrence counts for the approximately 18,000 terms used to index about 100,000 documents were obtained and association matrices based on various subsets of these counts were developed. One section of the report describes the system as a whole; the remainder is focused on a discussion of the behavior of the system observed during tests of the programs. Author

N68-18144*# Avco Corp., Wilmington, Mass.
INVESTIGATION OF THE DYNAMIC CHARACTERISTICS OF A V ANTENNA FOR THE RAE SATELLITE, PHASE A Final Report
Washington NASA Mar. 1968 211 p refs
(Contract NAS5-9179)
(NASA-CR-962; RAD-TR-65-28) CFSTI: HC $3.00/MF $0.65 CSCL 09F

This report presents the results of the first phase of an investigation of the dynamic characteristics of the Radio Astronomy Explorer satellite equipped with a double-V antenna. During this first phase, computer programs which will provide the analytical tools necessary for continued study of the satellite dynamic performance have been prepared. For this purpose, a flexible-body analog computer program, a rigid-body digital computer program, and a flexible-body digital computer program were developed. The first two programs have been checked out and are fully described and included in this report, together with results of checkout runs. The flexible-body computer program is being checked out; the detailed derivation and description of the simulation is contained in this report. It is recommended that the next phase of the study provide for improvement in the accuracy and capability of the computer simulations and evaluation of satellite and control system dynamics, damping requirements, and overall satellite design. Author

N68-18179*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
A LOGARITHMIC ENCODER FOR BINARY WORD COMPRESSION
Joseph A. Sciulli Washington Mar. 1968 12 p refs
(NASA-TN-D-4290) CFSTI: HC $3.00/MF $0.65 CSCL 09D

The present paper describes a logarithmic encoding device which has had particular application in energetic particle detection experiments. The paper provides a generalized encoding error analysis in order to evaluate the performance of the device. Both peak and average error are derived in terms of word size and desired accuracy. The implementation of a flexible logarithmic encoder is also described. Author

N68-18620*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYTICAL INVESTIGATION OF SUPERSONIC TURBOMACHINERY BLADING. 1: COMPUTER PROGRAM FOR BLADING DESIGN
Louis J. Goldman and Vincent J. Scullin Washington Mar. 1968 66 p refs
(NASA-TN-D-4421) CFSTI: HC $3.00/MF $0.65 CSCL 10A

A FORTRAN IV computer program for the design of supersonic blading based on establishing vortex flow within the blade passage is presented. The method of characteristics, as applied to the

two-dimensional isentropic flow of a perfect gas, was utilized for the blade design. The equations necessary for the design are developed. The information required for the program consists of an inlet flow angle, specification of the inlet, outlet, and lower- and upper-circular-surface Mach numbers, and the specific-heat ratio. The program output consists of the blade coordinates and, if desired, a printer plot of the blade profile and flow passage. In addition, supersonic starting and flow separation calculations are performed by the program and obtained as output. An example is included to indicate the use of the program and the results obtainable. Author

N68-19336*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.

SOME ARGUMENTS FAVORING NON-CONVENTIONAL TYPES OF COMPUTERS

Wayne A. Lea Washington Mar. 1968 35 p refs

(NASA-TM-X-1544) CFSTI: HC $3.00/MF $0.65 CSCL 09B

This paper considers the basic question of the adequacy of conventional, general-purpose digital computers, and whether new, non-conventional machine structures would be useful for expanding the capabilities of machine performance, to permit automatic solution of problems previously handled only by humans. Included in the class of "non-conventional" machines discussed herein are hybrid machines, multiprocessors, highly parallel computers, Holland and SOLOMON machines, bionics models, diffused-function anastomotic networks, pattern recognition machines, "linguistically intelligent" machines, and other more exotic machines. Several arguments favoring non-conventional machine structures are presented. Considered separately are arguments based on: (a) the opinions of certain experts; (b) ultimate theoretical capabilities of various machine types; (c) structures of biological counterparts in brains and nervous systems; (d) the potential for natural-language programming; (e) relative computational economies and efficiencies; and (f) the potential for successful development of new types of computer structures. Such arguments demonstrate the problems one can get into by confining study to present-day digital computer organizations, and the potential advantages of new, user-oriented designs. Author

N68-21499*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPUTER PROGRAMS FOR PLANE COLLISIONLESS SHEATHS BETWEEN FIELD-MODIFIED EMITTER AND THERMALLY IONIZED PLASMA EXEMPLIFIED BY CESIUM

Susan L. Button and James F. Morris Washington Apr. 1968 70 p refs

(NASA-TM-X-1562) CFSTI: $3.00 CSCL 20I

Two computer programs coded in FORTRAN IV are described for plane collisionless positive-ion and electron emission sheaths. Given the emitter temperature, emitter work function, atomic ionization potential, plasma electron and ion number density, and plasma electron, ion, and atom temperatures, the programs compute current densities, potential drop through the sheath, charge density, electron field, and sheath distance. Author

N68-22510*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

SPACE SCIENCES DATA PROCESSING

George H. Ludwig Washington May 1968 19 p refs

(NASA-TN-D-4508) CFSTI: HC $3.00/MF $0.65 CSCL 09D

Spacecraft carrying large numbers of scientific instruments presently transmit data at the rate of approximately 150 million data points per day which must be converted from raw digital form into a conceptually meaningful form for analysis. The task of processing these data rapidly and accurately is a large one, done in several steps. The first step involves converting the raw receiver output signals into computer compatible digital form, including signal clean-up, establishment of synchronization, and time decoding. In the newest processing lines, this first step also includes a moderate amount of editing and quality checking. The remaining steps employ large-scale computers for further editing, establishing accurate timing, computing spacecraft attitude, and sorting to provide data tapes for individual experimenters. The experimenters are responsible, at present, for further reduction to a more meaningful form. These operations include additional sorting, storage, compilation, computation, and display. Author

N68-24310*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

DUAL DETECTION SYSTEM FOR AIMP PFM DATA PROCESSING

Thomas J. Karras Washington May 1968 18 p

(NASA-TN-D-4561) CFSTI: $3.00 CSCL 09F

A dual detection system, used at present to process PFM telemetry data for satellites AIMP D and E at GSFC, has proved superior to a single threshold detection system. The dual system consists of: (1) threshold detection of 128 individual filters during buildup, when the filters are excited with a PFM burst, and (2) "auction detection," i.e., one filter (out of 128) which contains the largest amplitude near the end of the filter buildup. The threshold method is used only for system synchronization; the auction method is used only for data recovery. Auction and threshold detection use the same bank of filters. Up to 10 percent more data recovery on actual AIMP satellite tapes is being achieved; diminution up to one half in rms error in the experimenters analog data is expected. Test results on reprocessed telemetry data have shown a definite improvement in data recovery and resolution. The incoming signal-to-noise threshold of the system has not been lowered, because line synchronization has remained unchanged. Author

N68-24967*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPUTER PROGRAM FOR SYMBOLIC REDUCTION OF BLOCK DIAGRAMS USING FORMAC

Carl F. Lorenzo and Paul Swigert Washington, D. C. Jun. 1968 78 p refs

(NASA-TN-D-4617) CFSTI: HC $3.00/MF $0.65 CSCL 09B

Techniques have been established and a computer program has been written (in the experimental language, FORMAC) to symbolically reduce arbitrary block diagrams for desired transfer functions. Symbolic solutions are determined in several forms including an expanded form in terms of the driving frequency and system constants. Programs are written to numerically evaluate the symbolic solutions for real and imaginary parts and magnitude ratio and phase angle. The programs have been applied to several research problems which include both lumped and distributed parameter systems. The latter forms are built into the program and are handled automatically. Author

N68-25002*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.

HYDRA 1 DATA DISPLAY SYSTEM

Roger L. Hodgkins and Donald R. Osgood Washington May 1968 22 p

(NASA-TN-D-4554) CFSTI: HC $3.00/MF $0.65 CSCL 09B

Details are given on the Hydra 1 which is an extremely flexible and versatile data display system. A television monitor screen serves as a working surface upon which an operator can develop, or create, graphic displays such as written documents, charts, diagrams, graphs, background slides, and other graphic art through the use of special control keyboards and operating techniques. An operator can create, rearrange, delete, or add to the graphic display to develop any desired format. Upon completion of a graphic display, it can be recorded in a magnetic tape library, plotted on an X–Y plotter, recorded as a punched paper tape, or recorded as a frame of a sequential playback magnetic tape. Displays recorded in the magnetic tape library can be recalled for examination or revision. Author

N68-25268*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
DIGITAL SPECTRAL ANALYSIS
Anthony J. Villasenor Washington Jun. 1968 49 p refs
(NASA-TN-D-4510) CFSTI: HC $3.00/MF $0.65 CSCL 09B

This paper presents some mathematical considerations of spectral analysis and some FORTRAN computer programs that use the Fast Fourier Transform algorithm of Cooley and Tukey. These programs compute Fourier amplitude and phase spectra, cross-power spectra, auto- and cross-correlation, and filtered spectra, as well as some other frequency domain functions. Author

N68-26640*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRACTICAL STABILITY CRITERION AND ITS APPLICATION TO DIGITAL SIMULATION
Leslie L. Scalzott and Carl F. Lorenzo Washington Dec. 1967 36 p refs
(NASA-TN-D-4203) CFSTI: HC $3.00/MF $0.65 CSCL 09B

A stability criterion has been developed for use with digital simulations or graphical data. The criterion used is a simple one, which basically requires ultimate state boundedness of the time function representing the system output. Techniques are established so that a transient of finite duration may be used as a practical indication of stability. A stability test utilizing the criterion has been implemented into a general digital program which will allow the determination of system stability directly by computer. This program and criterion was demonstrated for three applications representing: (1) a linear system, (2) a continuously nonlinear system, and (3) a discontinuously nonlinear system. Author

N68-29404*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
X-15 ANALOG AND DIGITAL INERTIAL SYSTEMS FLIGHT EXPERIENCE
Melvin E. Burke Washington Jul. 1968 22 p refs
(NASA-TN-D-4642) CFSTI: HC $3.00/MF $0.65 CSCL 17G

Two different types of inertial flight data systems, an analog system and a digital system, have been used during the X-15 program to provide primary flight information for the X-15 pilot. This use has afforded an opportunity to compare the two mechanization concepts in the same operating environment. The two systems, although having basically different computers, use similar inertial measurements units. Equation mechanization is different primarily because of the difference in computers. The development problems on the analog system were considerably more complex than those with the digital system, inasmuch as the analog unit was the first of the miniature units conceived and thus was put into operation before it could be refined. These development problems ultimately brought about the redesign of the analog system and the utilization of the digital system. The performance of the analog and digital systems has been adequate for X-15 requirements. The performance of the digital system has indicated that it is a highly accurate mechanization, with the only significant problem that of the computer susceptibility to power transients. The digital system also provides a more flexible mechanization than the analog system through the programming capabilities of the computer. Author

N68-30240*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
SOME LABORATORY TECHNIQUES OF WAVE ANALYSIS WITH APPLICATION TO THE APOLLO PROGRAM
Roy A. Watlington Aug. 1968 49 p refs
(NASA-TM-X-1599; S-157) CFSTI: HC $3.00/MF $0.65 CSCL 09B

Time and frequency correlation, root-mean-square time histories, and power-spectral density analysis techniques are applied not only in perfecting communication systems but also in gaining vital information on the chemical and physical nature of things. The sophisticated instruments and techniques of the present age have made it possible to record, synthesize, and analyze wave data rapidly and in depth. This paper examines and discusses some of the major techniques of wave analysis being applied to the Apollo Program, describes the instrumentation involved, and provides an illuminating mathematical foundation for the analyses. Author

N68-31499*# North American Rockwell Corp., Anaheim, Calif.
STUDY OF SPACEBORNE MULTIPROCESSING, PHASE 2. VOLUME 1: SUMMARY
L. J. Koczela Washington NASA Aug. 1968 45 p ref
(Contract NAS12-108)
(NASA-CR-1158; C6-1476.22/33, V. 1) CFSTI: HC $3.00/MF $0.65 CSCL 09B

This final report presents the results of a research study of an advanced multiprocessor computer organization for future space missions. The organization is entitled the "Distributed Array Memory and Processor" computer. A manned Mars lander mission was selected as a representative mission for application and the computer requirements were developed. The organization developed utilizes an array of cells capable of a high degree of computational parallelism. The feasibility of such cells is dependent upon future LSI technology. Research was carried out in the hardware design and software analysis of this organization. This volume contains a summary of the results of the study. Author

N68-32055*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALOG COMPUTER SIMULATION OF A DC ARC EMISSION SPECTROMETER CONTROL SYSTEM TO DEFINE REQUIREMENTS FOR OPTIMUM CONTROL
Daniel J. Lesco Washington Aug. 1968 27 p refs
(NASA-TN-D-4770) CFSTI: HC $3.00/MF $0.65 CSCL 09B

The use of an analog computer in the simulation of a dc arc and its control system is described. The detailed model design is presented. Control parameters determined with the model are shown to be optimum with the real system. Repeatability of system control to a programmed input to ± 1 percent is achieved for both the model and the real system. Data from the model and the arc system show close agreement except in some areas of arc instability. Author

N68-32159*# National Aeronautics and Space Administration, Washington, D. C.
VISUAL INFORMATION DISPLAY SYSTEMS. A SURVEY
1968 101 p refs Prepared by Auerbach Corp.
(NASA-SP-5049) GPO: HC $0.60; CFSTI: MF $0.65 CSCL 09B

Visual information display systems that are computer connected or updated with computer-generated information were surveyed, with emphasis on alphanumeric and graphic devices. Details are included for the three basic elements of display systems: (1) human beings and task dependent parameters; (2) hardware components such as cathode ray tubes, generators, screens, and man–machine reactive input devices; and (3) computer systems, programming and software development. Checkout and control are considered for large-scale checkout, ground monitor, and control systems. Interactive displays systems described include mathematical, design automation, and educational display systems. Reservation and information access systems are mentioned for on-line information storage and retrieval display systems; and Manned Spacecraft Center simulation displays, General Electric computed displays, and computer-produced movies are cited as simulation display systems. Cockpit displays and image enhancement are also discussed. Separate bibliographies are listed for each of the major topics considered in this survey. M.W.R.

N68-35193*# Radio Corp. of America, Princeton, N. J.
MOS FIELD-EFFECT-TRANSISTOR TECHNOLOGY
J. T. Wallmark, W. A. Boesenberg, E. C. Ross, D. Flatley, and H. Parker Washington NASA Sep. 1968 67 p refs
(Contract NAS1-5794)

(NASA-CR-1113) CFSTI: HC $3.00/MF $0.65 CSCL 09B

Integrated metal oxide semiconductor (MOS) circuit technology was studied as part of a laminated-ferrite memory project. The target was the development of a 64-transistor word-driver circuit, but the technology was also applied to a 100-transistor load circuit for the decoder. The developments included: (1) a contact metallization technique suitable for low temperature, low pressure circuit connections; (2) a circuit encapsulation and passivation technique compatible with the packaging and connection technique; (3) a high-density, long-life packaging technique; and (4) fabrication of long-life MOS transistors. Word driver strips with the expected performance and with acceptable yield were fabricated. A detailed account is given of silver contact stability, a key point in the circuit packaging. Also investigated were insulators for the gate region and the crossovers, gate healing techniques, and mask limitations on yield. Author

N68-35560*# Autonetics, Anaheim, Calif.

STUDY OF SPACEBORNE MULTIPROCESSING–PHASE 2. VOLUME 2: TECHNICAL DESCRIPTION Final Report

L. J. Koczela Washington NASA Sep. 1968 391 p refs

(Contract NAS12-108)

(NASA-CR-1159; C6-1476.22/33, v. 2) CFSTI: HC $3.00/MF $0.65 CSCL 09B

Results are presented on a research study of an advanced multiprocessor computer organization for future space missions. The organization is entitled the "Distributed Array Memory and Processor" computer. A manned Mars lander mission was selected as a representative mission for application and the computer requirements were developed. The organization developed utilizes an array of cells capable of a high degree of computational parallelism. The feasibility of such cells is dependent upon future large scale integration technology. Research was carried out in the hardware design and software analysis of this organization. Author

N68-37254*# Wolf Research and Development Corp., West Concord, Mass.

DATA DISPLAY PROGRAMMING

Washington NASA Sep. 1968 304 p refs

(Contract NAS5-9756-47)

(NASA-CR-1107) CFSTI: HC $3.00/MF $0.65 CSCL 09B

Consideration is given to the problem of developing more efficient means by which the physical scientist might intimately control the complex data processing operations involved in the analysis and meaningful interpretation of large volumes of sensor data from scientific satellites. Areas of computer graphics technology in which pioneering efforts might prove fruitful are defined and approaches conceived. The results of pilot tests to evaluate proposed techniques from a human factors viewpoint are given. Specific techniques include information transfer via uncommon display media (full color; flicker; animation) and approaches to facilitate the use of a single input device as the means of processing control. Specifications are developed for an advanced hardware-software system for manipulating and displaying large volumes of data. A man computer communication station design is recommended which permits finger pointing as a means of input and peripheral equipment to service the display and input devices. Computer software to support man-computer communication is specified using a hierarchical approach. Author

09

ELECTRONIC EQUIPMENT

Includes electronic test equipment and maintainability; component parts, e.g., electron tubes, tunnel diodes, transistors; integrated circuitry; microminiaturization. For basic research see: 10 Electronics. For related information see also: 07 Communications and 21 Navigation.

N68-10420*# Melpar, Inc., Falls Church, Va.
THIN-FILM PERSONAL COMMUNICATIONS AND TELEMETRY SYSTEM (TFPCTS)
Washington NASA Nov. 1967 33 p
(Contract NAS9-3924)
(NASA-CR-914) CFSTI: HC$3.00/MF$0.65 CSCL 09F

The final electrical design of the Thin-Film Personal Communications and Telemetry System (TFPCTS) is proposed and discussed. A block diagram of the entire system is depicted, along with diagrams of the transmitter, receiver, and thin-film universal very high frequency modules. Project scheduling is described; and a PERT chart showing the module delivery data is given. Module processing information and mask drawings for the first IF module, are also given. L.S.

N68-13617*# Stanford Research Inst., Menlo Park, Calif.
MICROWAVE TECHNIQUE DEVELOPMENT FOR ADVANCED RADIO ASTRONOMY AND RADIOMETRY MISSIONS
B. M. Schiffman and Leo Young Washington NASA Jan. 1968 78 p refs
(Contract NAS12-126)
(NASA-CR-979) CFSTI: HC$3.00/MF$0.65 CSCL 09A

A scale model (f_o=20 GHz) of a birefringent wave filter for millimeter wavelengths is described. The filter consists of five cascaded identical half-wave plates, or crystals, each composed of an artificial anisotropic dielectric medium with its reference axis tilted at some prescribed angle to the plane of the input polarization. The design and analysis of an individual plate and the analysis of multielement filters are discussed. The experimental filter was tested in the range of 18–33 GHz, and its measured performance was found to compare well with the theoretical performance over a major portion of the range of frequencies used in the tests. A synthesis procedure for optimum (equal-ripple stop band) response multielement filters is given, together with tables of plate angles for such filters. This procedure combines the Fourier approximation method with the general synthesis method. Author

N68-15649*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SEMICONDUCTOR SWITCHES FOR AEROSPACE ALTERNATING-CURRENT POWER APPLICATIONS
James Vrancik Washington Feb. 1968 35 p refs
(NASA-TM-X-1495) CFSTI: HC$3.00/MF$0.65 CSCL 09A

The purpose of this investigation was to obtain insight into the merits and drawbacks of ac static switches, with particular attention to their application as aerospace power switches. Several ac static switches utilizing various semiconductor devices were studied with attention given to power loss, harmonic content, leakage, and temperature effects. The main desirable characteristics are probable high reliability (based on the fact that there are no known wear out modes) and long life, no moving parts, high vibration and shock resistance, and immunity to atmospheric conditions. A specific design was made to provide an example application for the devices and circuits investigated. A breadboard-type three-phase static switch for space use was designed, built, and tested. The breadboard switch was used as a motor starter for a 4-ampere fuel pump motor. The switch performance was determined and the power loss found to be 12 watts while transferring 800 watts (1.4 kVA). Other characteristics determined were harmonic content ($\leq$1.0 percent) and leakage (resistance in off state $\geq$50 kΩ). The switch was tested over a heat-sink temperature range of −40° to 80°C. Author

N68-15892*# General Electric Co., Schenectady, N. Y.
DEVELOPMENT OF HIGH-TEMPERATURE VAPOR-FILLED THYRATRONS AND RECTIFIERS
Arthur W. Coolidge, Jr. Washington NASA Feb. 1968 98 p refs
(Contract NAS3-6005)
(NASA-CR-994) CFSTI: HC$3.00/MF$0.65 CSCL 09A

High-temperature vapor-filled diodes and thyratrons were studied for potential use as power-conditioning elements in future space applications. A 600°C thallium-filled diode was developed using a barium-system cathode. Alkali-halide fills intended for use at 600°C did not produce successful results. Cesium-filled diodes for use at 300°C were also studied. After the accumulation of extensive data from the investigation of diodes, a cesium-filled thyratron was designed and three sample tubes–rated at 15 amperes average, 300 volts forward, and 500 volts inverse–were constructed. One thyratron tube was operated for 1500 hours. Author

N68-16530*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECTS OF CABLE AND CIRCUIT PARAMETERS ON THE PRECISION CALIBRATION OF A CHARGE AMPLIFIER
John J. Smithrick and Ira T. Myers Washington Feb. 1968 22 p refs
(NASA-TN-D-4300) CFSTI: HC$3.00/MF$0.65 CSCL 09A

The effects of cable and circuit parameters on the precision calibration of a charge amplifier for microsecond pulses, such as those obtained from semiconductor diode particle detectors, are evaluated. The precision calibration method is described. A mercury-wetted relay pulse generator driving a 1-picofarad capacitor was used as a charge generator. The accuracy of the calibration was ±0.4 percent. Author

N68-19062*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.
CHARACTERISTICS OF TUNNELING P-N JUNCTIONS
John B. Hopkins Washington Mar. 1968 22 p refs
(NASA-TN-D-4403) CFSTI: HC$3.00/MF$0.65 CSCL 09A

Procedures have been developed for the calculation of current-voltage characteristics of tunneling p-n junctions in semiconductors, given material constants and impurity-doping parameters. Accuracy higher than that acquired in similar efforts has been attained. When a digital computer is used, numerical differentiation permits calculation of parameters relevant to microwave mixing and detecting applications for tunnel and backward

diodes in any elemental or compound semiconductor. Typical results are indicated. Author

N68-19185*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

AN AUTOMATIC BALANCING SYSTEM FOR USE ON FRICTIONLESSLY SUPPORTED ATTITUDE-CONTROLLED TEST PLATFORMS

Norman M. Hatcher and Richard N. Young Washington Mar. 1968 24 p ref

(NASA-TN-D-4426) CFSTI: HC$3.00/MF$0.65 CSCL 14B

An automatic balancing system for frictionlessly supported, attitude-controlled test platforms about axes that are commonly orthogonal to the gravity vector is discussed. The system determines imbalance during limit-cycle operation by measuring the difference in total impulse exerted by opposing torquers that are used for attitude control in each axis to be balanced during some time interval. The system then moves a small weight by an appropriate distance to compensate for the measured imbalance. A model of the automatic balancing system has been constructed and tested on an air-bearing-supported platform that was fitted with sun sensors and a reaction-jet attitude-control system. Results indicated that the automatic balancing system can consistently balance this platform more accurately than it can be balanced manually, and that it can maintain this balance throughout prolonged test periods. The average accuracy to which the system balanced the platform during the tests was approximately 3000 dyne-dm. The system is compatible with present-day attitude-control systems, requires little power, and can be made small in weight and volume. Author

N68-22302*# National Aeronautics and Space Administration, Washington, D. C.

RECENT ADVANCES IN DISPLAY MEDIA

1968 129 p refs Symp. held at Cambridge, Mass., 19–20 Sep. 1967

(NASA-SP-159) GPO: HC$1.00; CFSTI: MF$0.65 CSCL 17G

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N68-24387*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

SUPPRESSION OF TEMPERATURE RISE IN LOSSY DIODES INSIDE RESONANT CAVITIES BY APPLICATION OF PRESSURIZED LIQUID NITROGEN

Hans-Juergen C. Blume Washington May 1968 31 p refs

(NASA-TN-D-4556) CFSTI: HC$3.00/MF$0.65 CSCL 09A

The suppression of temperature rise in lossy diodes due to electrical power dissipation inside resonant cavities of low noise devices such as parametric amplifiers is essential in maintaining optimum low noise performance. This suppression can be achieved by the application of pressurized liquid nitrogen inside the cavity. The expected temperature of the lossy diode under this condition is estimated by (1) a calculation based on the heat-flow equations, and (2) a salt-solution test. The results are correlated with direct measurements which reveal a temperature rise of 3.3°K above the temperature of liquid nitrogen at 1 atmosphere. The resonant frequency shift due to the liquid nitrogen dielectric is estimated and its correlation with measurements is included. The results indicate that this type of cooling can be successfully used and is particularly effective for parametric amplifiers with medium quality varactor diodes. Author

N68-24388*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.

LOW DRIVE TEMPERATURE STABLE MEMORY CORES

Howard Lessoff Washington May 1968 10 p refs

(NASA-TN-D-4573) CFSTI: HC$3.00/MF$0.65 CSCL 09A

Details are given on the use of calcium and molybdenum as substitutes in the preparation of temperature-stable memory cores. Substituted lithium compositions which effectively improve core uniformity and lower the power required in memory application have been developed for memory cores. These improvements have been achieved by control of the ceramic structure, lowering of the coercivity, and reduction of the sintering temperature. Author

N68-24389*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

A DIGITAL VOLTAGE-CONTROLLED OSCILLATOR FOR PHASE LOCK LOOPS

Dominick E. Santarpia and Thomas E. McGunigal Washington May 1968 16 p refs

(NASA-TN-D-4521) CFSTI: HC$3.00/MF$0.65 CSCL 09E

The development of a digital voltage-controlled oscillator phase lock loop is described. A large frequency-tracking range and high phase stability are conflicting requirements of a conventional voltage-controlled oscillator; however, a digitally controlled frequency synthesizer performing in place of the conventional tracking oscillator will provide the stability and spectral purity of a very good 1-MHz standard over very wide frequency excursions. Author

N68-26662*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECTS OF NUCLEAR RADIATION ON A HIGH-RELIABILITY SILICON POWER DIODE I-CHANGE IN 1–5 DESIGN CHARACTERISTICS
Julian F. Been Washington Jun. 1968 37 p refs
(NASA-TN-D-4620) CFSTI: HC $3.00/MF $0.65 CSCL 09A

Tests were conducted on 100 diodes in the NASA Plum Brook Reactor facility, which was designed to simulate a SNAP-8 nuclear environment. The diodes were irradiated in different operational and temperature modes for approximately 480 hr, with a resultant diode exposure to a total fast-neutron fluence (energies of 0.1 MeV and above) of 5×10^{13} neutrons/cm^2 and to a total gamma dose of 3×10^7 rads (C). Results showed that this diode could be reliably used in a nuclear electric generating system such as SNAP-8 provided that the total radiation levels were within those of the tests. No catastrophic failures occurred. The electrical characteristic that would limit the useful lifetime of the device with increased radiation is the forward voltage drop at high current levels. Author

N68-28668*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.
RADIATION AND COUPLING BETWEEN TWO COLLINEAR OPEN ENDED WAVEGUIDES
Robert J. Mailloux Washington Jul. 1968 50 p refs
(NASA-TN-D-4656) CFSTI: HC $3.00/MF $0.65 CSCL 09A

An experimental and theoretical study of collinear coupled waveguides radiating through a common perfectly conducting ground plane was described. The problem is formulated as a set of simultaneous integral equations and solved approximately by expanding the aperture field in a Fourier series. The special case of a single isolated waveguide is treated first, and the results are compared with experiment as well as with the approximate results of Lewin. Attention is given to the edge singularities. The more general case of two collinear coupled waveguide slots is solved by the same numerical method using the symmetrical properties of the geometry. Phase and amplitude of the mutual coupling are evaluated and compared with experiment. Considerable attention is given to comparing more simple approximations with this result, and on several occasions it is pointed out how these can be used and what error the additional approximations introduce. Author

N68-28879*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
FLAT CONDUCTOR CABLE TECHNOLOGY
Washington 1968 54 p
(NASA-SP-5043) GPO: HC $0.40; CFSTI: MF $0.65 CSCL 09A

Technical information necessary for engineering consideration of flat conductor cable (FCC) systems as integral parts of future electronic programs is reported. The FCC is made of rolled flat conductors laminated between thin flexible plastic insulating films. Flat plugs and receptacles are used to form FCC systems. Copper is the most often used conductor, and polyesters (Mylar), polyimides (Kapton), and fluorocarbons (Teflon) are frequently chosen for the insulating films. Fabrication procedures, advantages, and limitations of use are detailed. Conventional wiring and FCC system costs are compared, and electrical characteristics data are tabulated. The FCC is recommended for electrical systems design where weight, space, cost reduction, lead time, reliability, and uniform electrical characteristics are of prime importance. Suggested areas of use are aircraft wiring, communications and radar equipment, computers, radio and television equipment, instruments and controls, appliances, and automotive harnesses. F.O.S.

N68-29525*# ARINC Research Corp., Annapolis, Md.
MICROELECTRONIC DEVICE DATA HANDBOOK. VOLUME 1: TEXT
Washington NASA Jul. 1968 302 p refs
(Contract NAS12-528)
(NASA-CR-1110; Rept.-548-01-7-803, V. 1) CFSTI: HC $3.00/MF $0.65 CSCL 09A

Volume I of a two volume handbook which was designed as a quick reference document for use by design engineers, technicians, parts specialists, and contractors in the selection and application of microelectronic devices in space systems; is reported. Emphasis is placed upon considerations affecting reliability of systems employing such devices. This volume comprises six sections of user oriented technical discussion, ranging from design, manufacture, use of the devices in subsystems, and specifications to reliability and failure physics. S.C.W.

N68-29526*# ARINC Research Corp., Annapolis, Md.
MICROELECTRONIC DEVICE DATA HANDBOOK. VOLUME 2: MANUFACTURER AND SPECIFIC DEVICE INFORMATION
Washington NASA Jul. 1968 163 p
(Contract NAS12-528)
(NASA-CR-1111; Rept.-548-01-7-803, V. 2) CFSTI: HC $3.00/MF $0.65 CSCL 09A

Volume II of a two volume handbook which was designed as a quick reference document for use by design engineers, technicians, parts specialists, and contractors in the selection and application of microelectronic devices in space systems; is reported. This volume lists and gives the characteristics of approximately 2,000 devices, arranged to facilitate device selection. Included are separate sections for linear circuits, digital circuits, and digital arrays. The reported catalog of micorelectronic devices is restricted to those devices that are integral units and that cannot be broken down into smaller segments without destruction of the entire unit. The catalog is further restricted, in general, to those devices in which all active and passive elements necessary to a fully operable circuit are included and intraconnected in one package. Names of companies engaged in manufacturing standard microelectronic devices are listed along with basic information on the nature of their devices. Included are outline drawings, schematic drawings, and printouts for each of the three classes of devices considered. S.C.W.

N68-30501*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.
***ON* ELECTROMAGNETIC SWITCHING PROPERTIES OF A BI-STABLE FLUIDIC ELEMENT WITH NON-DESTRUCTIVE MEMORY**
Joseph S. Koziol, Jr. and Robert De Furia Washington Aug. 1968 39 p refs
(NASA-TM-X-1613) CFSTI: HC $.300/MF $0.65 CSCL 09E

The feasibility is discussed of controlling a magnetically permeable liquid bead with an electromagnet between two stable states of a particular system. Several useful properties of the switching system, namely, magnetomotive force required for switching, switching time, and ambient acceleration field limits are determined in terms of the system parameters. This concept suggests a simple, bi-stable, low-power, electric-to-fluid transducer with non-destructive memory. (The fluid bead retains its last stable state with all power off.) Development of a magnetically permeable liquid with high surface tension did not reach the stage for implementation, at the completion of the analysis, to permit experimental verification of the analytical results contained herein. Author

N68-33224*# Hartman-Huyck Systems Co., Huntington Station, N. Y.

A CATHODE RAY TUBE SUITABLE FOR VIEWING UNDER HIGH AMBIENT

Donald Amberger Washington NASA Sep. 1968 84 p refs (Contract NAS12-97)

(NASA-CR-1185) CFSTI: HC $3.00/MF $0.65 CSCL 09A

A high contrast cathode ray tube, employing nonreciprocal optical filtering techniques was developed. The non-reciprocal filter design consists of a UV bandpass filter, a fluorescent film and a visible bandpass filter. All elements are transparent. The filter is between the observer and an ultra-violet emitting cathodoluminescent phosphor. Incident light strikes the visible filter and is partially absorbed. The remaining ambient passes through the transparent fluorescent film and is absorbed by the UV filter. The two filter layers have no mutual bandpass. Return diffuse reflection or emission from the fluorescent film and any return reflection from the phosphor are therefore eliminated. Attention is focused on the problem of eliminating diffuse reflection. Author

N68-37944*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ELECTRICAL STRESS ANALYSIS OF A MICROTHRUSTOR POWER CONDITIONER

Vincent R. Lalli Washington Nov. 1968 23 p refs

(NASA-TM-X-1686) CFSTI: HC $3.00/MF $0.65 CSCL 10B

Obtaining suitable power conditioning equipment for propulsion experiments is a critical problem. Data obtained on several space projects indicated that failure was caused partly by overstressed electrical parts. A microthruster power conditioner was experimentally analyzed to reveal the problems associated with worst case overstressed parts. The power conditioner was then modified to eliminate these existing overstressed conditions and has since operated continuously for more than 7000 hours. Author

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ELECTRONICS

Includes circuit theory; and feedback and control theory. For applications see: 09 Electronic Equipment. For related information see: Specific Physics Categories.

N68-11513*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THEORETICAL ERROR ANALYSIS OF A DOPPLER RANGE-RATE AND PHASE-MODULATED RANGE TRACKING SYSTEM
Kenneth J. Bures and Gerald L. Smith Washington Dec. 1967 47 p refs
(NASA-TN-D-4267) CFSTI: HC$3.00/MF$0.65 CSCL 09F

A detailed error analysis is presented for a particular type of range and range-rate tracking system. Results are given in the form of analytical expressions for the variances of the various types of errors that affect tracking data. The expressions are written in terms of system parameters so that they can be applied to a wide range of specific systems and tracking situations. The majority of the errors considered are random, but some are bias like and others are deterministic. The equations given constitute an error model from which data weighing factors can be obtained for use in data processing for the construction of the best estimate of the trajectory of a space vehicle. Author

N68-11789*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
STATISTICAL TESTS FOR SIGNAL DETECTION
James C. Morakis Washington Dec. 1967 83 p refs
(NASA-TR-R-273) CFSTI: HC$3.00/MF$0.65 CSCL 09D

Some of the problems arising from maximum likelihood decision systems in time varying channels are solved by first introducing simple statistics which are functions of the outputs of the correlators of an n-ary detection system. Then methods are developed to use the statistics to a) attach a confidence level to each decision in a maximum likelihood decision system, b) control the error rate at the expense of data rejection, and c) define the critical region for an optimum generalized decision system. These improvements and optimizations are accomplished by taking advantage of the information already available in the sample representing the outputs of n-ary detection systems. The six statistics that are investigated are simple functions of the largest correlator output, the mean, the standard deviation, the sample mean, the sample variance, the next to the largest correlator output, and the smallest correlator output. Author

N68-16749*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
EFFECTS OF CORRELATED NOISE WITH APPLICATIONS TO APOLLO TRACKING PROBLEMS
B. Kruger Washington Feb. 1968 59 p refs
(NASA-TN-D-4121) CFSTI: HC$3.00/MF$0.65 CSCL 09D

The standard deviation η_i and the rms standard deviation $\bar{\eta}$ of least-squares fitted polynomials are analyzed in this paper. The general equations derived are demonstrated on several Apollo tracking problems: It is shown that $\bar{\eta}$ does not improve for higher sampling rates of angular data than 2 or 5 per second, for narrow and wide bandwidth setting of the angular servoloops, respectively. (Apollo GO, NO-GO decision.) The effect of negative correlation of measurement errors is analyzed. The effect of phase noise in range rate data is reduced by a factor $\sqrt{N}$ due to the negative correlation of $-1/2$ between adjacent measurement points. The effect of random-walk phase noise on the range rate data is shown to be proportional to the two-way propagation time of the signal. The maximum error in a least-squares fitted polynomial is also analyzed. Author

N68-19229*# Douglas Aircraft Co., Inc., Newport Beach, Calif.
RESEARCH ON THE UTILIZATION OF PATTERN RECOGNITION TECHNIQUES TO IDENTIFY AND CLASSIFY OBJECTS IN VIDEO DATA Final Report
Washington NASA Mar. 1968 285 p refs
(Contract NAS12-30)
(NASA-CR-999; SM-48464-F) CFSTI: HC $3.00/MF $0.65 CSCL 09F

The study consisted of a literature survey to select pattern recognition methods for testing, controlled recognition experiments to test the performance of the selected methods on five specimen classification tasks, and a hardware feasibility study, culminating in three potential designs for a spaceborne recognition system. Six methods for generating property filters and eight algorithms for designing decision functions were tested. Lunar photographs and Nimbus pictures of cloud patterns were used in the experiments. Decision networks were designed to perform three recognition tasks on the photographic data. Three recognition systems were designed: (1) parallel/analog, (2) sequential/hybrid, and (3) sequential/digital. Each has an image dissector tube which views the scene and scans the sensed image through a small aperture. The first implements all property filters separately in analog form. The second uses a single property filter repetitively with a diode matrix containing the weighting elements for each computed property. The third uses a compact core storage unit and an arithmetic unit with a combination hardware and software program to implement the required property filters. All three systems can classify TV pictures in real time. Author

N68-19882*# National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.
AN ANNOTATED BIBLIOGRAPHY OF COMPUTER-AIDED CIRCUIT ANALYSIS AND DESIGN
Charles W. Meissner, Jr. Washington 1968 44 p refs
(NASA-SP-7023) CFSTI: HC$3.00/MF$0.65 CSCL 09C

An annotated bibliography is presented on computer aided circuit analysis and design with emphasis on the application of computers to the analysis of electronic circuits. The bibliography presents a listing of authors and their works, and a chronology of the development of computer aided analysis. The bibliography covers the period from 1956 to 1966. B.S.D.

N68-21122*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COLLISIONLESS CYLINDRICAL DIODE
Charles M. Goldstein Washington Apr. 1968 41 p refs
(NASA-TN-D-4516) CFSTI: HC$3.00/MF$0.65 CSCL 09C

A complete formulation and numerical results for the collisionless space-charge problem of a cylindrical diode with thermionically emitted electrons are presented. This formulation allows calculation of the current-voltage characteristics from the Schottky retarding region to saturation. In addition, the onset of the Schottky retarding region is unambiguously defined. Author

N68-24338*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ATLAS–CENTAUR FLIGHT PERFORMANCE FOR SURVEYOR MISSION A
Washington May 1968 148 p refs
(NASA-TN-D-4580) CFSTI: HC $3.00/MF $0.65 CSCL 22D

The first operational Atlas–Centaur launch vehicle AC-10, with Surveyor spacecraft SC-1, was launched May 30, 1966. Surveyor was the first earth-launched spacecraft to soft land, under controlled conditions, on the lunar surface. Landing on the lunar surface occurred on June 2, 1966. This report includes a flight performance evaluation of the Atlas–Centaur launch vehicle systems from lift-off through spacecraft separation and Centaur retromaneuver. Author

N68-28307*# General Precision, Inc., Little Falls, N. J.
ADDITIONAL STUDIES OF QUASI-OPTIMUM FEEDBACK CONTROL TECHNIQUES
Bernard Friedland, Frederick E. Thau, Sanford Welt, Chong K. Ling, and Michael Schilder Washington NASA Jul. 1968 144 p refs
(Contract NAS2-3636)
(NASA-CR-1099) CFSTI: HC $3.00/MF $0.65 CSCL 09A

A quasi-optimal control technique was investigated by approximating a complicated dynamic process by a simpler process, designing a control system for the latter, and amending the design to account for any difference between the original process and the approximation. The simplified process must be a reasonably faithful representation of the original process and the solution of the two-point boundary-value problem governing the optimal control law of the process must be reducible to manageable proportions. The correction to the optimal control law requires evaluation of a correction matrix with a matrix Riccati equation, whose solution matrix is then used to correct the solution to the simplified process. Theoretical studies on the performance of the quasi-optimal control law as well as stochastic optimum control are reported. Applications are included for the three-axis attitude control of a space vehicle; minimum-time, bounded acceleration rendezvous in a central force field; and an aircraft landing problem. Some aspects of the inverse optimal control problem are considered for a class of nonlinear autonomous systems. M.W.R.

N68-33767*# Hughes Aircraft Co., Fullerton, Calif.
TRANSISTOR DESIGN EFFECTS ON RADIATION RESISTANCE
C. C. Berggren and V. R. Honnold Washington NASA Sep. 1968 97 p refs
(Contract NAS1-6954)
(NASA-CR-1167) CFSTI: HC $3.00/MF $0.65 CSCL 09A

Analytical expressions relating transistor design parameters to radiation induced gain degradation were developed. Emitter efficiency and base transport injection level effects have received prime consideration. Several statistically designed experiments, which employed custom designed planar transistor variations, were conducted to evaluate the theoretical conclusions. The need for accurate profile information, to correlate with radiation induced gain degradation, is established. Shallow junctions and low base doping are shown to contribute significantly to radiation resistance. Author

N68-37293*# Israel Program for Scientific Translations. Ltd., Jerusalem.
MULTIVARIABLE CONTROL SYSTEMS [SISTEMY MNOGOSVYAZNOGO REGULIROVANIYA]
M. V. Meerov 1968 294 p refs Transl. into ENGLISH of the book "Sistemy Mnogosvyaznogo Regulirovaniya" Moscow, Izd. Nauka, 1965 Support by NASA and NSF
(NASA-TT-F-435; TT-67-51371) CFSTI: HC $3.00/MF $0.65 CSCL 09C

The fundamental properties of multivariable automatic control systems (MCS) are elucidated and reviewed. The current methods and techniques are assessed and evaluated for the synthesis and analysis of MCS. Mathematical descriptions of some typical MCS, representative of metallurgy and oil industries, are presented. Equations of MCS consisting of single variable subsystems are derived for steady state and transient conditions. The matrix of error coefficients is determined for the case of plant and control coupling of the individual variable. The general structural properties of MCS are investigated with emphasis on infinite gain stability. Noninteraction and variance problems are discussed with respect to structural properties of a certain class of systems. Fixed structure systems with their properties equivalent to adaptive systems and variational aspects of MCS are reported. B.P.

N68-37906*# Chrysler Corp., New Orleans, La.
APPLICATIONS STUDY OF ELECTROADHESIVE DEVICES
Richard P. Krape Washington NASA Oct. 1968 90 p 3 refs
(Contract NAS1-7303)
(NASA-CR-1211) CFSTI: HC $3.00/MF $0.65 CSCL 13H

A summary is presented on studies to determine the feasibility of using electroadhesion as a means for aiding astronauts in performance of on-board and EVA experiments. Mathematical and experimental analyses were conducted to define the factors that control or affect the electroadhesion phenomenon. The parameters analyzed were: resistivity, coating thickness, current density, surface conditions, polarity, temperature, time, environmental conditions, and chemical nature of coating materials. Five types of electroadhesor mountings were investigated; power supply requirements and techniques for controlling electroadhesor operation were studied. Three prototype electroadhesor models were designed, fabricated, and tested to establish preliminary operational data. Evaluation included tests for static pull force, skid force, and battery longevity. In practice, electroadhesion was found to occur when any suitable insulator material was placed between two electrodes charged in a manner to allow a small current to pass from one to the other. The intimacy of the contacting surfaces was found the most difficult condition to establish and maintain. B.P.

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FACILITIES, RESEARCH AND SUPPORT

Includes airports; lunar and planetary bases including associated vehicles; ground support systems; related logistics; simulators; test facilities (e.g., rocket engine test stands, shock tubes, and wind tunnels); test ranges; and tracking stations.

N68-10384* Sandia Corp., Albuquerque, N. Mex.
CONTAMINATION CONTROL PRINCIPLES
Washington NASA 1967 51 p refs
(Contract NASw-12324)
(NASA-SP-5045) CFSTI: $3.00 CSCL 14B

A basic contamination control model is outlined to define the overall field in terms of contaminants and environments which they affect. Contamination control considerations and principles in product design are discussed followed by detailed descriptions of clean rooms, clean work stations, and other work enclosures used to control airborne contaminants. The discussion also covers processes and methods used in cleaning product surface; contamination in liquids, gases, and solids; the effects and means of controlling radiation and microbial contamination; methods of detecting the various types of contaminants; controlling contamination in packaging, transport, and storage; and personnel control and management at contamination control facilities. R.N.A.

N68-14115*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A 4500°R (2500°K) FLOWING-GAS FACILITY
Jack G. Slaby, Byron L. Siegel, William F. Mattson, and William L. Maag Washington Jan. 1968 32 p refs
(NASA-TM-X-1506) CFSTI: HC $3.00/MF $0.65 CSCL 14B

The design and operation of a high-temperature flowing-gas heater is described. The heater consists of four identical heater stages, each individually controlled. The heating elements consist of flat tungsten plates which are electrically resistance heated by high direct-current power supplies and operate at surface temperatures above 5000°R (2780°K). The maximum power that can be transferred to the gas is about 1.5 megawatts. The gas flows through the four heater stages in series. Gas temperatures exceeding 4500°R (2500°K) were obtained with hydrogen, helium, and nitrogen. Operating life of the heater elements was 10 hours or more. Power supply selection; connection of high current busing to the heater; heater expansion at operating temperature; materials compatibility, and heater surface temperature profiles associated with the physical dimensions of the heater, are discussed. Author

N68-15777*# Physics International Co., San Leandro, Calif.
EXPLOSIVE HYPERVELOCITY LAUNCHERS
E. T. Moore, Jr. Washington NASA Feb. 1968 74 p refs
(Contract NAS2-3577)
(NASA-CR-982; PIFR-051) CFSTI: HC $3.00/MF $0.65 CSCL 14B

This report summarizes the analytical and experimental effort that demonstrates the feasibility of using a two-stage explosively driven light gas gun to obtain high projectile velocities. The second stage of this gun consists of an explosive lensing system that is used to produce an implosively formed piston whose velocity can be increased uniformly. The uniformly accelerated piston is shown to generate a nearly constant base pressure for projectile accelerations. Velocities as high as 12.2 km/sec have been obtained for a 0.17-gram magnesium–lithium projectile. Author

N68-15858*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
VISUAL SIMULATION FACILITY FOR EVALUATION OF LUNAR SURFACE ROVING VEHICLES
F. L. Vinz, M. H. Knighton, H. F. Lahser, L. G. Thomas, J. T. Howell, et al Washington Feb. 1968 41 p refs
(NASA-TN-D-4276) CFSTI: HC $3.00/MF $0.65 CSCL 14B

A fixed base visual simulator was developed to serve primarily as an engineering tool which would include man–machine interaction in evaluations of preliminary Lunar Surface Vehicle design. Visual cues are obtained by means of a visual simulator consisting of a camera and model unit and a projector and screen providing a 30°×50° field-of-view of a three-dimensional terrain model. The crew station consists of a general-purpose two-man cockpit designed for maximum flexibility. The crew station and the general-purpose analog computers are interconnected through an interface console featuring a removable patch panel and containing power supplies, relay racks, servo panels, limiters, and other items common to most simulators. The terrain model is scaled 150:1 and has a maximum dimension of 12×27 feet. Maximum camera-model separation is eight inches. Lunar surface details required in the manufacture of the model were reduced from Ranger VIII photographs and supplied by the Branch of Astro-Geology. Terrain surface irregularities are detected by sensors mounted around the camera optics. Author

N68-16695*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESIGN AND PERFORMANCE OF TWO VACUUM CHAMBERS AND SOLAR SIMULATORS FOR SOLAR-CELL RESEARCH
Adolph C. Spagnuolo Washington Feb. 1968 18 p refs
(NASA-TM-X-1503) CFSTI: HC $3.00/MF $0.65 CSCL 14B

A facility containing a 5-foot- (1.52-m-) and a 2-foot- (0.61-m-) diameter space-environmental chamber with two solar-radiation simulators and support equipment is described. The facility is designed for testing solar cells, thermoelectric and thermionic devices, and related components at vacuum levels in the 10^{-8}- to 10^{-9}-torr (10^{-6}- to 10^{-7}-N/m^2) range. The pumping systems and liquid-nitrogen-cooled shrouds are described. Information concerning a test apparatus and a solar-cell installation method is also included. Author

N68-18460*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SNAP-8 SIMULATOR LOOP MECHANICAL DESIGN
Alfred S. Valerino, James C. Wood, and Joseph F. Reznik Washington NASA Mar. 1968 65 p refs
(NASA-TM-X-1515) CFSTI: HC $3.00/MF $0.65 CSCL 14B

A SNAP-8 system simulation facility was designed, assembled, and tested. Design flow rates of the three-loop system were 32,000 lb/hr of eutectic NaK in both the primary and heat-rejection loops and 9100 lb/hr of Hg in the power loop. The turbine, radiator, and nuclear reactor were simulated. A prototype boiler and condenser were employed. Fluid circulation was obtained by electromagnetic pumps and a centrifugal pump for NaK and Hg, respectively. Test results indicated errors in Hg vapor flow rate due

to erosion and/or corrosion of the entrance and throat sections of choked venturis. The location of spark-plug-type liquid-level indicators in the expansion tanks of the NaK loops resulted in frequent shorting of the indicators. Gas and vacuum lines located atop the tanks were often plugged. Metal flexible hoses installed to alleviate thermal expansion of the piping by lateral movement of the hoses were safely employed in the liquid metal loops. The NaK electric heater employed as the heat source in the primary loop was replaced because of external leaks and electric shorting of the heater-element lead wires. Author

N68-19207*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OUTGASSING OF WATER VAPOR FROM CONCRETE SURFACES IN VACUUM ENVIRONMENT

Adolph C. Spagnuolo and Edward A. Maslowski Washington Mar. 1968 11 p refs

(NASA-TM-X-1536) CFSTI: HC $3.00/MF $0.65 CSCL 14B

The amount of water loss by outgassing from two borated and two nonborated concrete blocks was measured at vacuum levels of 0.1 and 30 torr (1.3×10^{1} and 3.9×10^{3} N/m^2). The nonborated blocks were also baked out in a furnace and subsequently placed in a 100-percent humidity chamber to investigate the reabsorption power of the concrete. The amount of water loss proved to be approximately 0.06 lb/ft^2 (0.03 kg/m^2) for the nonborated and 0.320 lb/ft^2 (0.16 kg/m^2) for the borated blocks. The concrete reabsorbed 70 percent of the water loss within the first 20 hours in the 100-percent humidity chamber. Author

N68-19273*# North American Aviation, Inc., Los Angeles, Calif.

PROPULSION SYSTEM DYNAMIC SIMULATION THEORY AND EQUATIONS

Arnold W. Martin Washington NASA Mar. 1968 222 p refs

(Contract NAS2-3268)

(NASA-CR-928; NA-67-384) CFSTI: HC $3.00/MF $0.65 CSCL 14B

This report presents the theory, equations and assumptions for a propulsion system dynamic simulation program with emphasis on the air induction system. Although the simulation program was developed and used primarily for the XB-70, the theory and equations are sufficiently general to be applicable to a wide range of inlet configurations and flight conditions. Similarly, while the majority of simulation runs have utilized a digital computer in conjunction with the General Electric Company's "Dynasyar" program, the simulation is adaptable to other computing systems, and to analog computers. Author

N68-22737*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

VIEWING DEVICES FOR OBSERVING FLOW CONDITIONS IN HOT MERCURY SYSTEMS

Lawrence A. Mueller and David W. Medwid Washington May 1968 22 p refs

(NASA-TM-X-1578) CFSTI: HC $3.00/MF $0.65 CSCL 14B

Windows for both a mercury condensing tube and a mercury-boiler-outlet tube were investigated. A key factor in window design was proper matching of the thermal expansion coefficients of the window, the window sealants, and the window-support structure. The window for the mercury-condensing tube was tested with flowing condensing mercury at 670°F (628°K) and 15 psia (10^5 N/m^2). At room temperature, the window was also subjected to 20-g random vibration. The boiler window was heated in a furnace to 1350°F (1005°K) with gas pressurization of 350 psig (2.4×10^6 N/m^2). Author

N68-23357*# Stevens Inst. of Tech., Hoboken, N. J.

A LABORATORY SCALE MODEL TECHNIQUE FOR INVESTIGATING PNEUMATIC TIRE HYDROPLANING

H. Dugoff and I. R. Ehrlich Washington NASA May 1968 39 p refs

(Contract NSR-31-003-016)

(NASA-CR-1074; Rept.-1223) CFSTI: HC $3.00/MF $0.65 CSCL 01B

A new technique is developed for laboratory investigation of pneumatic-tire hydroplaning through experiment with small-scale tires on a treadmill runway-simulator. The tires are mounted on a modified aircraft-landing-gear assembly which permits freedom in heave under variable vertical load and allows measurement of the longitudinal force exerted on the tire. The treadmill is capable of speeds up to 90 feet per second, and is outfitted with a water-supply system and a nozzle which delivers a water layer 1-foot wide, of variable thickness, at matching speed. The model tires are fabricated of polyurethane foam the density of which is varied to simulate variations in pneumatic-tire inflation pressure. Correlation of detailed load-deformation data for model and prototype tires demonstrates that geometric similarity is achieved under static conditions. Dimensional analysis has been employed to derive additional requirements for dynamic similarity and to develop a design for the initial series of experiments. Author

N68-24560*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

A HIGH ENTHALPY PLASMA GENERATOR FOR ENTRY HEATING SIMULATION

Charles E. Shepard, Donald M. Ketner, and John W. Vorreiter Washington May 1968 19 p refs

(NASA-TN-D-4583) CFSTI: HC $3.00/MF $0.65 CSCL 14B

The constricted arc supersonic jet has a variety of applications, the most important probably being the simulation of entry heating from interplanetary missions. Within a constricted arc supersonic jet apparatus, a supersonic nozzle with an elongated throat, or arc constrictor, a direct-current arc and a longitudinal flow of gas are maintained. The working fluid, which may be air or any other gas, is heated as it passes near the arc, becomes electrically conductive and eventually becomes a part of the arc core. The arc core temperature is maintained by current flow while the gas passes through the supersonic nozzle into the test section. At present, total enthalpies and impact pressures corresponding to flight at 10 km/s at 60 km altitude and 30 km/s at 100 km altitude can be achieved. The three major limitations on performance are the maximum wall heat flux that can be removed by the cooling water, the maximum current that can be maintained without electrode erosion and subsequent stream contamination, and the maximum voltage gradient that can be maintained without destructive arc-over. Author

N68-24966*# Ling-Temco-Vought, Inc., Anaheim, Calif. LTV Research Center, Western Div.

THE SHOCK EXPANSION TUBE AND ITS APPLICATION AS A SONIC BOOM SIMULATOR

Hugo E. Dahlke, George T. Kantarges, Thomas E. Siddon, and John J. van Houten Washington, D. C. NASA Jun. 1968 46 p refs

(Contract NAS1-5652)

(NASA-CR-1055; TR-0-71200/TTR-125) CFSTI: HC $3.00/MF $0.65 CSCL 14B

The generation of simulated sonic booms by mechanically bursting a pressurized diaphragm in a shock tube and expanding through an acoustic horn is described. An analysis of the expansion tube phenomena is presented, the characteristics of the various wave and wave interactions in the tube-horn combination are established and projected in an x-t diagram. Mathematical expressions for these characteristic wave motions are computed for the expansion tube. The simulator can generate double blast waves with a maximum peak pressure of 27 psf at 10 feet from the horn (on axis) using static pressure of 30 psig. The boom duration is

variable from 10 to 600 msec. Subjective data were obtained for quantitative evaluation. Data showing the shape of the blast wave pressure signatures, the radiation pattern on the gound, and blast wave pressure as a function of distance from the simulator are presented. Author

N68-25853*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EVALUATION OF A FULL-SCALE LUNAR-GRAVITY SIMULATOR BY COMPARISON OF LANDING-IMPACT TESTS OF A FULL-SCALE AND A 1/6-SCALE MODEL

Ulysse J. Blanchard Washington Jun. 1968 47 p refs Film Supplement Number L-993 to this report is available on loan from NASA Langley Res. Center, Langley Station, Va.

(NASA-TN-D-4474) CFSTI: HC$3.00/MF$0.65 CSCL 14B

In order to subject the structural components of the prototype lunar module (LM) to the dynamic loads and conditions imposed during lunar-landing impact, full-scale tests were needed. To conduct such full-scale tests on earth, lunar gravity must be simulated. A lunar-gravity simulator for conducting landing-impact tests of a full-scale vehicle was constructed and evaluated. Results of landing tests of a full-scale test model of the LM conducted on the lunar-gravity simulator compare favorably with results of free-body tests of a similar 1/6-scale dynamic model conducted under earth gravity. Landing-gear strokes, center-of-gravity accelerations, and pitching motions were in good agreement. The full-scale simulator adequately reproduces two-dimensional landing-impact dynamics and is suitable for conducting detailed studies of prototype LM structure during landing impact. The effect of structural elasticity on landing motions and stability could also be investigated with the simulator. Author

N68-28311*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

CLEAN-ROOM FACILITIES FOR EXPLORER 35 SPACECRAFT

Francis N. Le Doux Washington Jun. 1968 16 p

(NASA-TN-D-4577) CFSTI: HC$3.00/MF$0.65 CSCL 14B

Costly delays and failures in past spacecraft projects have been attributed to the inadequacy or lack of contamination control. Currently, NASA requires that automated spacecraft with mission in the near vicinity of the moon be biologically decontaminated to a level of no more than 2.59×10^6 viable spore forms at time of launch. To reduce particulate and biological contamination of Explorer XXXV, various classes of clean rooms were used. Debris generating operations were performed in uncontrolled areas with protection for flight hardware in the near vicinity. Decontamination, conformal coating, and encapsulation of electronics were performed in a class 10,000 conventional clean room; spacecraft buildup and some engineering tests were conducted in a class 100,000 conventional clean room. Electronic systems field checkout, cleaning and decontamination of small hand tools, instrument assembly, and/or functional operation tests, final spacecraft decontamination and assembly, and bioassaying were conducted in a class 100 bio-clean room environment. All clean room areas were restricted in number of personnel, clean-room dress, deportment, and procedures. On the basis of the biorecords, it was determined that the Explorer XXXV surfaces contained not more than 9×10^5 microorganisms before decontamination. This low level has been attributed to the various clean-room environments and contamination controls utilized during assembly and/or testing. Author

N68-28947*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

DESCRIPTION AND INITIAL CALIBRATION OF THE LANGLEY 20-INCH HYPERSONIC ARC-HEATED TUNNEL

Raymond E. Midden and Bennie W. Cocke, Jr. Washington Jul. 1968 26 p refs

(NASA-TN-D-4653) CFSTI: HC$3.00/MF$0.65 CSCL 14B

Four different throat sizes (0.483, 0.680, 0.965, and 1.366 cm) were investigated to determine the effect of throat size on arc-heater performance in a 20-inch hypersonic arc-heated tunnel. The 1.366 cm-dia throat was found to be the most efficient. Three different center electrodes were evaluated, and electrode size and shape were found to have a large effect on arc-heater performance. This tunnel has an enthalpy range from 2790 to 27 900 kJ/kg. Four interchangeable nozzles (5.08, 8.39, 16.75, and 50.80 cm exits) are used to vary heating rate and model stagnation pressure at fixed arc-heater conditions. With these four nozzles the heating rate can be varied from 17 to 1700 W/cm^2 (on a 3.81-cm-dia hemisphere-cylinder model), and the model stagnation pressure can be varied from 0.01 to 2.7 atm. Hemisphere-cylinder models up to 10.15 cm in diameter have been tested in the 50.80-cm nozzle exit, and models up to 6.35 cm in diameter have been tested in the 16.75 cm nozzle exit. Author

N68-29478*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

COLD WALL THERMAL VACUUM, THERMAL DESIGN CHECK FOR FULLY INSULATED EXPERIMENT PACKAGES

Charles Dan Washington Jul. 1968 13 p refs

(NASA-TN-D-4644) CFSTI: HC$3.00/MF$0.65 CSCL 20M

Past procedure for testing the thermal balance of fully insulated experiment packages involved a solar-simulation test on the flight model as well as on the prototype. Experience gained during the OGO III spacecraft tests indicated that the solar simulation portion of the subsystem test could be eliminated for the flight model expermients without loss of confidence in the design. In the new procedure, validation of the flight model thermal balance is achieved, instead, by calculating the solar stabilization temperatures using data from a "cold-wall design check" and comparing the results with the solar-simulation test previously performed on the prototype model. Analytical development and procedures for employing this simplified approach are discussed. Author

N68-29957*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

ANALYSIS AND MECHANIZATION OF THREE AND FOUR GIMBAL SYSTEMS

John W. Wilson Washington Aug. 1968 33 p refs

(NASA-TN-D-4689) CFSTI: HC$3.00/MF$0.65 CSCL 14B

An approximate algebraic technique which extends the usefulness of three-gimbal systems is presented. In analyzing the three gimbal problem, the Euler angles are explored about the singular points and are found to be, in general, non-unique. This non-uniqueness is eliminated by minimizing the magnitude of the discontinuities at the singular points. An approximate mathematical model of the inverse Euler angle problem is developed which chooses the solution with minimum discontinuity and, in addition, replaces high rates over large angles by small discontinuities. A computer circuit is devised for this model. A proposed four gimbal system is investigated and a mathematical model is derived by finding a necessary differential constraint on the fourth angle to maintain a nonsingular formulation. This constraint is then used to derive a particular mathematical formulation in an essentially algebraic form, from which a computer circuit is developed. The rate equations of the four angles are also derived. Existing four gimbal stable platforms are analyzed and discussed. Author

N68-30317*# National Aeronautics and Space Administration, Washington, D. C.

VENTURE INTO SPACE: EARLY YEARS OF GODDARD SPACE FLIGHT CENTER

Alfred Rosenthal 1968 369 p refs

(NASA-SP-4301) GPO: HC$2.50; CFSTI: MF$0.65 CSCL 14B

The historical origins and traditions of this NASA Center, named in honor of Dr. Robert H. Goddard, one of the pioneers in the theory of space exploration, are described in terms of early rocket research and the growing interest in rocket technology after World War 2. The contributions of Project Vanguard to the United States space effort are reviewed, and it is pointed out that the personnel from Vanguard and other NACA laboratories formed the nucleus of the scientific team at the Center, which was dedicated on March 16, 1961. Organizational growth is traced, and project assignments are defined. The development of the tracking, data acquisition, and data reduction facilities is discussed, and details are given on the Goddard-managed satellites and space probes, the boosters that placed these satellites into orbit, and the sounding rocket flights. Organization charts and reports of procurement actions are included. The history covers the period through 1963, which is considered to be the end of Act One of the Space Age. M.G.J.

N68-30598*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

WATER CONDENSATION EFFECTS OF HEATED VITIATED AIR ON FLOW IN A LARGE SUPERSONIC WIND TUNNEL

Robert W. Cubbison and Edward T. Meleason Aug. 1968 12 p

(NASA-TM-X-1636) CFSTI: HC$3.00/MF$0.65 CSCL 14B

Natural gas was burned directly in the air stream of the Lewis 10- by 10-foot supersonic wind tunnel to control stagnation temperature. The test section Mach number was varied from 2.0 to 3.5, and stagnation temperature was varied to a maximum of 1140°R (634 K). Condensation of water vapor in the nozzle caused a decrease in test section Mach number and total pressure which was repeatable and accurately calibrated. The uniformity of the flow in the test section was similar to that of the unheated air. Author

N68-31592*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

TEST SECTIONS FOR SMALL THEORETICAL WIND-TUNNEL-BOUNDARY INTERFERENCE ON V/STOL MODELS

Ray H. Wright Washington Aug. 1968 85 p refs

(NASA-TR-286) CFSTI: HC$3.00/MF$0.65 CSCL 14B

A wind-tunnel test section with closed upper wall, slotted side walls, and open lower boundary was found theoretically to produce zero tunnel-boundary lift interference on a small wing with horizontal wake mounted at the center of the test section. For this test section the variation of the interference with angle of the vortex wake behind a high-lift-coefficient model was not large. Because of the small slot widths required for zero interference and of the effects of boundary layer, the theory is regarded as unreliable for predicting the slot widths required; however, the variation of the interference with the slot width for widths somewhat greater than those needed for zero interference was found to be small. The interference in the region likely to be occupied by the tail of a model was investigated in some detail and was found to change with slot width and with wake angle more strongly than did the interference at the lifting element. A limited investigation of the lift interference in a test section with closed upper wall and slotted side and lower boundaries was made to obtain the theoretically indicated slot width required for zero lift interference at a center-mounted wing with the wake horizontal. Author

N68-33190*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

DESCRIPTION AND OPERATING PARAMETERS OF A MACH 2 NOZZLE SYSTEM FOR THE LANGLEY 11-INCH CERAMIC-HEATED TUNNEL

Kenneth Sutton Washington Sep. 1968 69 p refs

(NASA-TN-D-4750) CFSTI: HC$3.00/MF$0.65 CSCL 14B

A Mach 2 nozzle system has been developed to operate interchangeably with existing Mach 4 and Mach 6 systems previously available for high-temperature materials research tests with air were made to determine the operating parameters and to define the test environment. Of particular concern were the definition of stream total temperature decay with time and the damage to test specimens due to stream contamination. The diameters of the calibration models and probes were approximately three-fourths of the diameter of the nozzle exit. Results show that the Mach 2 system has a linear decrease of total temperature of approximately 200°R (110°K) in a test time of 600 seconds for the standard operating range of chamber pressure of 115 to 165 psia (0.79 to 1.14 MN/m^2). The total temperature range as measured was 2100°R to 4000°R (1170°K to 2220°K). The damage to a test model due to stream contamination from the ceramic bed can be neglected for a significant number of experimental materials. Also, the comparison in pressure, heating-rate, and shear distributions indicates the suitability of material response tests at the stagnation region of a model. The results demonstrate the applicability of the Mach 2 system for an experimental program. Author

N68-35466*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A DIGITAL COMPUTER PROGRAM FOR CALCULATING THE PERFORMANCE OF SINGLE OR MULTIPLE DIAPHRAGM SHOCK TUBES FOR ARBITRARY EQUILIBRIUM REAL GAS MIXTURES

William L. Grose, John E. Nealy, and Jane T. Kemper Washington Oct. 1968 59 p refs

(NASA-TN-D-4802) CFSTI: HC$3.00/MF$0.65 CSCL 14B

A computer program written in FORTRAN IV language is presented which determines the performance of a shock tube. For specified initial gas composition and charging conditions, the program output includes velocity, pressure, density, enthalpy, temperature, sound speed, and species mole fractions at any point in the shock tube cycle. Several representative calculations illustrate the utility of the program. The program is applicable to both simple and buffered shock tubes as well as to the expansion tube. Author

N68-36522*# Washington Univ., Seattle.

THE EFFECT OF THE CONVERGING FLOW FIELD OF A TANDEM TEST SECTION ON LONGITUDINAL STABILITY MEASUREMENTS

Shojiro Shindo and Robert G. Joppa Washington NASA Oct. 1968 27 p refs

(Grant NGR-48-002-010)

(NASA-CR-1198) CFSTI: HC$3.00/MF$0.65 CSCL 14B

Calculations of the internal flow in tandem-test-section wind tunnels have shown the presence of converging flow in the large test section portion between the two contracting sections. Results of analytical and experimental work in a test section having length to height ratio of 3 show that the magnitude of the converging flow and its effect on longitudinal stability of a rigid rotor can be closely predicted. Maximum model sizes and satisfactory testing regions can be identified analytically. A prediction is made for two model sizes tested in a tunnel having length to height ratio of 1. Author

N68-37259*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESIGN AND PRELIMINARY OPERATION OF THE LEWIS MAGNETOHYDRODYNAMIC GENERATOR FACILITY

Lester D. Nichols, James L. Morgan, Lawrence A. Nagy, Joseph M. Lamberti, and Robert A. Ellson Washington Oct. 1968 26 p refs

(NASA-TN-D-4867) CFSTI: HC$3.00/MF$0.65 CSCL 14B

The closed loop facility has been designed to study the feasibility of an argon–cesium MHD generator. The construction details, performance, and some preliminary research data are discussed. The facility has operated for several hours at the following conditions: argon flow rate, 1.8 kg/sec; Mach number, 0.3 to 0.5; stagnation temperature, 2100°K. Thus far, open circuit voltages equal to 60 percent of theoretical value (at 50 V) were measured. In addition short circuit currents up to 0.8 A (per electrode pair) were measured. This is in agreement with the calculated value using equilibrium conductivity. Leakage currents prevented better performance. Author

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FLUID MECHANICS

Includes boundary-layer flow; compressible flow; gas dynamics; hydrodynamics; and turbulence. For related information see also: 01 Aerodynamics; and 33 Thermodynamics and Combustion.

N68-10499*# Massachusetts Inst. of Tech., Cambridge.
A THREE-DIMENSIONAL HARD SPHERES THEORY OF SCATTERING OF GAS ATOMS FROM A SOLID SURFACE
Frank O. Goodman Washington NASA Nov. 1967 95 p refs
(Grant NGR-22-009-121)
(NASA-CR-933) CFSTI: HC$3.00/MF$0.65 CSCL 20D

A three-dimensional model of the interaction of monatomic gases with solid surfaces is described. The solid surface is represented by similar, non-interacting, hard spheres, the centers of which form initially a regular two-dimensional array; an incident gas atom is represented by a hard sphere incident on this array. Collisions between the gas atom and the surface atoms obey the ordinary laws of classical hard spheres. The closely-related problems of the detailed velocity distribution of the gas atoms reflected from the surface, the energy and momentum accommodation coefficients and the forces exerted on a target by a directed gas beam, are discussed and illustrated by means of a fairly comprehensive set of results. Author

N68-10646* Stanford Research Inst., Menlo Park, Calif.
IMPLOSIVELY ACCELERATED SHOCK TUBE DRIVER
Stephen P. Gill and Robert C. Goettelman Washington NASA Nov. 1967 66 p refs
(Contract NAS2-3129)
(NASA-CR-950) CFSTI: $3.00 CSCL 14B

The feasibility of using an implosive driver in a shock tube facility for research in high energy gasdynamics was investigated. Two implosive shock tube systems, one using a jetting driver and the other a jetless driver, were used to drive shock waves at velocities from 11 to 15 km/sec into dry air at initial pressures in the range 0.5 to 5 torr. The characteristics of the driver were investigated in a combined experimental and theoretical program, and the high energy gas flow behind the shock front was studied to determine experimentally its uniformity, purity, duration, and quality. It is concluded that the jetting driver, which consists of a cylinder of high explosive that progressively collapses a glass tube and projects a diffuse glass jet into the shock tube, can be of significant value as a shock tube driver for initial test gas pressures less than 1 torr. The diffuse glass jet is as effective as a perfect piston at these pressures, and a plane shock of nearly uniform velocity is driven into the test gas, followed by high energy flow of exceptional uniformity, quality, and purity. In addition, the test time grows at a rate nearly equal to that calculated for a perfect piston, and is insensitive to boundary layer phenomena. Author

N68-12892*# IIT Research Inst., Chicago, Ill.
EVALUATION OF TURBULENCE CORRELATIONS IN A COAXIAL FLOW OF DISSIMILAR FLUIDS
Antonio Montealegre, Gerard J. D'Souza, and Herbert Weinstein Washington NASA Jan. 1968 85 p refs
(Grant NsG-694)
(NASA-CR-961) CFSTI: HC$3.00/MF$0.65 CSCL 20D

A method of measuring fluctuations in velocity by means of a hot wire anemometer system has been developed and applied in a flow field where large concentration gradients exist. The flow field chosen is a coaxial flow of the two dissimilar fluids with a density ratio of 4:1. The fluid medium is air and the other fluid is Freon-12. The new method based on the use of an aspirating density probe in conjunction with the parallel wires, when applied to coaxial flow data, give values that are reasonably damped with respect to density fluctuations. Also, these correlations are found to be inapplicable in certain mean velocity ranges, i.e., at low and very high velocities. Results of calculations of velocity, density and fluctuations in velocity and density in coaxial flow of the air–freon system are presented and discussed. Author

N68-13612*# IIT Research Inst., Chicago, Ill.
MEASUREMENT OF TURBULENT CORRELATIONS IN A COAXIAL FLOW OF DISSIMILAR FLUIDS
Gerard J. D'Souza, Anthony Montealegre, and Herbert Weinstein Washington NASA Jan. 1968 60 p refs
(Grant NSG-694)
(NASA-CR-960) CFSTI: HC$3.00/MF$0.65 CSCL 20D

In this work axial turbulence intensities in a coaxial flow of dissimilar gases are presented. The system consisted of a circular freon 12 stream issuing into a faster and much larger air stream. The air–freon 12 density ratio is 1/4. The velocity ratios ranged from 40:1 to 5:1 with an absolute air velocity not exceeding 56.0 ft/sec. The magnitude of the axial turbulence intensities depends much on the velocity ratio of the streams. It is usually found to have a maximum value at some point between the centerline and the radius of the inner jet and then diminish to the free stream turbulence intensity. In the two cases of high air–freon velocity ratio a maximum turbulence intensity of 70% was obtained in the initial mixing region. Density fluctuations were also measured but these are shown to be damped by the measuring device. Values of the correlation between velocity and density fluctuations obtained are not valid and hence are not presented, as the damped density fluctuations affect this quantity considerably. A comparison is made between axial turbulence intensities for the heterogeneous case and those for the homogeneous case available in the literature. Author

N68-13619*# IIT Research Inst., Chicago, Ill.
ANALYTICAL INVESTIGATION OF THE MIXING OF TWO PARALLEL STREAMS OF DISSIMILAR FLUIDS
Richard L. Baker and Herbert Weinstein Washington NASA Jan. 1968 128 p refs
(Grant NsG-694)
(NASA-CR-956) CFSTI: HC$3.00/MF$0.65 CSCL 20D

The free jet mixing of parallel streams of different fluids is of fundamental importance and interest. The degree of mixing depends on the regime of flow in the mixing region, i.e., laminar or turbulent, and the velocity and density ratios. In this work, similarity solutions were obtained for laminar and turbulent mixing of two parallel incompressible streams. The solutions apply to both similar and dissimilar fluids in the two streams with any velocity or density ratio and arbitrary laminar or turbulent Schmidt numbers. A solution is numerical in nature and a set of solutions are presented in tabular form for a spectrum of density, velocity and Schmidt numbers. Author

N68-14641*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECTS OF WALL PRESSURE DISTRIBUTION AND LIQUID TEMPERATURE ON INCIPIENT CAVITATION OF FREON-114 AND WATER IN VENTURI FLOW
Royce D. Moore, Robert S. Ruggeri, and Thomas F. Gelder Washington Jan. 1968 25 p refs
(NASA-TN-D-4340) CFSTI: HC$3.00/MF$0.65 CSCL 20D

Incipient cavitation of Freon-114 (dichlorotetrafluoroethane) and of water was studied over a range of liquid temperatures in three different transparent venturis mounted in a small hydrodynamic tunnel. Flow velocity in the approach section of the venturis was varied from 18 to 65 feet per second (5.5 to 19.8 m/sec). The venturis were designed to provide systematic changes in wall pressure distribution. Circular arcs of differing radii provided transition from a 1.745-inch- (4.432-cm-) diameter approach section to a 1.375-inch- (3.492-cm-) diameter throat section. For Freon-114, the magnitude of thermodynamic effects of cavitation was significantly reduced for the milder pressure distributions and increased with liquid temperature. No thermodynamic effects of cavitation were observed for water over the temperature range studied. For both water and Freon-114, the incipient cavitation parameter was always less than the noncavitating minimum pressure coefficient, which indicated that the liquids locally experienced effective liquid tensions at the incipient condition. The magnitude of these tensions was strongly dependent on the wall pressure distribution and decreased with the milder pressure distribution. Author

N68-15329*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
VENTURI SCALING STUDIES ON THERMODYNAMIC EFFECTS OF DEVELOPED CAVITATION OF FREON-114
Royce D. Moore and Robert S. Ruggeri Washington Feb. 1968 30 p refs
(NASA-TN-D-4387) CFSTI: HC$3.00/MF$0.65 CSCL 20D

Well-developed cavitation of Freon-114 (dichlorotetrafluoroethane) was induced on the walls of a venturi in a recirculating hydrodynamic tunnel. The venturi, which had a throat diameter of 0.976 inch (2.48 cm), was a 0.7 scale of one previously tested. The approach velocity was varied from 20 to 50 feet per second (6.1 to 15.2 m/sec) at controlled liquid temperatures from 0° to 86°F (255.4° to 303.2°K). Pressures and temperatures were measured in the cavitated region and compared with the results of the 1.0-scale venturi. For geometrically similar cavities and fixed flow velocity, the measured cavity pressure and temperature depressions below free-stream values of vapor pressure and temperature were nearly the same for both the 0.7- and 1.0-scale venturis. Cavity pressure and temperature depression trends with liquid temperature and velocity were also similar in the 0.7-scale venturi as in the 1.0-scale venturi. A previously derived method for predicting the thermodynamic effects of cavitation is extended to include the effect of scale. Similarity parameters for developed cavitation were evaluated by using the minimum cavity pressure as a reference rather than the free-stream vapor pressure. The cavitation parameter was shown to be nearly the same value for both the 0.7- and 1.0-scaled venturis. Author

N68-15530*# IIT Research Inst., Chicago, Ill.
STABILITY OF SHEAR FLOW WITH DENSITY GRADIENT AND VISCOSITY
Richard L. Baker, Tzvi Rozenman, and Herbert Weinstein Washington NASA Feb. 1968 58 p refs
(Grant NsG-694)
(NASA-CR-958) CFSTI: HC$3.00/MF$0.65 CSCL 20D

The stability of the mixing region between co-flowing streams of different velocity and density has never been adequately investigated, because a general similarity solution for velocity and density profiles has not been available until recently. A solution method for the homogeneous case was extended to the heterogeneous case in an attempt to find a neutral stability curve for the more complex case. The extension was based on a similarity solution obtained by the authors. A branch line of the neutral stability curve was found but curves with non-zero amplification and damping factors fell on the same side of the neutral stability curves. Author

N68-15571*# IIT Research Inst., Chicago, Ill.
EXPERIMENTAL INVESTIGATION OF THE MIXING OF TWO PARALLEL STREAMS OF DISSIMILAR FLUIDS
Richard L. Baker and Herbert Weinstein Washington NASA Jan. 1968 102 p refs
(Grant NsG-694)
(NASA-CR-957) CFSTI: HC$3.00/MF$0.65 CSCL 20D

In this work, velocity and density profiles for both homogeneous and heterogeneous systems were obtained. The range of density ratios was 1:1 to 7:1. The velocity ratio range was 1:1 to 5:1. Turbulence intensities were also measured for the homogeneous case. The experimental method was based on hot wire anemometry. The data obtained agreed well with the analytical investigations in the literature. Author

N68-15639*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SCALE MODEL STUDY OF FLOW PATTERNS IN THE INLET MANIFOLD OF THE FUEL PUMP DRIVE TURBINE FOR THE M-1 HYDROGEN-OXYGEN ROCKET ENGINE
John F. Kline and Roy G. Stabe Washington Feb. 1968 11 p refs
(NASA-TM-X-1513) CFSTI: HC$3.00/MF$0.65 CSCL 21H

Flow conditions in the inlet manifold of the M-1 fuel pump-drive turbine were investigated using circumferential static pressure measurements in conjunction with smoke trace photographs. This manifold is toroidal with a single radial feedpipe. The study was prompted by reference tests which indicated a large variation in total pressure around the turbine nozzle which was attributed to manifold flow conditions. In addition, the possibility of flow asymmetry in the manifold was indicated by circumferential measurements of manifold static pressure. The results obtained from both the static pressure measurements and smoke flow traces indicated that the flow pattern within this manifold was essentially symmetrical about the feedpipe. The large observed circumferential variation in static pressure and associated flow patterns afforded a better understanding of reference nozzle exit total pressure patterns. Author

N68-16227*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DYNAMIC PRESSURE LIMITS FOR FLAT PLATES AS RELATED TO NUCLEAR FUEL ELEMENTS
Roger L. Smith Washington Feb. 1968 29 p refs
(NASA-TN-D-4417) CFSTI: HC$3.00/MF$0.65 CSCL 18J

Tests with air or helium flowing over single flat plates were performed at room temperature to determine the values of dynamic pressure required to cause plate failure. Failure was defined as a deflection greater than 0.010 inch (0.0254 mm). The ranges of the plate dimensions used are given. The plate materials selected were lead, aluminum, copper, and steel, which provide ranges of Young's modulus of elasticity from 2×10^6 to 30×10^6 psi (1.38×10^6 to 20.7×10^6 N/cm^2), and of Poisson's ratio from 0.288 to 0.42. Gas density varied from 0.025 to 1.0 pound per cubic foot (0.4 to 16 kg/m^3). The experimental results were compared with an existing theoretical analysis which predicts dynamic pressure for sudden, complete plate collapse. The experimental results agree with the theoretical prediction for the

effect of the material properties, but disagree with the prediction for the effect of the plate and flow-channel dimensions. The large amount of experimental data scatter and the disagreement of these data with the theoretical prediction may be caused by leading-edge effect, flutter, turbulence, or other unknown factors. Author

N68-16839*# National Aeronautics and Space Administration, Washington, D. C.
STUDIES IN PHYSICAL GAS DYNAMICS
A. S. Predvoditelev, ed. Feb. 1968 267 p refs Transl. into ENGLISH of the book "Issledovaniya po Fizicheskoy Gazodinamike" Moscow, Nauka Press, 1966
(NASA-TT-F-505) CFSTI: HC $3.00/MF $0.65 CSCL 20D

A collection of articles is presented on basic research in physical gas dynamics, with emphasis placed on molecular band spectra, shock tube studies, and interactions between diatomic molecules. For individual titles, see N68-16840 through N68-16867.

N68-16897*# IIT Research Inst., Chicago, Ill.
EXPERIMENTAL INVESTIGATION OF TURBULENCE IN THE MIXING REGION BETWEEN COAXIAL STREAMS
Thomas S. Zawacki and Herbert Weinstein Washington NASA Feb. 1968 145 p refs
(Grant NsG-694)
(NASA-CR-959) CFSTI: HC $3.00/MF $0.65 CSCL 20D

An experimental study is made of axially symmetric, turbulent, incompressible, coflowing streams. Hot wire anemometry techniques are used to make measurements in three systems, the homogeneous system with a resultant density ratio of 1, and two heterogeneous systems, one with an inner to outer stream density ratio of 4 to 1, and another with an inner to outer stream density ratio of 7 to 1. The outer stream velocity was varied from 12 to 50 ft/sec. and the inner stream was changed to provide outer stream to inner stream velocity ratios of from 1 to 40. Data is presented for the relative axial turbulence intensity, the relative radial turbulence intensity, and the turbulent shear stress for various velocity ratios in the homogeneous system, in both the initial mixing region and the downstream or similar region. The maximum relative turbulence intensity found was 0.40. For the 4 to 1 density case, data is presented for average velocity, the average density, and the relative velocity turbulence intensity for various velocity ratios in both the initial mixing region and the downstream or similar region. The maximum relative turbulence intensity found was 0.70. Average density and velocity profiles are presented for the 7 to 1 density ratio in the near and downstream regions. Author

N68-16998*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE STUDY OF ROTATING GAS JET GENERATOR FOR STRONG TRAVELING TRANSVERSE ACOUSTIC MODES
Marcus F. Heidmann Washington Feb. 1968 37 p refs
(NASA-TN-D-4380) CFSTI: HC $3.00/MF $0.65 CSCL 21E

An experimental investigation is made of a traveling transverse acoustic mode generator which utilizes a rotating gas jet as an energy source. The gas jet is radially alined and located at the center of a short cylindrical cavity with an exhaust port at the center of one end plate. Jet rotation is varied over a range of speeds encompassing the rotational speeds of several spinning transverse acoustic modes and pressure amplitudes are measured at the circumference of the cavity. The effect of jet total pressure, jet configuration, and cavity diameter on amplitude is investigated. Pressure amplitude as a function of rotational speed for a single radial jet exhibits several conditions of resonance. One occurs when jet speed corresponds to the resonant frequency of the first transverse mode. Higher modes occur at lower rotational speeds when more than one pressure oscillation is obtained for each rotation of the jet. For all modes and jet configurations, pressure amplitudes increase with an increase in jet total pressure and flow rate. Maximum peak-to-peak pressure amplitudes for all conditions was 38 psi (2.62×10^5 N/m^2) which corresponds to a sound pressure level of 192 decibels. The wave shape at all resonant conditions was symmetrical with time about the peak pressure and appeared free of shocks. The conversion efficiency of potential jet power to acoustic power was evaluated for all resonant conditions. In general, efficiency increased with an increase in jet total pressure. A maximum efficiency of 44% was observed with a divergent nozzle. Small diameter jets in a large diameter cavity generally gave highest efficiencies; however, the result depends on jet total pressure. Two radial jets gave improved efficiencies over a single jet in generating the second transverse mode. Efficiencies for the higher modes, however, were nearly an order of magnitude lower than for the first mode for each increase in mode number. Author

N68-17376*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
PRESSURE AND FLOW FIELD STUDY AT MACH NUMBER 8 OF FLOW SEPARATION ON A FLAT PLATE WITH DEFLECTED TRAILING EDGE FLAP
Charles B. Johnson Washington Mar. 1968 99 p refs
(NASA-TN-D-4308) CFSTI: HC $3.00/MF $0.65 CSCL 20D

An experimental investigation was made of the flow separation on a flat plate model with a short trailing-edge flap deflected at angles of 10°, 20°, and 30° relative to the plate surface. These tests were conducted at a nominal free-stream Mach number of 8 and the nominal free-stream unit Reynolds number per foot was varied from 0.22×10^6 to 10.9×10^6. Pressure measurements and schlieren studies were made for wall-to-total temperature ratios. Surface oil-flow studies were made at a wall-to-total temperature ratio of 0.43. Local similarity boundary-layer calculations were made upstream of the interaction region. Properties of the interaction and separated flow region were calculated with the boundary-layer–shock-wave interaction theory. Author

N68-17563*# National Aeronautics and Space Administration, Washington, D. C.
CALCULATION OF THE TURBULENT BOUNDARY LAYER AND OF TRANSITION ON A PLANE PLATE [ESSAI DE CALCUL DE LA COUCHE LIMITE TURBULENTE ET DE LA TRANSITION SUR UNE PLAQUE PLANE]
R. Hirsch Feb. 1968 191 p refs Transl. into ENGLISH from Publ. Sci. Tech. Min. Air (France), no. 393, 1963
(NASA-TT-F-520) CFSTI: HC $3.00/MF $0.65 CSCL 20D

Calculations of the turbulent boundary layer and transition on a plane plate are derived in detail, including the following: study of a solution of two Navier–Stokes equations inducing a stationary field analogous to the average turbulent field; existence of an asymptotic solution and determination of the development of friction; study of the effect of an exterior harmonic perturbation of wavelength λ. For a critical Reynolds number of 0.0037, the Blasius state is unable to exist and must be replaced by the newly developed state. The perturbations permitting such substitution and formed over the segment of $1/2\ R_c$ are derived, and the calculations are extrapolated to the compressible state with heat exchange. Comparisons of the results with practical experiments show agreement with the Blasius theory of the laminar regime. A possibility exists to maintain the laminar state by replacing the rigid wall with an elastic membrane whose tension would be made dependent on the pulsation of the exterior perturbation which ordinarily causes passage to the turbulent state. Author

N68-18146*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPUTER PROGRAM FOR CALCULATING ISOTHERMAL, TURBULENT JET MIXING OF TWO GASES

Leo F. Donovan and Carroll A. Todd Washington Mar. 1968 42 p refs

(NASA-TN-D-4378) CFSTI: HC $3.00/MF $0.65 CSCL 20D

This report describes a computer program for solving a simplified model of the turbulent mixing that occurs between a central fuel jet and a surrounding, faster-moving coaxial stream of propellant. As such, this report constitutes a step toward a better understanding of this aspect of the gas-core nuclear rocket. Local values of time-averaged velocity and the mass fraction of fuel can be calculated for a reactor in less isothermal a minute on the IBM 7094. The von Mises transformation was used to convert the axisymmetric forms of the isothermal boundary layer momentum and diffusion equations to forms amenable to numerical solution. The effects of confining walls were not considered. The program can solve problems in which the initial velocities and densities of the two streams differ greatly, by using expressions for eddy viscosity that vary radially as well as axially. The effects of initial coaxial-stream- to jet-velocity and density ratios on velocity and mass fraction profiles are shown. An unspecified reference density occurs in the eddy viscosity formulation; the influences on velocity and mass fraction profiles of several choices for the reference density are illustrated. Radial and axial variations of eddy viscosity and the product of density and eddy viscosity are also given. Estimates are made of the effects of initial velocity ratio and initial density ratio on the mass of the major jet component contained within a given volume. The maximum and minimum amounts that could be present are included for comparison. Author

N68-18253*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

PRESSURE AND HEAT TRANSFER ON BLUNT CURVED PLATES WITH CONCAVE AND CONVEX SURFACES IN HYPERSONIC FLOW

Davis H. Crawford Washington Mar. 1968 59 p refs

(NASA-TN-D-4367) CFSTI: HC $3.00/MF $0.65 CSCL 20M

Pressure and heat transfer have been measured in the presence of both favorable and adverse pressure gradients at Mach numbers of 6.8 and 9.6 and Reynolds numbers based on length from 0.5×10^6 to 3.0×10^6. The pressure data were represented by a power law relationship, and the empirical constants from this relationship were used to calculate the heat transfer by a simplified method. This method allows similar compressible solutions of the laminar boundary layer with pressure gradient to be directly applied without the use of integral or iterative methods. The results of these calculations are compared with the experimental values and with the calculated results from a more complex laminar similarity method requiring a machine program and iterative procedures. Differences between the two theoretical methods are shown to be slight for many applications. Applications where the simple method is less accurate are defined. Author

N68-18997*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

RESULTS OF INCLUDING A BOUNDARY SHOCK WAVE IN THE CALCULATION OF THE FLIGHT PARAMETERS OF A LARGE HIGH-SPEED METEOR

E. Dale Martin Washington Mar. 1968 58 p refs

(NASA-TN-D-4325) CFSTI: HC $3.00/MF $0.65 CSCL 20D

The results of including a boundary shock wave in the calculation of the flight parameters of a large high speed meteor with rapid vapor ablation are investigated. Calculations for the meteor use a data curve fitted graphically to the meteor tracking data. These calculations indicate that the proper range of conditions was present on the meteor for a significant portion of its trajectory, for a very thin strong boundary shock to occur at the meteor surface in the vapor, according to the boundary shock wave theory. Accounting for the effects of the boundary shock wave decreases the pressure drag, but the viscous-compressive drag is high, so the effective drag coefficient is unchanged by the boundary shock. Detailed calculations of the flow about a large high speed meteor would be greatly affected by the boundary shock effects, but overall gross values of the heating and motion parameters calculated by methods used recently by H. J. Allen and N. A. James are valid because of their use of appropriate assumed values of certain parameters. Author

N68-19000*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

FORCES AND MOMENTS PRODUCED BY AIR AND HELIUM JETS EXHAUSTING PARALLEL TO A FLAT PLATE IN A NEAR VACUUM

Joseph J. Janos and Sherwood Hoffman Washington Mar. 1968 40 p refs

(NASA-TN-D-4408) CFSTI: HC $3.00/MF $0.65 CSCL 20D

An investigation was conducted in the 41 foot vacuum sphere to determine the impingement forces, moments, and centers of pressure on a flat plate produced by small control type nozzles or jets discharging generally parallel to the plate in a near vacuum. The nozzles tested were conical, had approximately the same throat areas, utilized unheated gas, and had nominal exit Mach numbers of 1, 3, 5, and 7 for air, and 1, 3, and 7 for helium. The ratios of nozzle total pressure to ambient pressure varied from 15×10^6 to about 22×10^6; the ratios of nozzle exit pressure to ambient pressure varied from about 1.4×10^4 to 12×10^6 for the tests at a constant pressure altitude of 95 kilometers. Nozzle positions were varied longitudinally and vertically relative to the plate. Angle of incidence of the flat plate relative to the nozzle center line was varied between -2° and 10° for the air nozzles. The flat plate was detached from the nozzle and mounted on a balance to measure the impingement effects directly. Significant normal forces and moments were obtained and were found to be dependent on nozzle vertical position, longitudinal position, jet exit Mach number, jet flow turning angle, and angle of incidence of the plate. The largest normal force was equal to about 50% of the gross thrust of the Mach number 1 nozzle when located relatively close to the plate. The impingement forces decreased with increasing height or jet Mach number, and decreasing jet turning angle or angle of plate incidence. Helium jets produced lower impingement forces and moments than the corresponding air jets at comparable locations. Author

N68-19225*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL INVESTIGATION OF VAPOR INGESTION IN THE CENTAUR LIQUID HYDROGEN TANK

Raymond F. Lacovic and Andrew J. Stofan Washington Mar. 1968 16 p refs

(NASA-TM-X-1482) CFSTI: HC $3.00/MF $0.65 CSCL 20D

An investigation of vapor ingestion during liquid outflow was conducted in a 1/3.67 and 1/38 scale-model Centaur liquid hydrogen tank at the Lewis Research Center. The purpose of the investigation was to establish the height above the concave oblate ellipsoidal tank bottom at which vapor ingestion would occur for two tank outflow rates at various acceleration levels in order to define Centaur propellant residuals. Experimental values of the liquid height at which vapor ingestion occurs were obtained at normal gavity. A Froude number simulation was then used to relate the normal gravity experimental data to other acceleration levels. The experimental values were correlated with an analytical expression based on Bernoulli's equations. The analytical expression correlated well with the experimental values over the entire range of tank outflow rates. Author

N68-19246*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SIMILARITY SOLUTION FOR TURBULENT MIXING BETWEEN A JET AND A FASTER MOVING COAXIAL STREAM

Leo F. Donovan Washington Mar. 1968 27 p refs

(NASA-TN-D-4441) CFSTI: HC $3.00/MF $0.65 CSCL 20D

An analysis of turbulent mixing of a jet with a faster moving coaxial stream is presented, and a similarity solution is obtained for large initial ratios of coaxial-stream velocity to jet velocity. The analysis is compared with experimental data, and the velocity profiles at different axial positions are shown to be similar. Centerline velocities follow the predicted behavior reasonably well except for the smallest experimental velocity ratio; half-radii, an indication of the amount of jet spreading, vary as expected after a certain axial distance. The shear-stress distributions are not similar, even at the largest axial positions for which data are available. In addition, the similarity solution is extended to include constant-density mass transfer or heat transfer. Author

N68-19340*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MODEL FOR FREQUENCY RESPONSE OF A FORCED FLOW, HOLLOW, SINGLE-TUBE BOILER

Eugene A. Krejsa Washington Mar. 1968 29 p refs

(NASA-TM-X-1528) CFSTI: HC $3.00/MF $0.65 CSCL 20D

A simple model is given for the frequency response of boiler inlet pressure to inlet flow. The boiler analyzed is a forced flow, single tube, shell and tube boiler with no inserts. The model yields a simple description of the boiler dynamic characteristics. The characteristics included in the model are boiler pressure drop, time required for the liquid temperature to reach saturation temperature, inertia of the liquid in the subcooled region, and mass storage due to the movement of the boundary between the subcooled and two-phase regions. The model is compared with experimental boiler frequency response data. The boiling fluid was Freon-113, which was heated by counterflowing hot water. The boiler exit quality ranged from 12 to 63 percent. Good agreement between the model and the data was obtained for qualities ranging from 23 to 63 percent. Author

N68-19709*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EVALUATION OF BOUNDARY LAYER AND WAKE SURVEY DATA REDUCTION TECHNIQUES IN COMPRESSIBLE FLOWS

K. R. Czarnecki and Russell B. Sorrells, III Washington Apr. 1968 32 p refs

(NASA-TN-D-4401) CFSTI: HC $3.00/MF $0.65 CSCL 20D

The analytical study was limited to turbulent boundary layers with no heat transfer and to a Mach number range from 0 to 10. The experimental portion of the investigation was confined to zero-heat-transfer turbulent-wake surveys made behind a swept wing at free-stream Mach numbers of 1.61 and 2.01. Results of the analytical boundary-layer calculations indicate that if simplified data-reduction techniques that neglect the deviation of the local Mach number from the average free-stream or normalizing value are utilized, sizable differences in momentum, displacement, and velocity thicknesses are incurred over much of the Mach number range for relatively small deviations in the local-flow characteristics or parameters. In general, use of the free-stream Mach number as a base both for determining velocity defects due to skin friction and for normalizing the thickness parameters, will introduce larger differences than use of local Mach number as the base for both items and interpretation of results as being obtained under stream conditions. Experimental wake data indicate that because of increased wake widths and reduced viscous heating or compressibility effects in comparison with boundary layers of equal momentum deficiency, the use of the free-stream-flow technique generally results in proportionately larger differences in wake-data reduction. Author

N68-20352*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AN EXPERIMENTAL INVESTIGATION OF THE EFFECT OF GRAVITY ON A FORCED CIRCULATION PATTERN IN SPHERICAL TANKS

Steven G. Berenyi, Ralph C. Nussle, and Kaleel L. Abdalla Washington Apr. 1968 25 p refs

(NASA-TN-D-4409) CFSTI: HC $3.00/MF $0.65 CSCL 20D

An experimental investigation of the effect of gravity on a forced circulation pattern in spherical tanks was conducted. The tank systems tested were exposed to acceleration levels of approximately 0.005, 0.01, 0.02, 1.0, and less than 10^{-5} g. The flow pattern of an axisymmetric wall jet was experimentally established in three different size tanks. The results indicate that the minimum jet inlet velocity required to establish and maintain the flow pattern is a function of jet inlet thickness, tank radius, and gravity level. Author

N68-21365*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AN EXPERIMENTAL STUDY OF LIQUID FLOW INTO A BAFFLED SPHERICAL TANK DURING WEIGHTLESSNESS

Charles R. Andracchio and Kaleel L. Abdalla Washington Apr. 1968 23 p refs

(NASA-TM-X-1526) CFSTI: HC $3.00/MF $0.65 CSCL 20D

Liquid flow into a baffled spherical tank during weightlessness was investigated. A sphere within a sphere configuration was tested using a partially wetting liquid and a totally wetting liquid while varying the percent initial filling in the tank. Both liquids can be pumped into the tank over a range of velocities which maintains the liquid-vapor interface in a stable orientation; the maximum value of these velocities is a function of initial liquid filling in the tank. A baffled tank allowed higher stable filling rates than an unbaffled tank; similarly, the partially wetting liquid allowed higher stable filling rates than the totally wetting liquid. The use of a deflector mounted on the baffle improved the stable filling rate of the totally wetting liquid at low initial fillings. Author

N68-21724*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

VISCOSITY OF GAS MIXTURES

Richard S. Brokaw Washington Apr. 1968 27 p refs

(NASA-TN-D-4496) CFSTI: HC $3.00/MF $0.65 CSCL 20D

An approximate method is developed for predicting the viscosities of mixtures involving both nonpolar and polar gases. For nonpolar mixtures, only the viscosities and molecular weights of the constituents are required, in addition to the mixture composition. With polar gases, dipole moments, boiling points, and boiling-point densities are also needed. The method is tested by comparison with experimental data on 25 gas pairs comprising 280 mixtures. The average error is 0.7 percent; the maximum error is 3.7 percent. (Errors may be much larger if this method is used for gas mixtures involving ions, free radicals, or valence-unsaturated atoms.) Author

N68-22087*# Tracor, Inc., Rockville, Md.

AN ANALYTICAL STUDY OF THE MEASURED WALL PRESSURE FIELD UNDER SUPERSONIC TURBULENT BOUNDARY LAYERS

Thomas J. Black Washington NASA Apr. 1968 167 p refs

(Contract NAS1-6952)

(NASA-CR-888; TRACOR-RL/67-070-U) CFSTI: HC $3.00/MF $0.65 CSCL 20D

This report presents the results of a short analytical study of the turbulent wall pressure field under supersonic shear layers.

The study is based on a theory of wall turbulence which asserts that the turbulent transfer of mass, heat, momentum and energy within the boundary layer are essentially effected within discrete, horseshoe-vortex structures which are generated and maintained by powerful, localized non-linear instabilities within the sublayer and which move downstream over the wall in a characteristic, quasi-frozen, spatial array. In particular, the theory explains the generation of turbulent shear stress in terms of the dynamic interaction between these vortex systems and the basic shear flow through which they move. On the basis of this theory, new scaling laws are proposed for the turbulent wall pressure field under subsonic and supersonic layers. These laws feature quite different scaling parameters for the high and low frequency portions of the spectra and indicate the effect of pressure gradient on the spectra. Author

N68-22200*# United Aircraft Corp., East Hartford, Conn.
EXPERIMENTAL INVESTIGATION OF CONTAINMENT IN CONSTANT-TEMPERATURE RADIAL-INFLOW VORTEXES
John S. Kendall Washington NASA May 1968 49 p refs
(Contract NASw-847)
(NASA-CR-1029; F-910091-15) CFSTI: HC $3.00/MF $0.65 CSCL 20D

An experimental investigation was conducted to determine the containment characteristics of radial-inflow vortexes for potential application to a vortex-stabilized nuclear light bulb engine. Tests were conducted using 10-in.-dia by 30-in.-long vortex tubes. Air used to simulate the buffer gas was injected through ports in the peripheral walls of the vortex tubes. Iodine mixed with one of four other gases (helium, nitrogen, sulfur hexafluoride or a heavy fluorocarbon, FC-77) was used to simulate the gaseous nuclear fuel. The amount and radial distribution of simulated fuel contained in the vortex were determined using an axial light beam absorption technique. The effects on containment of changes in the following were investigated: (1) the geometry of the simulated-fuel injection configurations, (2) the number of thru-flow ports used, (3) the radial Reynolds number (a measure of the amount of flow withdrawn through the thru-flow ports) and the corresponding amount of bypass flow, and (4) the molecular weight of the simulated fuel. Author

N68-23353*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CAPILLARY RISE IN THE ANNULAR REGION OF CONCENTRIC CYLINDERS DURING COAST PERIODS OF ATLAS CENTAUR FLIGHTS
Raymond F. Lacovic and James A. Berns Washington May 1968 14 p refs
(NASA-TM-X-1558) CFSTI: HC $3.00/MF $0.65 CSCL 20D

The Centaur space vehicle liquid oxygen and liquid hydrogen tanks each contain a mass sensing system which utilizes flow through a helical inlet tube into a probe consisting of two concentric cylinders. During the coast periods of the Atlas-Centaur flights, each mass sensing system acted as a capillary system under low gravity conditions. Data for the capillary rise height in the annular region of concentric cylinders as a function of time were obtained from the flights of three Atlas-Centaurs at acceleration levels of approximately 7.0×10^{-3} and 4.2×10^{-4}g with durations of up to 100 and 1341 seconds, respectively. The capillary rise data were correlated with an analytical expression which accurately described the fluid flow through the sensing system under low gravity conditions. Author

N68-23423*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECTS OF HIGH-WAVE AMPLITUDE AND MEAN FLOW ON A HELMHOLTZ RESONATOR
Bert Phillips Washington May 1968 21 p refs
(NASA-TM-X-1582) CFSTI: HC $3.00/MF $0.65 CSCL 21H

An experimental investigation was conducted to determine the effects of mean flow and high-wave amplitude on the impedance of a Helmholtz resonator. The oscillatory phase and pressure relations across the aperture of a resonator were measured and converted into values of acoustic resistance and reactance. The results indicate that (1) the aperture effective length in a rocket-engine environment should be considered approximately equal to the aperture thickness and (2) the acoustic resistance at high-wave amplitude can be considered to be a turbulent jet loss. Author

N68-23482*# Douglas Aircraft Co., Santa Monica, Calif.
NARROW BAND CROSS-CORRELATION ANALYSIS OF FLUCTUATING PRESSURES BENEATH A TURBULENT BOUNDARY LAYER
C. M. Ailman and A. S. Hopkins Washington NASA May 1968 83 p refs
(Contract NAS1-6901)
(NASA-CR-1066; DAC-60874) CFSTI: HC $3.00/MF $0.65 CSCL 20D

Selected narrow-band cross-correlations were calculated for pressure fluctuations at a rigid wall under both a uniform and a disturbed turbulent boundary layer at supersonic speeds. Flow disturbances resulted from: (1) a forward-facing step-spoiler, (2) an aft-facing step (with a well-behaved, slowly growing turbulent boundary layer prior to the step); and (3) an impinging (and reflected) shock generated by an obstruction to the airstream some distance from the wall. The data are presented in terms of contours of equal correlation coefficient, spatial decays of the correlation, and convection velocities. Author

N68-24129*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RAREFIED-GAS COUETTE FLOW AND HEAT TRANSFER BETWEEN PARALLEL PLATES BY MODEL SAMPLING
Morris Perlmutter Washington May 1968 44 p refs
(NASA-TN-D-4579) CFSTI: HC $3.00/MF $0.65 CSCL 20D

A rarefied gas with hard sphere molecules enclosed between parallel walls is analyzed for the case of couette flow and heat transfer by a model sampling procedure. In one case, both walls are stationary and at different temperatures. In the other case, the upper wall is moving in a direction parallel to the lower wall and both walls are at the same temperature. The wall accommodation factor is taken as unity. The target molecule velocity distribution is presumed to be the sum of two different half-Maxwellians. The parameters describing the half-Maxwellians are assumed constant over a given zone. By scoring the properties of sample molecules as they pass scoring positions, the macroscopic quantities, of interest are obtained. The problem is iterated until these values agree with the assumed distribution values. Author

N68-24758*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECTS OF LIQUID DEPTH ON LATERAL SLOSHING UNDER WEIGHTLESS CONDITIONS
Jack A. Salzman, Thom A. Coney, and William J. Masica Washington May 1968 18 p refs
(NASA-TN-D-4458) CFSTI: HC $3.00/MF $0.65 CSCL 20D

As a part of the general study of liquid behavior in weightlessness, an experimental drop-tower investigation was conducted to determine the effects of shallow liquid depths on lateral sloshing in a zero Bond number environment. Contact angles were restricted to very near 0°, so that the sloshing equilibrium interface was hemispherical. Cylindrical tanks were tested with both hemispherical and flat bottoms. Natural frequency data were correlated as a function of normalized liquid depth for both tank bottom shapes, and damping data were compared with predictions from high Bond number theory. Author

N68-25866*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LIQUID INFLOW TO INITIALLY EMPTY, HEMISPHERICAL ENDED CYLINDERS DURING WEIGHTLESSNESS
Eugene P. Symons, Ralph C. Nussle, and Kaleel L. Abdalla Washington Jun. 1968 16 p refs
(NASA-TN-D-4628) CFSTI: HC $3.00/MF $0.65 CSCL 20D

An experimental investigation was conducted in a weightless environment during which liquid was pumped into hemispherical ended cylinders which were initially void of liquid. During inflow, two distinct types of liquid-vapor interfaces were observed; a stable interface and an unstable interface. The stability of the liquid-vapor interface was correlated by a Weber number based on inlet line radius and inlet velocity. Results indicate that above a Weber number of 1.3, the interface became unstable. Furthermore, this filling process was independent of the radii of the experiment tanks (2 to 4 cm). No gross effects due to the viscosity of the test liquid were observed. Author

N68-26651*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DETAILED PERFORMANCE OF A RADIAL-BLADED CENTRIFUGAL PUMP IMPELLER IN WATER
Max J. Miller and Richard F. Soltis Washington Jun. 1968 52 p refs
(NASA-TN-D-4613) CFSTI: HC $3.00/MF $0.65 CSCL 20D

Shrouded and unshrouded versions of a 7.44-in.-(18.89-cm-) diameter, radial-bladed centrifugal pump impeller were tested in room-temperature water. Detailed measurements permitted the calculations of both circumferential and spanwise distributions of flow and performance parameters over a wide range of flows. Primary emphasis is on essentially noncavitating flow conditions, although a limited amount of performance data obtained under cavitating flow conditions is presented. Author

N68-28282*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
LOCAL AFTERBODY HEAT TRANSFER TO A BLUNT TWO-DIMENSIONAL CONFIGURATION AT MACH 8
Dennis M. Bushnell (M.S. Thesis—Va. Univ.) Washington Jul. 1968 50 p refs
(NASA-TN-D-4443) CFSTI: HC $3.00/MF $0.65 CSCL 01A

Local heat-transfer rates and pressures were measured on a blunt two-dimensional configuration the afterbody of which was subjected to an extensive region of separated flow. The investigation was conducted at a free-stream Mach number of 8 and at free-stream Reynolds numbers based on the model face width of 2 inches (5.08 cm) from 1.27×10^5 to 7.55×10^5. The predictions from two theories were compared with the heat-transfer data obtained in the afterbody region. One of these theories was a constant-pressure integral method utilizing profiles from similar solutions for enthalpy and velocity distributions. The other theory was a local flat-plate method in which the velocity and enthalpy conditions obtained from the integral method in the reverse-flow region were used as effective free-stream quantities. Both theories were in reasonable agreement with the general level of the data. The integral method predicted the correct trend in the vicinity of the separation point, whereas the flat-plate method gave the correct trend over the aft portion of the afterbody. Author

N68-28364*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MAXIMUM DROP DIAMETERS FOR THE ATOMIZATION OF LIQUID JETS INJECTED CONCURRENTLY INTO ACCELERATING OR DECELERATING GAS STREAMS
Robert D. Ingebo Washington Jul. 1968 26 p refs
(NASA-TN-D-4640) CFSTI: HC $3.00/MF $0.65 CSCL 20D

The determining effect of six dimensionless groups on the maximum drop-diameter was studied for the atomization of jets of ethanol or water injected into nitrogen or helium gas streams cocurrently or into still air. Values of the ratio of orifice diameter to maximum drop-diameter D_o/D_m were obtained from photomicrographs of the sprays and related to dimensionless groups. Liquid-injection velocities covered a range of nearly 0 to 6250 cm/sec. Gas-stream velocities were varied from the still-air condition to helium-gas velocities of 14,000 cm/sec. Gas-stream accelerations ranged from 833,000 to 19,200,000 cm/sec^2, and decelerations of 672,000 to 4,880,000 cm/sec^2. Author

N68-28370*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PHOTOGRAPHIC STUDY OF A BROMINE JET IN A COAXIAL AIRSTREAM
Maynard F. Taylor and Charles C. Masser Washington Jul. 1968 19 p refs
(NASA-TN-D-4660) CFSTI: HC $3.00/MF $0.65 CSCL 20D

Photographs were taken of a bromine jet issuing into a coaxially flowing airstream. The bromine jet appeared laminar for jet velocities below 1.5 m/sec and airstream velocities below 2.1 m/sec. If either the jet or stream velocity exceeded the aforementioned velocity the bromine jet appeared nonlaminar. These velocities can be expressed as nondimensional parameters, jet Reynolds number and stream- to jet-velocity ratio. In terms of these parameters, the jet will have a laminar appearance if both the jet Reynolds number is less than about 2400 and the product of the stream- to jet-velocity ratio and the Reynolds number is less than about 3400. The investigation covered only the region from the injection point to five jet radii downstream. Author

N68-28801*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
WIND-TUNNEL CALIBRATION OF A 40° CONICAL PRESSURE PROBE AT MACH NUMBERS FROM 3.5 TO 7.4
Frank W. Burcham, Jr. Washington Jul. 1968 26 p refs
(NASA-TN-D-4678) CFSTI: HC $3.00/MF $0.65 CSCL 01A

A wind-tunnel calibration of a 40° included-angle flow-field cone probe was made over a Mach number range of 3.5 to 7.4. The cone probe was designed and fabricated to obtain flow-field data on the X-15 airplane. Estimated accuracy of the calibration was ±2 percent in Mach number and ±0.2° in flow angularity at a Mach number of 7.4. Reynolds number effects were negligible over the test range of 0.65 million to 3.25 million per foot (0.20 million to 1.0 million per meter). A rake designed for flight on the X-15 was used to mount two cone probes. Slightly different calibrations resulted for the two cones because of differences in the cone afterbody configurations. Author

N68-28842*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
VISUAL OBSERVATIONS OF FLOW THROUGH A RADIAL-BLADED CENTRIFUGAL IMPELLER
Richard F. Soltis and Max J. Miller Washington Jul. 1968 26 p refs
(NASA-TN-D-4282) CFSTI: HC $3.00/MF $0.65 CSCL 20D

A 7.44-inch-(18.89-cm-) diameter radial-bladed centrifugal impeller designed by the stream-filament technique was operated in water over a range of flow conditions. Flow through the blade passages was visualized by observing the movement of nylon tufts glued to the impeller and by injecting dye into fluid at the pump inlet. Photographs and film sequences of the tufts and dye in the rotating passages are presented. A comparison of visual observations is also made with the measured performance results and with the flow conditions within the blade passages as calculated from an analytical procedure. Author

N68-31593*# Stevens Inst. of Tech., Hoboken, N. J.
HYDRODYNAMICS OF AIRCRAFT TIRE HYDROPLANING
S. Tsakonas, C. J. Henry, and W. R. Jacobs Washington NASA Aug. 1968 46 p refs

(Contract NSR-31-003-016)
(NASA-CR-1125; REPT.-1238) CFSTI: HC $3.00/MF $0.65 CSCL 01B

An approximate theory has been developed for a study of the hydroplaning tire by considering it as a planing surface of small aspect ratio in extremely shallow water. The results of this approximation exhibit hydrodynamic behavior similar to that of hydroplaning pneumatic tires and thus indicate that the tire hydroplaning phenomenon can be described from the standpoint of inviscid hydrodynamics. The analysis furnishes families of curves which can be considered to represent, qualitatively, the start of hydroplaning and thus give qualitative guidance for avoiding the undesirable hydroplaning condition. Author

N68-31960*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NONCAVITATING AND CAVITATING PERFORMANCE OF TWO LOW-AREA-RATIO WATER JET PUMPS WITH THROAT LENGTHS OF 5.66 DIAMETERS
Nelson L. Sanger Washington Aug. 1968 34 p refs
(NASA-TN-D-4759) CFSTI: HC$3.00/MF$0.65 CSCL 13K

Performance of two jet pumps was determined over a range of spacings of the nozzle exit from the throat entrance of 0 to 2.9 throat diameters. Maximum measured efficiencies of 31.3 and 37.6 percent were achieved for nozzle- to throat-area ratios of 0.066 and 0.197, respectively. These efficiencies were improvements over those obtained for previously investigated jet pumps with throat lengths of 7.25 diameters. A simple one-dimensional analysis predicted noncavitating performance within 2 percent at the best-efficiency conditions. The point of total headrise deterioration due to cavitation was predicted with reasonable accuracy by each of two related parameters. Author

N68-32982*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
STUDY OF OPTICAL RADIATION IN THE WAVELENGTH REGIONS OF 0.4216 μ, 0.4278 μ, 0.4825 μ, AND 0.5165 μ BEHIND NORMAL SHOCK WAVES IN A SIMULATED MARTIAN ATMOSPHERE
Anthony P. Modica (Avco Corp.), Harry B. Dyner (Avco Corp.), and James O. Arnold Washington Aug. 1968 10 p refs
(NASA-TM-X-1634) CFSTI: HC$3.00/MF$0.65 CSCL 20D

Shock-tube measurements of equilibrium and nonequilibrium radiation in a 50-percent CO_2–50-percent N_2 gas mixture are analyzed and compared to theoretical estimates and other measurements. The ratio of the integrated radiation from the nonequilibrium zone behind the normal shock wave to the equilibrium radiation from an equal volume of gas is of particular interest. The measurements show no appreciable differences in nonequilibrium enhancement from four different spectral regions. Author

N68-33054*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
DRAG DUE TO TWO-DIMENSIONAL SURFACE ROUGHNESS IN A TURBULENT BOUNDARY LAYER AT MACH 3 WITH AND WITHOUT HEAT TRANSFER
William J. Monta, K. R. Czarnecki, and William D. Deveikis Washington Sep. 1968 41 p refs
(NASA-TN-D-4746) CFSTI: HC$3.00/MF$0.65 CSCL 20D

An investigation was conducted on an ogive-cylinder model to determine the effect of heat transfer on the drag due to two fabrication roughness shapes (steps with grooves and circular arc waves) at Reynolds numbers from 36×10^6 to 195×10^6. The results indicate only a slight effect of heat transfer and Reynolds number upon the roughness drag for the two configurations of the investigation. The zero heat transfer data are in good agreement with previously published results. The step roughness drag is correlated on the basis of a step-height Reynolds number and is in good agreement with both existing data and an existing prediction method based on effective dynamic pressure. For the wave-shaped wall, a nondimensional drag parameter was found to be a function of the ratio of roughness height to boundary layer thickness for a constant value of the roughness thickness ratio h/l. At the lower values of h/l, the parameter is a unique function of the ratio of roughness cycle length to boundary layer thickness. Author

N68-33056*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
FINITE AMPLITUDE WAVES IN FLUID-FILLED ELASTIC TUBES: WAVE DISTORTION, SHOCK WAVES, AND KOROTKOFF SOUNDS
Richard M. Beam Washington Sep. 1968 52 p refs
(NASA-TN-D-4803) CFSTI: HC$3.00/MF$0.65 CSCL 20D

The Lagrangian form of the one-dimensional equations of motion for a fluid-filled elastic tube is developed. The resulting nonlinear equations are combined with a general nonlinear internal pressure cross sectional area relation for the tube to obtain the finite amplitude wave equation. After determination of the tube pressure–area relation which leads to a linear wave equation, a solution for the general wave equation is presented. The solution is applicable for simple waves in tubes with general pressure–area relations. The solution is then used to develop criteria for the steepening and nonsteepening of finite amplitude waves. The theory is further developed to include the calculation of wave distortion. The criterion for a sharp wave is derived and the critical length of tube required for a sharp wave to develop is determined. The propagation of the resulting sharp wave or shock wave is considered. The velocity and the energy loss formulas for the shock wave are developed. Finally, the analysis and experimental results are used to support new hypotheses for the mechanism and source of the Korotkoff sounds which have a major role in the indirect determination of blood pressure. Author

N68-33165*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LIQUID DROPS: NUMERICAL AND ASYMPTOTIC SOLUTIONS OF THEIR SHAPES
Kenneth J. Baumeister and Thomas D. Hamill Washington Sep. 1968 34 p refs
(NASA-TN-D-4779) CFSTI: HC$3.00/MF$0.65 CSCL 20D

The shapes of liquid drops resting on flat surfaces were determined by a Runge-Kutta solution of the Laplace capillary equation. A characteristic length equal to the square root of surface tension divided by the product of density and gravity was used to nondimensionalize the numerical results. In addition, asymptotic solutions for small and large drops were combined to give explicit expressions for the maximum drop height and radius. These correlations apply for the complete range of liquid volumes and contact angles. Author

N68-33642*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LAMINARIZATION OF A TURBULENT BOUNDARY LAYER AS OBSERVED FROM HEAT-TRANSFER AND BOUNDARY LAYER MEASUREMENTS IN CONICAL NOZZLES
Donald R. Boldman, James F. Schmidt, and Anne K. Gallagher Washington Sep. 1968 34 p refs
(NASA-TN-D-4788) CFSTI: HC$3.00/MF$0.65 CSCL 20D

Heat transfer measurements were obtained in 30° and 60° half-angle of convergence nozzles at a nominal stagnation temperature of 970°R (539 K) and over a range of stagnation pressures of 2.0 to 20.4 atmospheres (2.03×10^5 to 20.67×10^5 N/m^2). These conditions provided nozzle throat Reynolds numbers based on diameter of about 6.0×10^5 to 5.0×10^6. Boundary layer time-mean velocity and temperature measurements were obtained at one station in a water cooled pipe inlet and at a subsonic (Mach number ≤0.08) station in each nozzle at stagnation pressures of 3.1 and 20.4 atmospheres (3.14×10^5 and 20.67×10^5 N/m^2). The heat transfer and boundary layer surveys suggested the occurrence of laminarization of an initially turbulent boundary layer. Author

N68-34089*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECTS OF BOUNDARY LAYER BUILDUP IN SHOCK TUBES UPON CHEMICAL RATE MEASUREMENTS
Marvin Warshay Washington Sep. 1968 18 p refs
(NASA-TN-D-4795) CFSTI: HC$3.00/MF$0.65 CSCL 20D

A theory by Mirels was employed to investigate the effects of boundary layer buildup in shock tubes upon dissociation rate measurements. A comparison was made of bromine dissociation rate constant which were obtained assuming no boundary layer buildup to those obtained when boundary layer was taken into account. Mirels' wholly turbulent boundary layer case was used in the latter calculations. At low temperatures (1264°K), where reaction rates are low, the measured rate constant increased significantly; at high temperatures (1827°K), where rates are high, the effect was negligible. In quantitative terms, the activation energy decreased from 31.5 to 30.0 kilocalories (1.32×10^5 to 1.26×10^5 j). Author

N68-35086*# Southwest Research Inst., San Antonio, Tex.
FLOW-INDUCED VIBRATIONS OF A FLAT PLATE SUSPENDED IN A NARROW CHANNEL Final Report
Franklin T. Dodge and Arthur F. Muller Washington NASA Sep. 1968 62 p refs
(Contract NAS1-6714)
(NASA-CR-1186) CFSTI: HC$3.00/MF$0.65 CSCL 18I

Elastically restrained plates in narrow flow channels can vibrate excessively when the flow rate past them reaches some critical value. Because of the importance of this phenomenon in nuclear reactor design, an analytical study of such vibrations has been conducted. The theory is based upon the one-dimensional, hydraulic flow assumption and includes viscous pressure drops and energy losses at channel contractions and expansions. Since the vibrating plate influences the hydrodynamic loading and vice versa, the unknown flow velocity and plate vibration freuqency are coupled and must be determined simultaneously. The results of the calculations for several typical flow situations show that the flow velocity necessary to induce vibrations decreases as the channel height-to-plate length ratio decreases; this is in substantial agreement with previous potential flow calculations although not with experimental data. Author

N68-35096*# Princeton Univ., N. J.
A METHOD OF CALCULATING COMPRESSIBLE TURBULENT BOUNDARY LAYERS
H. James Herring and George L. Mellor Washington NASA Sep. 1968 112 p refs
(Grant NGR-31-001-074)
(NASA-CR-1144) CFSTI: HC$3.00/MF$0.65 CSCL 20D

The essential unknown quantity in a compressible turbulent boundary layer is shown to be the kinematic Reynolds stress, as in incompressible flow, and does not explicitly involve density fluctuations. Based on this, the incompressible turbulent viscosity proposed by Mellor is extended to include compressible flows. The same values of the three empirical constants, which were obtained solely from constant-property, constant-pressure experiments, are also used. Without making any further assumptions beyond those related to the usual time averaged boundary layer equations, this system of equations has been programmed for numerical solution. Solutions have been compared to a considerable amount of constant-pressure data in the range from subsonic flows to flows with Mach numbers around 5.0 and the comparisons are quite favorable. Much less pressure gradient data are available but comparison was made to some axisymmetric flow data taken in a positive pressure gradient which indicated fairly good prediction of the boundary layer growth, while at the same time pointing up a systematic error in the detailed profile shape prediction in regions of finite longitudinal curvature. Author

N68-35104*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF OUTFLOW RESIDUALS IN INTERCONNECTED SPHERICAL TANKS
Harold J. Kasper and Robert J. Boyle Washington Sep. 1968 36 p refs
(NASA-TN-D-4828) CFSTI: HC$3.00/MF$0.65 CSCL 21H

An analysis is presented for predicting the propellant distribution during outflow of multiple-interconnected spherical tanks for possible space vehicle application. Analytical and experimental data are presented for four spherical tanks using water as the working fluid. The effects on final liquid residuals were determined for tanks that: (1) did or did not utilize crossflow lines between tanks for liquid level equilibration, (2) were initially equally or unequally loaded, and (3) had equal or unequal length outflow lines. The analysis adequately predicted the experimental residuals as well as the point at which crossflow lines ceased to be effective equilibration flow paths. Author

N68-35114*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LIQUID REORIENTATION IN SPHERES BY MEANS OF LOW-G ACCELERATIONS
Thomas L. Labus and William J. Masica Washington Oct. 1968 32 p refs
(NASA-TM-X-1659) CFSTI: HC$3.00/MF$0.65 CSCL 20D

An experimental drop-tower investigation of liquid reorientation in spherical containers was conducted from two initial interface conditions. One initial condition was a centrally located vapor bubble (the interface configuration in a zero-Bond-number environment). A second initial condition was an essentially flat interface (the configuration in a relatively high-Bond-number environment). Liquid reorientation was observed to be axisymmetric under both initial conditions. Qualitative observations of the gross effects of percent liquid volume and acceleration on the reorientation process are presented. Also included are graphic profiles of the liquid-vapor interface at selected times during the reorientation process. Author

N68-35117*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EQUILIBRIUM NORMAL-SHOCK AND STAGNATION-POINT PROPERTIES OF HELIUM FOR INCIDENT-SHOCK MACH NUMBERS FROM 1 TO 30
Walter B. Olstad, Jane T. Kemper, and Roger D. Bengtson Washington Sep. 1968 51 p refs
(NASA-TN-D-4754) CFSTI: HC$3.00/MF$0.65 CSCL 20M

Charts are presented of the thermodynamic properties of helium, including the effects of ionization and particle interactions, for temperatures to 100,000°K and pressures from 10^{-7} to 10^4 atmospheres. The properties behind the incident, standing, and reflected shocks and at the in-flight and shock-tube stagnation conditions are also presented for incident-shock Mach numbers from 1 to 30 and quiescent gas pressure from 10^{-7} to 1 atmosphere. Author

N68-35252*# Illinois Univ., Urbana.
DRAG ASSOCIATED WITH SEPARATED FLOW OVER TWO-DIMENSIONAL V-SHAPED NOTCHES UNDER TRANSONIC AND SUPERSONIC CONDITIONS
Ronald H. Howell and Helmut H. Korst Washington NASA Sep. 1968 87 p refs
(Grant NsG-13)
(NASA-CR-1132) CFSTI: HC$3.00/MF$0.65 CSCL 01A

The wall geometry was limited to two-dimensional symmetric notches defined by specifying the length and angle of the notch. For any given notch geometry the free stream Mach number was the primary variable while the viscous effects, specified by the boundary layer momentum thickness and the length Reynolds number, were secondary variables. The Mach number ranged from 0.5 to 1.2 and at 2 , while the approaching boundary layer was

always turbulent and reasonably well representative of fully developed shear layers along adiabatic flat plates with the momentum thickness Reynolds number from 7500 to 15000. To cover a wide range of boundary layer momentum thickness-to-notch-depth ratios, experiments were carried out with notches of various lengths and notch angles. Schlieren observations, pressure distributions, and direct drag force measurements were used in studying the viscid-inviscid flow phenomena controlling the drag of notches and the redevelopment of the boundary layer downstream of the disturbance. Author

N68-35823*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LIQUID VAPOR INTERFACE CONFIGURATIONS IN TOROIDAL TANKS DURING WEIGHTLESSNESS

Eugene P. Symons and Kaleel L. Abdalla Washington Oct. 1968 13 p refs

(NASA-TN-D-4819) CFSTI: HC$3.00/MF$0.65 CSCL 20D

An experimental investigation was conducted in the Lewis Research Center drop tower facility to study the isothermal liquid-vapor interface configuration in a toroidal tank during weightlessness for a 0°-static-contact-angle liquid. Results are presented for a range of liquid volumes in tanks normally positioned horizontally and also for tanks mounted at angles to the gravity field prior to the weightless test. The angle tests simulated the effect of nonaxial maneuvers on the initial position of the liquid-vapor interface before entering weightlessness. Three basic interface configurations were observed and were shown to be dependent on tank mounting angle and liquid volume and to be independent of tank size. Author

N68-36071*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

DETAILED DESCRIPTION AND RESULTS OF A METHOD FOR COMPUTING MEAN AND FLUCTUATING QUANTITIES IN TURBULENT BOUNDARY LAYERS

Ivan E. Beckwith and Dennis M. Bushnell Washington Oct. 1968 118 p refs

(NASA-TN-D-4815) CFSTI: HC$3.00/MF$0.65 CSCL 20D

The conservation equations for mass, mean momentum, and turbulent kinetic energy for the incompressible turbulent boundary layer have been solved by an implicit finite-difference procedure. Mathematical models developed by Glushko for the production, dissipation, and diffusion of the turbulent kinetic energy in the flat plate turbulent boundary layer have been modified and used to calculate a nonequilibrium turbulent boundary layer subjected initially to a large adverse pressure gradient followed by a run of constant pressure. Comparisons of both mean and fluctuating flow properties have indicated generally good agreement between the calculated results and experimental measurements of Goldberg. The best overall agreement with data was obtained by reducing the scale of turbulence in the outer part of the boundary layer to about 70 percent of the flat plate values as used by Glushko. The calculations have indicated that further simple modifications to the turbulence scale function and to some of the mathematical models for the turbulence correlation terms should improve the accuracy of predictions for the Goldberg data. The authors have shown that the predictions in good agreement with data were obtained for other arbitrary pressure distributions. Author

N68-36343*# IIT Research Inst., Chicago, Ill.

ANALYTICAL INVESTIGATION OF INCOMPRESSIBLE TURBULENT SWIRLING FLOW IN PIPES

Avelino P. Rochino and Zalman Lavan Washington NASA Sep. 1968 137 p refs

(Grant NsG-694)

(NASA-CR-1169) CFSTI: HC$3.00/MF$0.65 CSCL 20D

Turbulent swirling flows in ducts were investigated analytically using mixing length theories. The governing equations for the mean flow were derived using Taylor's modified vorticity transport theory and the concept of isotropy of the transport coefficients. The similarity theory of von Karman was extended to swirling flows in a cylindrical geometry considering a three-dimensional fluctuating velocity field. The resulting similarity conditions were used to formulate the expression for eddy diffusivity in the entire flow field except for a small region near the pipe wall where a mixing length expression analogous to that assumed by Prandtl for parallel flow in channels was used. The tangential equation of motion was then solved numerically to study the decay of angular momentum in a swirling flow field inside a stationary pipe. It is pointed out that for pure rotational as well as irrotational flow, some of the similarity conditions become indeterminate suggesting that the said formulation may not be valid for these situations. Author

N68-36458*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

LOW-DENSITY, LEADING-EDGE BLUNTNESS, AND ABLATION EFFECTS ON WEDGE-INDUCED LAMINAR BOUNDARY LAYER SEPARATION AT MODERATE ENTHALPIES IN HYPERSONIC FLOW

C. L. W. Edwards and John B. Anders Washington Oct. 1968 31 p refs

(NASA-TN-D-4829) CFSTI: HC$3.00/MF$0.65 CSCL 20D

A study of real gas wedge induced laminar boundary layer separation has been made. The investigation was conducted in low-density air on a highly cooled flat-plate model with interchangeable leading edges and various trailing edge flap angles. All tests were conducted in the Langley 1-foot hypersonic arc tunnel at a nominal free stream Mach number of 12, free stream unit Reynolds numbers from 1.1×10^4 to 2.7×10^4 per foot (3.6×10^4 to 8.9×10^4 per meter), and dimensionless stagnation enthalpies from 39.0 to 72.4. The extent of separation was found to increase with increasing leading edge bluntness at these test conditions. Significant low density effects are shown to delay the onset of separation in comparison with what would be expected from predictions by a strong interaction theory. The direct effect of mass addition on the extent of separation through ablative leading edges was found to be negligible; however, an indirect effect on the extent of separation due to leading edge regression was found to be significant. Author

N68-37067*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

STUDIES OF FLOW DISTORTION IN THE TAILPIPES OF HYDROGEN PEROXIDE GAS GENERATORS USED FOR JET ENGINE SIMULATION

Leland B. Salters, Jr. and Nicholas C. Chamales Washington Oct. 1968 51 p refs

(NASA-TM-X-1671) CFSTI: HC$3.00/MF$0.65 CSCL 21E

An investigation was made of the effect of variation in configuration of hydrogen peroxide decomposition engines on the jet exhaust flow characteristics. Sixteen configurations of hydrogen peroxide decomposition engines were tested under static conditions over a jet exit total pressure to static pressure ratio range from 1.2 to 4.6 using hydrogen peroxide of approximately 90.5 percent concentration. Jet exit total pressure flow distortion was found to vary inversely with the contraction ratio of the tailpipe. The propellant distribution plate and catalyst bed retainer plate designs also influenced exhaust flow patterns. Flow straightener plates were effective in reducing flow distortion in the jet exhaust. Author

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GEOPHYSICS

Includes aeronomy; upper and lower atmosphere studies; oceanography; cartography; and geodesy. For related information see also: 20 Meteorology; 29 Space Radiation; and 30 Space Sciences.

N68-10079*# Israel Program for Scientific Translations, Ltd., Jerusalem.
ELECTRICITY OF THE FREE ATMOSPHERE
I. M. Imyanitov and E. V. Chubarina 1967 216 p refs Transl. *into ENGLISH of the publ. "Elektrichestvo Svobodnoi Atmosfery"* Leningrad, Gidrometeorol. Izd., 1965 Published for NASA and NSF
(NASA-TT-F-425; TT-67-51374) CFSTI: HC $3.00/MF $0.65 CSCL 04A

A general picture of the electric structure of the atmosphere on cloudy and cloudless days, based on data obtained in systematic aircraft soundings of the atmosphere's electric field, is presented. Detailed tables of the initial data are included as well as data on the structure of the fair weather electric field, on the distribution of electric space charges and potentials in these conditions, and on the electric structure of stratus clouds. The data were gathered during the International Geophysical Year and the Year of *International Geophysical Collaboration.* R.N.A.

N68-10283*# Little (Arthur D.), Inc., Cambridge, Mass.
THE APPLICATION OF HIGH TEMPERATURE RADIATIVE THERMAL CONDUCTIVITY OF MINERALS AND ROCKS TO A MODEL OF LUNAR VOLCANISM
Washington, NASA Nov. 1967 73 p refs
(Contract NAS9-5840)
(NASA-CR-916) CFSTI: HC $3.00/MF $0.65 CSCL 08G

At the relatively high temperatures that probably exist deep in the lunar interior, heat flow takes place by both lattice conduction *and radiative transfer. The radiative transfer which should be* dominant at the higher temperatures is caused by a process of repeated emission and re-absorption of radiation modified by the effect of scattering by discontinuities such as inclusions or grain boundaries. The rate of emission depends on the blackbody spectral distribution at the temperature of the medium and on the optical constants n and k of the medium which are, in general, strong functions of the wavelength. The rate of re-absorption also depends on n and k. The scattering depends on the size and spatial distribution of the discontinuities in n and k. Author

N68-10369*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
TEMPORAL VARIATIONS OF MESOSPHERIC OXYGEN AND OZONE DURING AURORAL EVENTS
Kaichi Maeda and A. C. Aikin Washington, NASA, Nov. 1967 36 p refs
(NASA-TN-D-3993) CFSTI: HC $3.00/MF $0.65 CSCL 04A

Temporal solutions are given for the photochemical equations describing the distribution of ozone and atomic oxygen in an oxygen atmosphere for the equatorial and polar regions. Similar *calculations are applied to auroral events. These calculations indicate* a strong dependence of the distribution of mesospheric atomic oxygen on the intensity and energy spectrum of auroral electrons that dissociate molecular oxygen. It is shown that there can be no significant atmospheric ozone and atomic oxygen modifications due to soft spectrum electron events which appear to characterize most bright auroras. The hard spectrum auroral electrons which *appear in most weak, quiet auroras should cause significant increases* in the atomic oxygen and ozone concentrations below 80 km, provided that their flux is more than 10^6 per cm^2 sec. Author

N68-11714* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
GEOLOGIC APPLICATIONS OF ORBITAL PHOTOGRAPHY
Paul D. Lowman, Jr. Washington Dec. 1967 42 p refs
(NASA-TN-D-4155) CFSTI: HC $3.00 CSCL 08G

The potential geologic applications of orbital photography (photography of the surface of the earth or similar bodies from orbiting spacecraft) with illustrations from various Gemini flights are summarized. Advantages of orbital over conventional aerial photography include: large area per photograph, *rapid coverage,* rapid repetition of coverage, world-wide coverage (subject to orbital parameters), absence of restrictions on dissemination of American *photographs, availability of color at small* added cost, and a wide range of scales. The major limitations of orbital photography include: restriction by orbital characteristics (inclination to equator, *apogee, and perigee),* the generally high global cloud cover, daylight restrictions, atmospheric scattering, resolution limit inherent in extremely small scales, loss of resolution and color fidelity in oblique photos, site acquisition, and degradation of film by radiation and other space environmental conditions. Three major geologic uses of orbital photography can be predicted: regional geologic mapping, monitoring of variable properties and geological education. Author

N68-18902*# National Aeronautics and Space Administration, Washington, D. C.
POTENTIAL APPLICATIONS OF SATELLITE GEODETIC TECHNIQUES TO GEOSCIENCES
1968 26 p
(NASA-SP-158) GPO: HC $0.15; CFSTI: MF $0.65 CSCL 08E

The possible applications of the techniques and capabilities of satellite geodesy to support other areas of science are assessed. Attention is centered on the nonmapping applications and the need for precise geometric and gravitational information to which the techniques of satellite geodesy can be applied. Some possible *applications to the sciences of solid earth geophysics and geology,* oceanography, glaciology, atmospheric sciences, technology, and space operations are summarized according to the physical quantities to be measured. The accuracies required to obtain useful information as well as the extent and frequency of coverage required are indicated. The applications are categorized according to those which can be accomplished with presently achievable accuracies; those which require an increase in accuracy with which ground stations can be located by using present satellite geodetic techniques, or an increase in the accuracy with which a satellite can be located in space at any given instant; and those requiring as yet untried instrumentation. M.G.J.

N68-20278*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SCALAR AND COMPONENT WIND CORRELATIONS BETWEEN ALTITUDE LEVELS FOR CAPE KENNEDY, FLORIDA, AND SANTA MONICA, CALIFORNIA
Glenn E. Daniels and Orvel E. Smith Washington Apr. 1968 118 p refs
(NASA-TN-D-3815) CFSTI: HC$3.00/MF$0.65 CSCL 04A

The analysis of large quantities of atmospheric data for use in space vehicle design studies requires the application of statistical methods. An envelope of means or any given percentile derived from a sample of winds taken at discrete altitudes is not necessarily a mean profile and may not define a physically attainable wind profile. Coefficients of correlations with means and standard deviations may be used in a statistical model to derive realistic wind profiles. The statistics presented in this report are based on rawinsonde wind data samples for Cape Kennedy, Florida, and Santa Monica, California, which are greatly improved samples over those previously available. These samples represent an improvement in that they are from a more recent observational period with fewer missing measurements than earlier records and because the data have been carefully edited, checked, and serially completed for missing data. Author

N68-21543*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE GEOMAGNETIC SECULAR VARIATION 1900–1965
Joseph C. Cain and Shirley J. Hendricks Washington Apr. 1968 224 p refs Presented at the Intern. Union of Geodesy and Geophys. 14th Gen. Assembly, St. Gall, Switzerland, 30 Sep. 1967
(NASA-TN-D-4527) CFSTI: HC$3.00/MF$0.65 CSCL 04A

The GSFC (12/66) model of the main geomagnetic field uses linear and parabolic terms in time, to represent secular change over the interval 1900–1965. The predicted field is compared with observatory annual means to investigate systematic residuals. Deviations of the order of 100_{γ} occur for short spans of years and only in limited regions. Otherwise, the trends of the computed field parallel the observations. Secular-change charts agree well with those drawn by earlier analyses. The westward drift is generally apparent in the vector representation of the harmonic coefficients, except that a few terms predominantly undergo an amplitude change. The components below (g_6^6, h_6^6) that show a recognizable estward drift are the (3,2), (5,1), and (5,2) terms. Both dipole poles move smoothly northwestward over the interval, whereas the dipole position initially drifts eastward, reverses direction near 1920, and then moves westward at a rate up to about 0.07 degrees per year. Its 1965 position is found to be 78.8°N, 7.0°W. Author

N68-21904*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PHASE AND GROUP REFRACTIVE INDICES FROM THE COLLISIONLESS MAGNETOIONIC THEORY
Lawrence Colin, Kwok-Long Chan, and Jack G. K. Lee (Informatics, Inc.) Washington Apr. 1968 130 p refs
(NASA-TM-X-1553) CFSTI: $3.00 CSCL 04A

Graphs of phase and group refractive indices computed from the collisionless magnetoionic theory are presented. The indices are computed for both the entire range of electron concentration and the intensity of the earth's magnetic field to be encountered by operational topside ionospheric sounders in the International Satellites for Ionospheric Studies (ISIS) series (Alouette I, Explorer XX, Alouette II, ISIS-A, ISIS-B). Author

N68-22462*# Scientific Translation Service, La Canada, Calif.
SCATTERING OF LIGHT IN A TURBID MEDIUM
K. S. Shifrin Washington NASA Apr. 1968 217 p refs Transl. into ENGLISH of the book "Rasseyaniye Sveta v Mutnoy Srede" Moscow, Gosgeoltekhizdat., 1951 p 1–212
(Contract NASw-1496)
(NASA-TT-F-477) CFSTI: $3.00 CSCL 04A

Presented is a systematic discussion of the theory of scattering and absorption of plane electromagnetic waves by particles of a turbid medium. Considered in the discussion are the following: linear dimensions of the particles, their electrical characteristics, and a general formulation of the problem of perturbation introduced by a particle into a field; fundamental formulas; partial waves; small particles; large particles; absorbing and fully reflecting particles having any dimensions; and particles with electrical properties deviating slightly from the surrounding medium properties. S.C.W.

N68-22861*# National Aeronautics and Space Administration. Goddard Inst. for Space Studies, N. Y.
RADIATIVE EQUILIBRIUM IN AN ATMOSPHERE WITH CONSTANT EINSTEIN ABSORPTION COEFFICIENT
Rupert Wildt and Sandra Schwartz Washington May 1968 51 p refs
(NASA-TN-D-4479) CFSTI: HC$3.00/MF$0.65 CSCL 04A

In the classical gray atmosphere, the phenomenological coefficient of absorption that enters into Kirchhoff's law is assumed to be independent of the frequency ($\kappa_{\nu}=\text{const}=\kappa^{-}$). Strictly considered, this coefficient is the product obtained by multiplying the Einstein coefficient of true absorption by a frequency-dependent correction for induced emission (Rosseland factor). The alternative here examined is to set the Einstein coefficient constant, incorporate the effects of induced emission into the transfer formalism, and determine the march of the local thermodynamic equilibrium source function by numerical iteration. This second kind of gray atmosphere differs markedly from the classical one in respect to many physical characteristics and represents, in conventional terminology, the simplest nongray problem that is physically realistic. Author

N68-23436*# Massachusetts Inst. of Tech., Cambridge.
CORRECTION OF BALLOON X-RAY ASTRONOMY DATA FOR THE EFFECTS OF ATMOSPHERIC ATTENUATION, K X-RAY ESCAPE, AND ENERGY RESOLUTION
James W. Overbeck Washington NASA May 1968 30 p refs (Grant NsG-386)
(NASA-CR-1045) CFSTI: HC$3.00/MF$0.65 CSCL 04A

An X-ray flux from outside the atmosphere determines the counting rate of an X-ray detector beneath several g/cm^2 of atmosphere, but a unique inverse relationship does not exist. Therefore X-ray astronomy data analysis requires the computer simulation of the processes which transform assumed X-ray energy spectra into detectors' counting rates. The programs used by the author, E. Allen Womack, Jr., and Harvey D. Tananbaum are presented and are applied to a specific example. A set of conventions for presenting one's results as an X-ray spectrum above the atmosphere is also explained. Author

N68-23706*# North American Aviation, Inc., Downey, Calif.
EARTHQUAKE PREDICTION FROM LASER SURVEYING
R. A. Fowler Washington NASA 1968 37 p refs Prepared for NASA
(NASA-SP-5042) GPO: HC$0.35 CFSTI: MF$0.65 CSCL 08K

A geodetic laser survey system is described that overcomes the uncertainty introduced by atmospheric fluctuations affecting the refractive index value; and the resultant variations in the velocity of the electromagnetic waves that ordinarily cause distortions in distance measurements are considered. Applications of such systems to earthquake prediction and engineering research, geodetic problems, dam construction, and space research are described. Probability maps and laser survey technology development are discussed in relation to earthquake prediction; and passive versus active systems as well as the limitations of existing systems are considered for precise measuring of long distances. The theory for atmospheric refractive index corrections using dispersion techniques is considered, along with the mathematical models required for making the necessary calculations. M.W.R.

N68-25579*# Bendix Corp., Ann Arbor, Mich. Aerospace Systems Div.

STUDY OF MINERAL STABILITY IN THE LUNAR ENVIRONMENT Final Report

Washington, D. C. NASA Jun. 1968 285 p refs

(Contract NAS9-3734)

(NASA-CR-1034; BSR-2022) CFSTI: HC $3.00/MF $0.65 CSCL 08G

Stability of selected earth minerals in simulated lunar environments were investigated through laboratory experiments. Analyses of the reactions of the minerals to exposure of vacuum and thermal environments and their chemical and structural stability when exposed to spacecraft and earth environments were studied. Short term experiments included validation of mineral identification of 14 minerals, and provision of insight into reactions expected and standards for comparison with results obtained from the long term experiments. Long term testing involved a single temperature cycle at simulated lunar vacuum environment, X-ray photographs of each sample at various stages of the temperature cycle, a four day simulation of spacecraft environment, and a two day exposure to earth environment. It was noted that the change in environment, even over a short time interval, was sufficient to cause major changes in some phases, and that predicted equilibrium stability relations should be the overriding factor in determining the phase occurring on the lunar surface. A.L.

N68-28222*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

THE RADIATION BALANCE OF THE EARTH-ATMOSPHERE SYSTEM FROM RADIATION MEASUREMENTS OF THE NIMBUS 2 METEOROLOGICAL SATELLITE

Ehrhard Raschke Washington Jul. 1968 81 p refs

(NASA-TN-D-4589) CFSTI: HC $3.00/MF $0.65 CSCL 04A

Measurements of the reflected solar radiation and emitted infrared radiation were obtained over the entire globe from the Nimbus II meteorological satellite during the period from 16 May 1966 to 28 July 1966. From these measurements, the outgoing long-wave radiation flux, the albedo, and the radiation balance of the earth-atmosphere system were computed for five subperiods, each of a half month's length. The global albedo was found to be between 29 and 31 percent, which is less than earlier accepted values of 33 percent and more. The globally emitted long-wave radiation flux results in an equivalent black-body temperature of the planet earth of about 255°K, which is 3–4 degrees higher than was found in earlier studies. The global averages of the radiation balance obtained were between 0.002 cal cm^{-2} min^{-1} of surplus and 0.007 cal cm^{-2} min^{-1} deficit. Author

N68-28872*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

REMOTE DETECTION OF TERRAIN FEATURES FROM NIMBUS 1 HIGH RESOLUTION INFRARED RADIOMETER NIGHTTIME MEASUREMENTS

Jean Pouquet Washington Jul. 1968 12 p refs Sponsored in part by NAS-NRC

(NASA-TN-D-4603) CFSTI: HC $3.00/MF $0.65 CSCL 08B

Brightness temperature analyses were made from nighttime Nimbus high resolution infrared data in the 3.5–4.2μ region. Data for the northeast Sahara Desert and the Nile delta regions, obtained during September 1964, were selected. The brightness temperatures were found very useful because they detect: (1) the widespread humidity in the upper soil horizons, and (2) the heat storage capacity in various rock formations such as sands and alluvial deposits. Author

N68-33416*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

ATMOSPHERIC CONDITIONS ASSOCIATED WITH TURBULENCE ENCOUNTERED BY THE XB-70 AIRPLANE ABOVE 40,000 FEET ALTITUDE

L. J. Ehernberger Washington Sep. 1968 49 p refs

(NASA-TN-D-4768) CFSTI: HC $3.00/MF $0.65 CSCL 04B

High-altitude atmospheric turbulence has been encountered by the XB-70 airplane during flight test over the Western United States. The encounters from 36 flights were analyzed for the meteorological features associated with high-altitude turbulence. This study used data from an NACA VGH recorder carried on the airplane and from rawinsonde observations made near turbulence encounters at altitudes above 40,000 feet (12,200 meters). These data showed that turbulence of significant intensity at high altitudes is related to wind velocity, vertical wind shear, and the vertical temperature gradient. It is also indicated that the disturbances causing high-altitude turbulence can originate in both the lower atmosphere and the stratosphere. Author

N68-35151*# Teledyne Industries, Inc., Garland, Tex.

SEISMIC EFFECTS OF SONIC BOOMS

Tom T. Goforth and John A. McDonald Washington NASA Sep. 1968 130 p refs

(Contract NAS1-6342)

(NASA-CR-1137) CFSTI: HC $3.00/MF $0.65 CSCL 08K

Earth particle velocities produced by sonic booms were recorded at Edwards Air Force Base, California, the Tonto Forest Seismological Observatory near Payson, Arizona, and the Uinta Basin Seismological Observatory near Vernal, Utah. Analysis of the field data indicates that the seismic effects of sonic booms are largely confined, laterally, to the boom pressure envelope and vertically to the upper few meters of the earth's surface. The maximum particle velocity associated with a sonic boom is in response to the rapid pressure changes of the leading and trailing edges of the acoustic N-wave. Comparison of peak particle velocities recorded at Edwards Air Force Base show good agreement with theoretically-predicted values. Empirical relations developed from the recorded data indicate that peak particle velocity is linearly related to the maximum positive overpressure of the N-wave. On hard, well-consolidated rock, each pound per square foot of overpressure produces about 75 microns per second peak particle velocity. On more loosely-consolidated rock, each pound per square foot of overpressure produces about 100 microns per second peak particle velocity. Author

N68-35179*# National Aeronautics and Space Administration, Washington, D. C.

ON THE COMPUTATION OF SOLAR ELEVATION ANGLES AND THE DETERMINATION OF SUNRISE AND SUNSET TIMES

Harold M. Woolf (Natl. Meteorol. Center) Sep. 1968 23 p refs Prepared for NASA by the Natl. Meteorol. Center

(NASA-TM-X-1646) CFSTI: HC $3.00/MF $0.65 CSCL 04A

The complete procedure for precise computation of solar elevation angle as a function of latitude, longitude, data, and time is given. Construction of a graphical aid for determining times of sunrise and sunset, with a precision of one minute, as functions of latitude, longitude, date, and altitude is described. Author

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INSTRUMENTATION AND PHOTOGRAPHY

Includes design, installation, and testing of instrumentation systems; gyroscopes; measuring instruments and gages; recorders; transducers; aerial photography; and telescopes and cameras.

N68-10057*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
A USEFUL MODIFICATION OF THE WRIGHT SPIROMETER
James Roman and Robert N. Sato Washington NASA Nov. 1967 13 p ref
(NASA-TN-D-4234) CFSTI: HC$3.00/MF$0.65 CSCL 14B

The Wright spirometer is a gas flowmeter for physiological use which is small and reliable. However, data collected with this device must be reduced manually, and the calibration curve is nonlinear at low flow values. The instrument was modified by fitting the output shaft with a spoked wheel that interrupts the light beam between a low-power light source and a photonsensor. This modification provides a digital electrical output that can be computer-reduced, permitting correction of the data for the nonlinearity of the calibration curve. The power drain is 96 milliwatts, which is small enough to be drawn from the battery supplies of most self-contained miniature tape recorders. Author

N68-10647* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE APPLICATIONS TECHNOLOGY SATELLITE IMAGE DISSECTOR CAMERA EXPERIMENT
G. A. Branchflower, R. H. Foote, and D. Figgins Washington NASA Nov. 1967 15 p
(NASA-TN-D-4186) CFSTI: $3.00 CSCL 14E

The image dissector camera experiment, which is scheduled to fly aboard the Applications Technology Satellite-C, is described. Camera system parameters are presented and a description of system operation, including the clock synchronizer and timing and control logic, is given. Ground support equipment is also discussed. Author

N68-11867*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
SENSITIVITY OF QUARTZ, PIEZOELECTRIC PRESSURE TRANSDUCERS AS A FUNCTION OF TEMPERATURE FROM 20° TO 477°K
Lloyd W. Canfil and William C. Nieberding Washington Dec. 1967 9 p refs
(NASA-TM-X-1479) CFSTI: HC$3.00/MF$0.65 CSCL 14B

Quasi-static calibrations were performed to determine the sensitivity of quartz, piezoelectric type, pressure transducers in the temperature range of 20° to 477°K. Results were obtained which show that the sensitivity at 20°K differs from the sensitivity at room temperature by 4 percent maximum. The corresponding difference at 477°K is 9 percent. The change in room temperature sensitivity due to each temperature excursion was negligible. The conclusion is reached that this type of transducer is particularly applicable to dynamic pressure measurement at cryogenic temperatures. Author

N68-12669*# National Research Corp., Cambridge, Mass.
STUDY OF DENSITY CALIBRATION IN SPACE Final Report, Jun. 29, 1966–Jan. 16, 1967
P. Fowler and F. J. Brock Washington NASA Dec. 1967 46 p refs
(Contract NAS5-3959)
(NASA-CR-987) CFSTI: HC$3.00/MF$0.65 CSCL 14B

Methods of calibrating ion gauges and mass spectrometers were studied to determine a method for in-flight calibration of detectors installed on spacecraft. The method developed consists of diffusing a known hydrogen flux through the wall of a small diffuser tube into the detector enclosure which produces a pressure increment equal to the ratio of hydrogen flux to exhaust conductance, by raising the temperature of the tube with an internal heater which dissipates a prescribed power for a prescribed time interval. Three successive generations of prototype in-flight calibrators were designed and constructed and evaluated. The results indicate that the diffuser generates a hydrogen flux which is linear over a dynamic range of 3×10^5, that calibration pulse heights are repeatable within ±2.0% and that pulse height variation can be maintained less than 1.0% for 30 seconds. The data indicate that the pressure decay rate, associated with the diffuser, following a calibration pulse is such that after 15 minutes the pressure is no more than several percent of the external pressure if the calibration pulse is no more than an order of magnitude above the external pressure, except for pressures less than 10^{-9} Torr, which require a longer recovery time. Author

N68-13973*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
DUCTILITY MECHANISMS AND SUPERPLASTICITY IN CHROMIUM ALLOYS
Joseph R. Stephens and William D. Klopp Washington Jan. 1968 32 p refs
(NASA-TN-D-4346) CFSTI: HC$3.00/MF$0.65 CSCL 11F

Alloys with lower ductile-to-brittle transition temperatures than that of unalloyed chromium (≈300°F or 422°K) included chromium −35 to 40 atom percent rhenium, chromium −15 to 24 atom percent ruthenium, chromium—30 atom percent cobalt, and chromium—30 to 50 atom percent iron. Equilibrium diagrams have two features in common, an intermediate σ phase, and a high maximum solubility of solute in chromium. The following observations were made on alloys with compositions approaching the solubility limit in the chromium–rhenium, chromium–ruthenium, and chromium–cobalt systems and the σ composition in the chromium–iron system: ductile-to-brittle transition temperature decreased significantly; grain size increased sharply with increasing solute content after annealing at a constant temperature; hardness decreased substantially; and initial deformation was primarily by twinning. The ductile-to-brittle transition temperatures of near saturated alloys can be related to the fractional difference in specific volume between the σ phase and the respective chromium-base solid solution. Chromium—30 atom percent cobalt and chromium—24 atom percent ruthenium alloys were tensile tested at elevated temperatures and exhibited superplasticity. Observation suggests the rhenium ductilizing effect and superplasticity may have common basic features. Author

N68-13974*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
FLIGHT EVALUATION OF AN ELECTROSTATIC ACCELEROMETER FOR MEASUREMENT OF LOW-LEVEL ORBITAL ACCELERATIONS
Daniel J. Lesco Washington Jan. 1968 13 p refs
(NASA-TM-X-1488) CFSTI: HC$3.00/MF$0.65 CSCL 14B

The results of the first flight test of an experimental electrostatic accelerometer are presented. Measurements of liquid-hydrogen venting accelerations as low as 6×10^{-5} g were obtained aboard an orbiting Saturn S-IVB stage. Comparison of the accelerometer readings is made with other flight measurements. The time correlation between output data and attitude control system firings is also described. Author

N68-14018*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DIGITAL READOUT AND CONTROL SYSTEM FOR A 64-INCH (1.63-m) SCATTERING CHAMBER
Lawrence P. Madson Washington Jan. 1968 13 p refs
(NASA-TN-D-4324) CFSTI: HC $3.00/MF $0.65 CSCL 18D

This report describes an automatic digital position control system for scattering chamber now in use with the 60-inch (1.52-m) cyclotron at the Lewis Research Center. It features programmed remote control of detector positions with accuracies of ±0.03 degree for these positions. The system has been in continuous operation for a period of 6 months and has resulted in a 20 percent saving in experiment running time. Author

N68-15893*# National Aeronautics and Space Administration. Lewis Research Center, Langley Station, Va.
TEMPERATURE AND LIQUID-LEVEL SENSOR FOR LIQUID-HYDROGEN PRESSURIZATION AND EXPULSION STUDIES
Robert J. Stochl and Richard L. De Witt Washington Feb. 1968 23 p refs
(NASA-TN-D-4339) CFSTI: HC $3.00/MF $0.65 CSCL 14B

A temperature-measurement technique that uses thermopiles (i.e., thermocouples in series) as sensors was developed. The results of this development indicate (1) that an instrument rake using measurement stations constructed of thermopiles can measure temperatures to within ±1.65°K (for gas temperatures between 20° and 300°K) and (2) that, in addition to their use as temperature sensors, thermopile units can be used as point liquid-level sensors for subcooled liquid during liquid outflow. Tests indicate that thermopiles can detect liquid level to within ±0.453 centimeter. Author

N68-15936*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BIMETAL SENSOR FOR AVERAGING TEMPERATURE MEASUREMENT OF NONUNIFORM TEMPERATURE PROFILES
Ralph T. Dittrich and Michael P. Lynch Washington Nov. 1967 19 p refs
(NASA-TN-D-4242) CFSTI: HC $3.00/MF $0.65 CSCL 14B

A single-probe instrument was developed for measuring an average temperature over a nonuniform temperature profile. This probe uses the principle of differential thermal expansion of two different materials. The performance of such a probe was demonstrated experimentally by using a prototype probe for a single temperature indication over temperature profiles which varied as much as 750°C. Probe temperature measurements obtained during several runs averaged as much as 13°C lower than temperatures obtained from averaging the measurements of eight thermocouples equally spaced along the probe length; analysis shows that for steep temperature gradients the probe-measured temperature is a better average than the average temperature obtained from the eight thermocouples. The instrument can be adapted to wide temperature ranges by the proper selection of probe geometry and materials. Author

N68-16529*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AN UNCERTAINTY ANALYSIS FOR SATELLITE CALORIMETRIC MEASUREMENTS
John P. Millard Washington Feb. 1968 64 p refs
(NASA-TN-D-4354) CFSTI: HC $3.00/MF $0.65 CSCL 20M

The use of an uncertainty analysis for analyzing current data and for designing future satellite calorimetric experiments is described. Calorimetric experiments considered are those for measuring the radiative properties of solar absorptance and infrared emittance of test surfaces, and those for measuring the emissive and reflective properties of the sun and planets. The paper describes the uncertainty-analysis technique, lists all pertinent equations for each measurement, presents several illustrative examples, and includes a section on design guides for future experiments. Author

N68-16838*# Lockheed Electronics Co., Houston, Tex.
ANALYSIS OF LUNA 9 PHOTOGRAPHY
Washington NASA Feb. 1968 88 p
(Contract NAS9-5191)
(NASA-CR-980; LEC/HASD-671-40-019) CFSTI: HC $3.00/MF $0.65 CSCL 14E

The techniques and procedures used for a detailed scientific evaluation and analysis of Luna 9 spacecraft imagery is presented along with results and conclusions. A discussion is given on the nature and specifications of the spacecraft and its instruments. Included here also are the image transmissions and images received. Detailed descriptions of the image frames are given. These include: scale and panoramic coverage of the frames, azimuth and distances of the image features, size and classification of the surface materials, and size and classification of the visible craters. The procedures and techniques used for the above calculations are discussed. These are discussed as applied to monoscopic panoramas, dihedral mirror images, and stereoscopic panoramas. Author

N68-17329*# GCA Technology Div., GCA Corp., Bedford, Mass.
IMPROVEMENT AND OPTIMIZATION OF A MASS SPECTROMETER EMPLOYING A PHOTOIONIZATION SOURCE
Walter P. Poschenrieder and Peter Warneck Washington Mar. 1968 55 p refs
(Contract NAS1-6335)
(NASA-CR-1018; GCA-TR-67-12-N) CFSTI: HC $3.00/MF $0.65 CSCL 20F

Further improvements of the photoionization mass spectrometer are described. The experiments performed showed the basic feasibility of analytical photoionization mass spectrometry. At the same time, certain limitations were indicated, particularly with regard to the discrimination of ions with different ionization potentials and coinciding mass numbers, e.g., CO and N_2. This limitation could be traced back to two main sources: namely, the second and higher order uv spectrum produced by the grating, and uv light scattering the monochromator. A considerable improvement has been achieved by the use of uv filters which reduce the intensity of the higher order spectrum and scattering by about two orders of magnitude. Accordingly, the detection limit for CO in N_2 was improved from 5000 to 100 ppm. The performance of a thin-metal indium filter was compared with an argon gas filter. Author

N68-18834*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY TESTS WITH MASS FLUX PROBE IN SUPERSONIC STREAM
Lloyd N. Krause and George E. Glawe Washington Mar. 1968 15 p refs
(NASA-TM-X-1524) CFSTI: HC $3.00/MF $0.65 CSCL 14B

This investigation was undertaken to determine experimentally the accuracy of a mass flux probe system using two inlet designs. One inlet design was sharp-lipped and had both the internal lip surfaces bevelled at 15° (symmetrical). A second inlet, which had

only an external 15° bevel (unsymmetrical), was initially sharp and then was progressively blunted to various degrees during the test program. The purpose of using the two shapes was to compare the ideal, sharp inlet lip with the blunt lip inlets that are considered necessary to achieve adequate cooling in streams developing high stagnation-point heat-transfer rates. The Mach number of the tests ranged from 2.0 to 2.6, and the total temperature ranged from 530° to 700°R (290° to 390°K) with a tunnel inlet Reynolds number of the order of 2.5×10^6 per foot (8.2×10^6 m^{-1}). The symmetrical sharp-lipped inlet yielded excellent results, while the unsymmetrical wedge inlet with both sharp and blunt lips had an effective capture area up to 4 percent greater than the geometric capture area. Author

N68-19001*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INSTRUMENTATION OF A SNAP-8 SIMULATOR FACILITY
James N. Deyo and William T. Wintucky Washington Mar. 1968 61 p refs
(NASA-TM-X-1525) CFSTI: HC$3.00/MF$0.65 CSCL 18D

The philosophy and experience with high temperature instrumentation, pressure sensors, thermocouples, and flowmeters are discussed. Secondary and support instrumentation in the test facility and control room are also included. The approach described is based on the parameters to be measured as well as the time schedule, physical characteristics, and available instrumentation for the facility. Results include data handling, accuracy, and reliability of the system. Over 2000 hours of operation were accumulated, during which time the mercury loop was at operating temperature for about 1000 hours. More than 2000 data runs were taken. Author

N68-19642*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.
DESIGN OF A PRECISION TILT AND VIBRATION ISOLATION SYSTEM
Herbert Weinstock Washington Mar. 1968 169 p refs
(NASA-TR-R-281) CFSTI: HC$3.00/MF$0.65 CSCL 17G

The design of a two axis servomechanism leveling system controlled by gyroscopes and level sensors which is mounted on a massive conventional pneumatic isolation system is presented. At frequencies below 0.012 cps the system is controlled by the level sensors. From 0.012 cps to 25 cps the gyroscopes maintain control. Above 25 cps the servomechanism system is locked out and the test device and massive frame act as a rigid body mounted on springs, resulting in the isolation that would be provided by a damped 1 cps conventional vibration isolation system. The design alternatives for the system, the general design parameters required to meet the performance specification, and the specific components required to achieve these parameters are discussed. The isolation efficiency and other performance functions of a realizable design are presented. The design, assembly, and test results of an experimental single axis full scale model of the servomechanism portion of the system are reviewed. R.N.A.

N68-20324*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CRYOGENIC TEMPERATURE MEASUREMENT USING PLATINUM RESISTANCE THERMOMETERS
Donald H. Sinclair, Howard G. Terbeek, and Jerry H. Malone Washington Apr. 1968 37 p refs
(NASA-TN-D-4499) CFSTI: HC$3.00/MF$0.65 CSCL 20M

Results of evaluation tests on commercial platinum resistance thermometers (PRT) are reported. Three selective types of compact high-resistance PRT (1000 to 5000 ohms at 273.15°K) have proved to be stable, rugged, and sensitive. Resistance difference ratios as a function of temperature, called Z functions, conform closely to those of the high-quality standard PRT even in the nonlinear cryogenic range. Fixed point calibrations at 273.15°, 77.40°, and 20.20°K plus interpolation between points by Z ratios yield probable uncertainties less than ±0.05°K from 20° to 300°K. Also described are a calibration facility, cryostat, procedures for calibrating in liquid-hydrogen and liquid-nitrogen baths to ±0.02°K, and instrumentation for field installations. Author

N68-21169*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE OPERATION OF AN ELECTRON PARAMAGNETIC RESONANCE SPECTROMETER
F. E. Geiger, Jr. Washington Apr. 1968 13 p refs
(NASA-TN-D-4469) CFSTI: HC$3.00/MF$0.65 CSCL 20F

Discussed is the operation of an electron paramagnetic resonance microwave spectrometer and expressions are given for the signal obtained from a paramagnetic sample with RF susceptibility $\chi = \chi' - j\chi''$. Calculations are made to the second order of χ'' and χ'. Also studied are the effect of relative microwave power in the signal arm and in the bias or reference arm of the microwave bridge, and the effects of crystal detector characteristics on the optimum cavity reflection coefficient. Expressions for signals are developed for balanced-bridge operation with small phase or amplitude unbalance and for bridge operation with biasing arrangements for the detecting crystal. Author

N68-21384*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE OF A VENTURI METER WITH SEPARABLE DIFFUSER
Thomas J. Dudzinski, Robert C. Johnson, and Lloyd N. Krause Washington Apr. 1968 18 p refs
(NASA-TM-X-1570) CFSTI: HC$3.00/MF$0.65 CSCL 14B

The effects on venturi meter efficiency and discharge coefficient of a radial, outward step at the transition from throat to diffuser are reported over a Reynolds number range of 1×10^4 to 5×10^5 and over a Mach number range of 0.2 to 1.0. Step size was varied from 0 to 12.5 percent of the throat radius. Diffuser efficiency was dependent on Reynolds number, Mach number, and step size greater than 2 percent. The discharge coefficient was independent of Mach number, step size, and back-pressure variation for critical flow. Author

N68-21942*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
A LIGHTING STRATEGY FOR LUNAR ORBITER MISSION DESIGN
Friedrich O. Huck Washington May 1968 38 p refs
(NASA-TN-D-4501) CFSTI: HC$3.00/MF$0.65 CSCL 14E

An analysis is presented which relates quality of lunar photographs to Lunar Orbiter trajectory. Furthermore, since several parameters which affect picture quality are uncertain, a strategy is developed which optimizes confidence levels in detecting specific lunar surface detail. This strategy is illustrated by examining Lunar Orbiter's capability to reveal small obstables in the form of right-circular cones which have lunar reflective properties. Results show that the smallest lunar detail can be detected at high phase angles (angle between incident light and camera) and long exposure times; however, the effects of variances in lunar reflectance, vehicle trajectory, and image smear result in higher levels of confidence in the detection of larger detail at lower phase angles and shorter film exposures. Author

N68-22290*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
FLIGHT INVESTIGATION OF CAPACITANCE-TYPE METEOROID DETECTOR USING AN INFLATABLE PARAGLIDER
James H. Siviter, Jr. Washington May 1968 42 p refs
(NASA-TN-D-4530) CFSTI: HC$3.00/MF$0.65 CSCL 14B

One of the meteoroid-detection systems under development consists of thin-film multiple capacitors made of layers of aluminized polyethylene terephthalate (PET). The capacitor momentarily

discharges when penetrated by a hypervelocity projectile. The multilayer capacitor-type detector used in this experiment was designed to detect particle penetrations in 6.5, 20, and 45 microns of PET. Eighteen square meters of the micrometeoroid-detector material was attached to the wing of an inflatable paraglider. The paraglider provided a convenient mounting structure for the sensors and a means of recovering the sensors after the flight test. The packaged paraglider and sensors were boosted to an altitude of 93 kilometers where the paraglider was ejected and inflated. The inflated paraglider then continued along a ballistic trajectory to a maximum altitude of 154.7 kilometers. Sensor data were recorded for approximately 169 seconds at altitudes above 121 kilometers. The excessive noise on the telemetry-data channels made exact analysis of the penetration data inconclusive. The deployment and inflation of the paraglider were normal and it attained the proper flight attitude during reentry; however, the telemeter section failed to release, and, as a result, the reentry loads were excessive. Author

N68-22883*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
CAPACITOR-TYPE METEOROID-PENETRATION SENSORS: DESCRIPTION AND TEST RESULTS
John J. Broderick Washington May 1968 109 p refs
(NASA-TN-D-4529) CFSTI: HC $3.00/MF $0.65 CSCL 14B

Capacitor sensors were tested and evaluated, in various configurations, under hypervelocity-impact conditions which simulate, as nearly as possible with present laboratory facilities, the impacts of meteoroids in space. Light-gas guns, explosive devices, electrostatic accelerators, and exploding-wire guns were used. Three types of signals were observed during hypervelocity perforations. The first is characterized by a complete discharge of the sensor within a few microseconds. The second is characterized by the rapid discharge of a substantial portion of the applied voltage. The third is characterized by the loss of less than about 10 percent of the applied voltage with the discharge time in excess of 10 μsec. During the test program most of the perforations resulted in small signals or no signals. The applied voltage was the only parameter observed which had a pronounced effect on the sensor operation. Completely charged capacitor sensors were not permanently shorted when perforated by small single hypervelocity projectiles; however, some uncharged and partially charged sensors were permanently shorted when perforated. Author

N68-24244*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
INVESTIGATION OF TEMPERATURE MEASUREMENTS IN 300° TO 1100°K LOW-DENSITY AIR USING AN ELECTRON BEAM PROBE
William W. Hunter, Jr. Washington May 1968 37 p refs
(NASA-TN-D-4500) CFSTI: HC $3.00/MF $0.65 CSCL 20M

Laboratory measurements of rotational and vibrational temperatures have been performed over a range from 300° to 1100°K in static low-density air with an electron beam probe. Rotational-temperature measurements were made from the (0,0) band of the first negative system of the nitrogen constituent of air. Some tests were also performed by using the (0,1) band of the first negative system of nitrogen. No substantial differences were noted between the results of the (0,1) band tests and those of the (0,0) band tests. The accuracy of the measured rotational temperatures was found to vary with gas temperature and gas number density. A difference existed between the measured rotational temperature and the gas temperature. This difference increased with increasing gas temperature. With the inclusion of an experimentally determined correction for the gas-number-density effect, the rotational-temperature measurements were made with an accuracy that varied from approximately 0 to −6 percent with increasing gas temperature. Vibrational-temperature measurements were made by using the intensity ratios of the (0,1) and (1,2) bands of the first negative system of nitrogen. The measurements were found to be within ±20 percent of the gas temperature. Author

N68-25316*# Ling–Temco–Vought, Inc., Dallas, Tex. LTV Research Center.
INVESTIGATION OF THE CALIBRATION OF MICROPHONES FOR SONIC BOOM MEASUREMENT
John J. Van Houten and Ron Brown Washington, D. C. NASA Jun. 1968 60 p refs
(Contract NAS1-5652)
(NASA-CR-1075; TR-0-71200/7TR-112) CFSTI: HC $3.00/MF $0.65 CSCL 14B

Examination of the various procedures available for microphone calibration indicated that application of the electrostatic actuator technique and the use of an infrasonic pistonphone would satisfy NASA's microphone calibration requirements. These instruments provide the equipment necessary for a comprehensive evaluation of microphones currently being used by NASA as well as those which may be used in the future. The system is capable of sinusoidal evaluation of the frequency response and sensitivity of a microphone over the range of 0.01 Hz to above 20 kHz. Sinusoidal sound pressure levels of 94 dB and 114 dB are achieved with the infrasonic pistonphone and sound pressures in excess of 128 dB are obtained by use of the electrostatic actuator system. The calibration procedure demonstrates the compatibility of steady state and transient response characteristics of the microphone and provides illustrations of idealized N-waveform measurement capability of currently available microphones and complementing instrumentation. Author

N68-25317*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
CHARACTERISTICS AND USE OF X-15 AIR-DATA SENSORS
Lannie D. Webb Washington, D. C. Jun. 1968 59 p refs
(NASA-TN-D-4597) CFSTI: HC $3.00/MF $0.65 CSCL 14B

The uses, techniques of correlation, and analysis of flight-guidance and air data sensors that have been flown on the X-15 airplane are examined. Methods by which meteorological balloons and high altitude rocketsondes were used to define the atmospheric envelope around the X-15 airplane are discussed. The application of onboard sensor data, meteorological data, and radar data in obtaining altitude, velocity, Mach number, and dynamic pressure is explained. Onboard systems considered are the nose-boom pitot-static tube, hypersonic flow-direction sensor (ball nose), fuselage static system, fuselage pitot probe, stagnation-temperature probe, and inertial flight-data system. Author

N68-25375*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
MONOMOLECULAR CONTAMINATION OF OPTICAL SURFACES
H. Shapiro and J. Hanyok Washington Jun. 1968 25 p refs
(NASA-TN-D-4612) CFSTI: HC $3.00/MF $0.65 CSCL 20F

This paper describes the measurement of ultraviolet reflectance change in mirrors, caused by oil contamination. Spacecraft equipped with such mirrors are tested in a vacuum generated by oil diffusion pumps. Within instrumental limits, our experimental mirrors show no change in reflectivity when the vacuum chamber is operated in the usual mode. Contamination is plotted against amount of oil deposited, the amount being measured by a quartz-crystal microbalance. The observed phenomena give a more complete picture of the contamination process than existed previously. Deposited oil, it is found, forms minute droplets on the surface of mirrors coated with MgF_2 The droplets can be evaporated from the surface at a much higher chamber pressure than the rated vapor pressure of the bulk liquid; this provides a way of cleaning the mirrors. It is possible to operate diffusion-pumped systems so as to minimize Author

N68-25518*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
AN AUTOCORRELATION APPROACH TO THE BROWN–TWISS INTERFEROMETER

Frank C. Jones Washington May 1968 29 p refs
(NASA-TN-D-4480) CFSTI: HC $3.00/MF $0.65 CSCL 20F

Consideration is given to interference phenomena which occur with light produced by incoherent sources. Starting from the familiar interference pattern produced by two coherent sources, one can proceed in simple steps to a picture of two incoherent sources producing an interference pattern that moves about at random. This randomly moving pattern leaves behind a footprint in the form of the intensity autocorrelation function. This report describes how the autocorrelation function for an extended, incoherent source may be constructed. It is this function that is measured by the Brown–Twiss stellar interferometer. Author

N68-25830*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE INFLUENCE OF FIXTURE STRESS CONCENTRATIONS ON RING ACCELEROMETERS
James A. Nagy and Charles E. Henley, Jr. Washington May 1968 11 p refs
(NASA-TN-D-4540) CFSTI: HC $3.00/MF $0.65 CSCL 14B

Tests have revealed that the most commonly used accelerometer can be subject to a subtle source of error from strains developed in vibration fixtures. Accelerometers mounted on supposedly rigid surfaces may show errors on the order of 100 percent at the very low frequencies below any resonances. A study was initiated to determine the nature of the fixture stress concentration and means of avoiding it. This paper describes the test methods used during the study and the results obtained. The test methods discussed include standard accelerometer calibration techniques; calibrations varying torque, position, and mounting hole angle; photoelastic techniques; base sensitivity checks; and tests with a transducer devised to detect the presence of base-strain in mounted accelerometers. Author

N68-25862*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE INTERPRETATION OF DAYTIME MEASUREMENTS BY THE NIMBUS 1 AND 2 HIGH RESOLUTION INFRARED RADIOMETERS
G. Kuers Washington Jun. 1968 23 p refs
(NASA-TN-D-4452) CFSTI: HC $3.00/MF $0.65 CSCL 20F

Dense cumulus clouds and fog banks have been selected to determine mean values of their reflectances by means of the High Resolution Infrared Radiometers (HRIR) of Nimbus I and Nimbus II in the wavelength region between 3.6μ and 4.2μ. While both instruments yielded satisfactory results at night, it became apparent that Nimbus I delivered too high reflectance values by day. It was concluded that spurious shortwave radiation entered the radiometer. The amount of the energy difference was used to determine the most probable cause of the malfunctioning, which was considered to be an uncoated rim or a crack of the interference filter. Author

N68-25903*# Northrop Corp., Hawthorne, Calif.
A STUDY OF AN ELECTRIC FIELD MEASURING INSTRUMENT
S. H. Levine and S. R. Harrison Washington NASA Jun. 1968 44 p refs
(Contract NAS2-4143)
(NASA-CR-970; NCL-67-39) CFSTI: HC $3.00/MF $0.65 CSCL 14B

The feasibility of employing a cesium ion beam electric field meter has been experimentally investigated in the laboratory using two types of cesium ion sources. The first source used radiant heating, the other electron bombardment heating. Excellent results were obtained with these sources attaining a sensitivity for measuring electric fields of 0.03 volts/meter. Methods for attaining sensitivites of the order of 0.01 V/m are presented together with a preliminary theoretical investigation of the processes pertaining to the production of cesium ions in the ionizer. Also, an electronic-readout system design is presented so that all aspects of constructing a cesium ion beam electric field instrument have been studied. Author

N68-26703*# Stanford Research Inst., Menlo Park, Calif.
CRYOGENIC MAGNETOMETER DEVELOPMENT Final Report, 1 Jul. 1964–7 Mar. 1967
William S. Goree, Bascom S. Deaver, Jr., V. W. Hesterman, and T. W. Barbee, Jr. Washington NASA Jun. 1968 72 p refs
(Contract NAS2-2088, SRI Proj. PHU-5093)
(NASA-CR-1073) CFSTI: HC $3.00/MF $0.65 CSCL 14B

A low field superconducting shield has been developed and used to provide stable magnetic fields of less than 10^{-6} G, maintained stable for as long as 6 days. The shield is a superconducting cylinder 91.5 cm long by 16.5 cm ID. The measured attenuation of externally applied axial field changes is a factor of 31 per shield radius. The Meissner effect and zero resistance property of superconductors has been used in the development of a magnetometer for measuring the absolute value of magnetic fields. This device has been used to measure fields as small as 2×10^{-6} G. A magnetometer utilizing the unique zero resistance and quantized flux properties of superconductors has been developed and used to measure magnetic field changes as small as 5×10^{-7} G. The dc Josephson tunneling effect has been used to construct (1) magnetometers with field sensitivity as good as 10^{-7} G, (2) magnetic gradiometers with which field gradients of 10^{-8} G cm have been measured, (3) linear displacement detectors with which displacements of less than 1500 Å have been measured, and (4) a system for measuring static magnetic susceptibility, which was used to study the time dependence of the Meissner effect in hollow tin cylinders. Author

N68-28327*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
A PRECISION SPACECRAFT RADIOMETER FOR HECTOMETER WAVELENGTHS
C. R. Somerlock and J. Krustins Washington Jul. 1968 24 p refs
(NASA-TN-D-4634) CFSTI: HC $3.00/MF $0.65 CSCL 20F

The Radio Astronomy Explorer program at Goddard Space Flight Center has pointed out the need for sophisticated radio astronomy receivers for spacecraft use. Development of such a receiver is described with design details. The resulting instrument is a feedback radiometer of the Ryle-Vonberg type. It measures at nine different frequencies between 0.4 Mc and 10 Mc with a 60-db dynamic range centered at an antenna temperature of 106°K. The incorporation of a novel thermistor-bridge power meter yields a long-term measurement accuracy of $\pm 1/2$ db. Author

N68-28965*# Santa Barbara Research Center, Goleta, Calif.
DUAL RADIOMETER ASSEMBLY FOR PROJECT SCANNER
Stillman C. Chase Washington NASA Jul. 1968 95 p
(Contract NAS1-3827)
(NASA-CR-1086) CFSTI: HC $3.00/MF $0.65 CSCL 20F

Design and performance data are presented on the radiometer assembly which is part of a spin-stabilized suborbital space probe payload used to make measurements in two far-infrared wavelength bands of the earth's horizon radiance profile. The equipment consists essentially of two vertical reflecting-type telescopes using true aspheric surfaces on both the primary and secondary mirrors, with flat object space scan mirrors to scan across the horizon as the vehicle spins. Performance specifications are summarized, and comparisons are given between the proposed design and the values actually obtained for the final systems. The difficulties encountered, which made these changes necessary, are explained. The problem areas which developed during the procurement, fabrication, assembly, and test phases are described in detail, and the data are presented as an aid in developing guidelines for future projects. M.G.J.

N68-29418*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
PHOTOGRAPHIC PHOTOMETRY OF ARTIFICIAL METEORS
Wendell G. Ayers Washington Jul. 1968 27 p refs
(NASA-TN-D-4667) CFSTI: HC$3.00/MF$0.65 CSCL 03A

Two methods of photographic photometry of artificial meteors are presented. These methods relate the amount of radiation that is produced by an artificial meteor in the photographic region of the spectrum to the amount of radiation produced by stars appearing close to the meteor. The relationship is expressed in terms of absolute meteor magnitude. The first method is general and is used when an appreciable difference exists between the structure of the streak image formed by the meteor and of those formed by the stars. The second method is restricted and is used when little difference exists between the structure of the meteor and star images. Author

N68-29951*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
STRIKING CHARACTERISTICS OF THE MAGNETRON IONIZATION GAGE IN HELIUM FROM 1.9×10^{-7} TORR TO 7×10^{-10} TORR
William S. Lassiter Washington Aug. 1968 37 p refs
(NASA-TN-D-4681) CFSTI: HC$3.00/MF$0.65 CSCL 14B

The striking characteristics of the magnetron gage were measured in helium over a pressure range of 1.9×10^{-7} torr (N_2) (25.3 $\mu N/m^2$) to 7×10^{-10} torr (N_2) (93.1 nN/m^2). The measured striking characteristics on the upper branches of the striking characteristics diagram agree with the Townsend discharge theory except that, for a given pressure, the characteristics deviate slightly from the theoretical parabolic prediction. On the lower branches, a significant disagreement with theory was found to exist in the dependence of the minimum striking voltage with pressure. Otherwise, on the lower branches, the measured striking behavior agrees with the theoretical prediction and with measurements at higher pressures. Measured striking-time lags occurred in the magnetron gage at pressures bwlow 5×10^{-8} torr (N_2) (6.65 $\mu N/m^2$). The lags were determined to cause no significant error in the measurements of the striking characteristics. Author

N68-30127*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
CALIBRATION OF 30° INCLUDED-ANGLE CONE FOR DETERMINING LOCAL FLOW CONDITIONS IN MACH NUMBER RANGE OF 1.51 TO 3.51
Walter A. Vahl and Robert L. Weirich Washington Aug. 1968 41 p refs
(NASA-TN-D-4679) CFSTI: HC$3.00/MF$0.65 CSCL 14B

A 30° included angle cone was calibrated to permit determination of the local Mach number, total pressure, and flow angles from measurements of total pressure at the cone apex and static pressure at four equally spaced orifices on the cone surface. The calibration data were obtained at Mach numbers of 1.51, 2.37, 2.96, and 3.51 over an angle of pitch range of 0° to 20°. The test Reynolds number ranged from 6.56×10^6 to 9.85×10^6 per meter. The test results indicate that the accuracy of Mach number determination varies from approximately ±0.010 to ±0.050 at Mach numbers of 1.51 to 3.51, respectively. The accuracy of the total-pressure measurement varies from approximately ±0.5 percent to ±4.5 percent at Mach numbers of 1.51 to 3.51, respectively. The flow angles nay be determined within approximately ±0.25° for angles less than 10° and within approximately ±0.50° for angles greater than 10°. Generally, an iterative procedure is required only for accurate determination of the Mach numbers near or greater than 2.37, with angles of pitch above approximately 10°. Author

N68-31958*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MODIFIED VIBRATION TRANSDUCER CALIBRATION SYSTEM WHICH DIRECTLY YIELDS A PLOT OF SENSITIVITY VERSUS FREQUENCY
William C. Nieberding, Edward F. Miller, and David L. Wright Washington Aug. 1968 16 p ref
(NASA-TN-D-4760) CFSTI: HC$3.00/MF$0.65 CSCL 14B

A commercially available vibration transducer calibration system was modified to directly produce an output plot of transducer sensitivity versus frequency over the range of frequencies from 10 to 10,000 Hz. This was accomplished by the insertion of a readily programmed automatic attenuation in the exciter control-system feedback loop to maintain constant vibration amplitude versus frequency. National Bureau of Standards primary calibration data are repeated to within ±0.5 percent over the frequency range of 10 to 9000 Hz and within ±1 percent from 9000 to 10,000 Hz. Calibrations are obtained in 15 minutes. Author

N68-33022*# National Research Corp., Cambridge, Mass. Norton Exploratory Research Div.
STUDY OF NEW METHODS TO MEASURE LOW PRESSURE
Richard Hecht Washington NASA Aug. 1968 79 p refs
(Contract NAS1-5347)
(NASA-CR-1120) CFSTI: HC$3.00/MF$0.65 CSCL 14B

A theoretical and experimental evaluation of the concept of electrostatic control of capacitance-manometer sensitivity has been carried out. The results have been encouraging, although problems have been created by high-voltage breakdown at the electrode and diaphragm surfaces of the gauge. This breakdown can undoubtedly be eliminated by choosing more appropriate surface materials. It is hoped that absolute pressures well below 10^{-6} Torr can ultimately be measured with this gauge if uncertainties in work-function can be avoided; a voltage-modulation technique is suggested which should accomplish this. It is suggested that the use of superconducting-bolometers to detect the kinetic energy of incident gas molecules will permit absolute measurements of pressures as low as 5×10^{-9} Torr, and also measurements of molecular beam densities as low as 10^6 molecules/cc. It is suggested that the juxtaposition of a low-frequency heater and a sensitive microphone will permit absolute pressure measurements as low as 10^{-6} Torr. Author

N68-33277*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
INVESTIGATION OF ELECTRON-RADIATION-INDUCED DIELECTRIC BREAKDOWNS IN A TYPICAL CAPACITOR METEOROID DETECTOR SYSTEM
George M. Storti, George E. Rambo, Herbert D. Hendricks, and Thomas B. Ballard Washington Sep. 1968 29 p refs
(NASA-TN-D-4738) CFSTI: HC$3.00/MF$0.65 CSCL 14B

The effects of electron radiation on capacitor-type detector systems similar to those used on the Pegasus satellite were investigated. Each system that was tested consisted of a polyurethane foam panel containing two capacitor-type-meteoroid detectors, several meters of polyethylene terephthalate insulated electrical leads, and other items such as rubber shock mounts and polyethylene terephthalate adhesive tape. Three different target thicknesses for the meteoroid detectors were tested, these thicknesses being 40, 200, and 400 microns (1.5, 8, and 16 mils). The incident kinetic energy of electrons used in the tests ranged from 30 keV to 1000 keV, and the temperature of the detector systems was maintained at either 197° K or 297° K. It was found that radiation-induced dielectric breakdowns were produced in the systems and that some of these signals were indicated as meteoroid penetrations. It was determined that the primary source of the breakdowns and, hence, the penetration indications was the polyethylene terephthalate insulated wire. The number of breakdowns and penetration indications

obtained for a fluence of 5×10^{13} e/cm^2 was found to be dependent on the incident kinetic energy of the electrons and the system temperature; that is, more breakdowns and penetration indications occurred at the lower temperature (197° K) and the lower energies (30 keV to 100 keV). Tests were performed with different modifications made to the signal processing circuits. Several of these modifications resulted in a significant reduction or the total elimination of the radiation-induced penetration indications. Finally, it was found that those systems containing 200 and 400 micron detectors with 200- and 400-micron-thick targets suffered severe decreases in resistance in the capacitor-type detectors. Author

N68-35105*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
USE OF AN ELECTRONIC VISUALIZATION TECHNIQUE IN THE STUDY OF GAS JOURNAL BEARING BEHAVIOR
Robert Y. Wong, Hugh A. Klassen, Robert C. Evans, and Donald J. Spackman Washington Oct. 1968 18 p Film Supplement Number C-259 to this report is available on loan from NASA. Lewis Res. Center, Cleveland
(NASA-TM-X-1609) CFSTI: HC$3.00/MF$0.65 CSCL 13H

A visualization technique was developed and applied to data obtained during a test of a pivoted-pad gas journal bearing. Clearance probe measurements, recorded on a data tape, were used to show motions of the bearing components relative to each other, on an oscilloscope screen, with bearing motions amplified relative to the journal diameter. Author

N68-35149*# Research Triangle Inst., Durham, N. C.
AN INVESTIGATION OF THIN FILM OXYGEN PARTIAL PRESSURE SENSORS
T. M. Royal, J. J. Wortman, and L. K. Monteith Washington NASA Sep. 1968 61 p refs
(Contract NAS1-7087)
(NASA-CR-1182) CFSTI: HC$3.00/MF$0.65 CSCL 14B

Design, development, and testing of a laboratory model involving semiconducting zinc oxide and tin oxide films were investigated. Zinc oxide films at elevated temperatures were found to experience resistance changes greater than an order of magnitude when cycled from N_2 to O_2 environments. The zinc oxide films are relatively insensitive to other gases such as N_2, Ar, He, CO_2. A theoretical discussion of the physical mechanisms responsible for the observed phenomena is presented based on oxygen induced changes in the semiconductor donor and acceptor influences. A suitable film substrate, heater, electrical contacting technique, and housing was designed and fabricated into a sensing head. The sensor head was coupled with a control unit for maintaining a constant operating temperature to form the complete sensor. Operating characteristics of the unit were evaluated. Author

N68-35152*# Virginia Univ., Charlottesville. Dept. of Physics.
AN ANNULAR LITHIUM-DRIFTED GERMANIUM DETECTOR FOR STUDYING NUCLEAR REACTION GAMMA-RAYS
A. J. Levy, R. C. Ritter, and K. Ziock Washington NASA Sep. 1968 85 p refs
(Grant NsG-455)
(NASA-CR-1138) CFSTI: HC$3.00/MF$0.65 CSCL 18D

A fabrication technique was developed for truly annular Ge(Li) gamma detectors. Featuring spark-cutting to precisely control the undamaged germanium volume, the detector is capable of standard-geometry techniques such as are used with NaI detectors. Background material relevant to the annular geometry is presented. An extremely explicit, detailed description of the complete fabrication procedure is given, including special cutting, radiant diffusion, and drifting techniques developed here. Measured properties of several detectors are presented, with the emphasis being on the usefulness of the detector high energy gamma ray spectra. Author

N68-35534*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN INTEGRATING SPHERE SPECTRORADIOMETER FOR SOLAR SIMULATOR MEASUREMENTS
Orlando W. Uguccini Washington Oct. 1968 27 p refs
(NASA-TN-D-4822) CFSTI: HC$3.00/MF$0.65 CSCL 20F

A spectroradiometer, utilizing an integrating sphere and a grating monochromator, and a technique for performing low error spectral measurements of solar simulators are described, together with their evaluation tests. A point by point technique is used in which the spectroradiometer is calibrated with an NBS spectral irradiance standard at each wavelength. Evaluation consisted of checking the calibration of several NBS spectral irradiance standards. Accuracy was also checked by correlating these measurements with measurements obtained with a filter radiometer. Results of the measurements of a carbon arc solar simulator and a xenon arc solar simulator are presented. Author

N68-35620*# National Aeronautics and Space Administration, Washington, D. C.
NASA CONTRIBUTIONS TO DEVELOPMENT OF SPECIAL-PURPOSE THERMOCOUPLES. A SURVEY
C. Eugene Moeller 1968 97 p refs
(NASA-SP-5050) GPO: HC$1.25; CFSTI: MF$0.65 CSCL 14B

Special-purpose thermocouples, their characteristics, and their application to difficult problems are discussed in relation to innovations and contributions by NASA research programs. Historical development and thermocouple operational principles are reviewed, and mention is made of important symposia and seminars in the thermocouple field. Recent developments in thermoelectric materials for measuring cryogenic temperatures are described, as are thermoelectric materials and electrical insulators used in thermocouples for measurements above 3000°F. Special thermocouple applications for the measurement of gas, surface, and solids temperatures are discussed; as are new thermocouple developments in rocket nozzles, thermal protection systems, and high speed fluid dynamics. Energy-measuring devices that use special thermocouples are described, along with heat flux gauges, a radiant energy calorimeter, and an intrinsic thermocouple device. Developments associated with techniques of attaching thermocouples to test items are discussed, and test circuits to check out many thermocouples at remote locations are included. M.W.R.

N68-36021*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A SMALL COMBINATION SENSING PROBE FOR MEASUREMENT OF TEMPERATUE, PRESSURE, AND FLOW DIRECTION
George E. Glawe, Lloyd N. Krause, and Thomas J. Dudzinski Washington Oct. 1968 20 p refs
(NASA-TN-D-4816) CFSTI: HC$3.00/MF$0.65 CSCL 14B

The design features and characteristics of a small combination sensing probe for the measurement of total temperature, total pressure, and flow direction of a gas stream are presented. Also, with proper consideration, a flow direction sensing hold hole indication can be used to determine static pressure. Experimental data are presented for the aerodynamic recovery and time response of the temperature sensor, the flow angle characteristics of the total pressure sensor, and the sensitivity of the flow direction wedge. These data were obtained over a subsonic Mach number range of $0.2 \leq M < 1$, as well as at $M = 1.4$. Author

N68-36530*# Utah Univ., Salt Lake City.
ENTRY LENGTH FOR THE ROCKET METEOROLOGICAL RADIATION SHIELD

Forrest L. Staffanson, Sadiq Alsaji, and Ronald Fazzio Washington
NASA Oct. 1968 27 p refs
(Grant NGR-45-003-025)
(NASA-CR-1200) CFSTI: HC $3.00/MF $0.65 CSCL 14B

A derivation is presented for the thermal entry length which determines the depth within a tubular radiation shield that a temperature sensor may be placed without incurring convective heat transfer between the shield and sensor. Data are presented as a function of shield diameter, altitude, and sensor viewing angle. It is concluded that radiation shields of the diameter of the 4-inch meteorological rocket will provide significant shielding to 80 km altitude and shields of the diameter of the 1-inch dart to 60 km.
Author

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MACHINE ELEMENTS AND PROCESSES

Includes bearings, seals, pumps, and other mechanical equipment; lubrication, friction, and wear; manufacturing processes and quality control; reliability; drafting; and materials fabrication, handling, and inspection.

N68-10120*# *Martin Co., Baltimore, Md.*
PARTS AND MATERIALS APPLICATION REVIEW FOR SPACE SYSTEMS
J. P. Craig et al Washington NASA 1967 58 p refs Prepared for NASA
(NASA-SP-6505) CFSTI: HC $3.00/MF $0.65 CSCL 14A

Parts and materials application–review activity for project management of space systems is defined, and a guide for performance of effective reviews by parts and materials specialists and design engineers is provided. Parts application review is necessary with regard to: flammability and outgassing properties of parts; compatibility of leads with metal joining processes; compatibility of parts surfaces with coating and encapsulants; and environmental resistance and physical and electrical properties of coatings, encapsulants, and insulating materials. A method for selecting the scope of review activities appropriate to various levels of project requirements is illustrated by examples of projects and their hardware. S.P.

N68-10402*# Midwest Research Inst., Kansas City, Mo.
ADVANCED VALVE TECHNOLOGY, A SURVEY
Louis C. Burmeister, John B. Loser, and Eldon C. Sneegas Washington NASA 1967 190 p refs Revised
(NASA-SP-5019) GPO: $1.00 CSCL 13K

The purpose of this book is to disseminate advanced valve technology throughout all branches of industry. To achieve this objective, it was necessary to (1) determine the present industrial state-of-the-art—this was accomplished by conducting interviews, a literature search, and discussions with application and systems engineers at NASA installations; (2) recognize new advances—valves which have qualified for newer missiles, advanced aircraft, and spacecraft usually represent improvements beyond the industrial state-of-the-art; and (3) report the new technology—when a considerable number of custom-made valves fall within a given category, the combined technology information in that category will often fall into a pattern and indicate new trends and approaches. New trends and techniques mentioned are concerned with leakage, materials, compatibility, contamination, wear, reliability, response time, repeatability, valve actuators, proportional flow control, heat transfer, high pressure and temperature, pressure surge protection, flutter and chatter, and unique designs and applications. R.W.H.

N68-10503* General Electric Co., Cincinnati, Ohio. Missile and Space Div.
DESIGN OF TWO ELECTROMAGNETIC PUMPS
G. E. Diedrich and J. W. Gahan Washington NASA Nov. 1967 103 p refs
(Contract NAS3-8500)
(NASA-CR-911) CSCL 13K

A design study program to determine three specific EM pump designs for possible use as boiler feed pumps in Rankine-cycle, space electric power systems is described. The three designs were: (1) 9 lb/sec, 240 psi pump for 1000°F potassium using a T-111 duct; (2) 9 lb/sec, 240 psi pump for 1000°F potassium using a 316 SS duct; and (3) 3.25 lb/sec, 240 psi pump for 1000°F potassium using a T-111 duct. A specific design for each of these ratings is described in detail. Complete calculated performance and evaluation for each design are also presented. Final design selection for each rating was based on efficiency, reliability, weight, and fabricability. In general, efficiency was optimized. Author

N68-12890*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EQUIPMENT AND PROCEDURES FOR GLASS-BEAD PEENING TITANIUM-ALLOY TANKS
Thomas T. Bales, Charles R. Manning, Jr., and W. Barry Lisagor Washington Jan 1968 32 p refs
(NASA-TN-D-4288) CFSTI: HC $3.00/MF $0.65 CSCL 13H

Glass-bead peening equipment which utilizes programmed motions has been developed and used to peen uniformly the inner surface of 26 titanium alloy spacecraft tanks for the alleviation of stress corrosion resulting from exposure to nitrogen tetroxide. The tanks which were peened varied from 20 inches to 14 feet (0.5 to 4.2 m) in length and from 12.5 to 51 inches (0.3 to 1.3 m) in diameter. The function of each component of the developed equipment and the procedures used for peening are described herein. Glass-bead peening parameters have been investigated and parameters were established which produced a compressive stress of approximately 100 ksi on the peened surface of titanium test strips. The effect of glass-bead peening on the mechanical properties of the titanium Ti-6Al-4V alloy was determined from tests conducted by using peened and unpeened standard tensile and V-notch specimens as well as from results of a burst test of a peened tank. A slight reduction in the yield and notch properties of the material was noted after peening; the ultimate tensile strength, elongation, and modulus of the material, however, were found to be unaffected. Author

N68-15010*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REDUCED PRESSURE ENVIRONMENT EFFECTS ON ROLLING ELEMENT FATIGUE LIFE WITH SUPER REFINED MINERAL OIL LUBRICANT
David W. Reichard, Richard J. Parker, and Erwin V. Zaretsky Washington Jan. 1968 17 p refs
(NASA-TN-D-4348) CFSTI: HC $3.00/MF $0.65 CSCL 13I

A modified NASA five-ball fatigue tester was used to investigate the effect of a reduced-pressure environment on rolling-element fatigue life, deformation, and wear of SAE 52100 steel balls with a super-refined naphthenic mineral oil used as the lubricant. Tests were conducted at atmospheric pressure, at a 20° contact angle, with a thrust load of 60 pounds (267 N) to produce an initial maximum Hertz stress of 800,000 psi (5.5×10^9 N/m^2) at a shaft speed of 4900 rpm with no heat added. The atmospheric-pressure tests served as reference data for tests conducted at a reduced pressure, approximately the vapor pressure of the lubricant. For these reduced-pressure tests, the ball specimens were lubricated by a quasi-mist method and by immersion in the lubricant. In both cases, all other test conditions were the same as those in the atmospheric-pressure tests. No significant difference in the fatigue lives was observed for tests conducted at atmospheric pressure and those conducted at reduced ambient pressure. The amounts of deformation and wear for the two pressure conditions differed little, regardless of the lubrication mode employed, which was an indication of a sufficient elastohydrodynamic lubricating film at the reduced-pressure levels. Author

N68-16468*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FRICTION TORQUE OF BALL BEARINGS IN VACUUM WITH SEVEN POLYTETRAFLUOROETHYLENE COMPOSITION RETAINER MATERIALS

Herbert W. Scibbe, Dean C. Glenn, and William J. Anderson Washington Feb. 1968 20 p refs

(NASA-TN-D-4355) CFSTI: HC $3.00/MF $0.65 CSCL 13I

Self-lubricating retainer materials containing various weight percentages of polytetrafluoroethylene (PTFE), glass fibers, molybdenum disulfide (MoS_2), and bronze were evaluated in 20-millimeter-bore ball bearings operating in a vacuum of 10^{-6} torr (1.33×10^{-4} N/m^2). The lubricating capability of the retainer materials was evaluated by measurement of the bearing friction torque. The test bearings were run at 3600 rpm with axial loads from 35 to 100 pounds for periods of approximately 1 hour. Although all retainer materials lubricated the bearings reasonably well, the best lubrication, as measured by the lowest average friction torque, was obtained with a bearing equipped with a retainer of 70 percent PTFE, 15 percent glass fibers, and 15 percent MoS_2. In an initial run at a load of 50 pounds with this material, the bearing torque was high and erratic; in the next three consecutive runs, however, the torque remained at a low, constant level. In the following three consecutive runs, the bearing registered low, steady torque upon restart and thereby demonstrated good restart capability. During the time intervals of 24 hours or more between the runs, the bearing "soaked" in the vacuum chamber. The good performance with this retainer was partly attributed to a fabricating process that produced a homogeneous mixture of PTFE, glass fibers, and MoS_2 in the material. Author

N68-17564*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NONCAVITATING PERFORMANCE OF TWO-AREA-RATIO WATER JET PUMPS HAVING THROAT LENGTHS OF 7.25 DIAMETERS

Nelson L. Sanger Washington Mar. 1968 62 p refs

(NASA-TN-D-4445) CFSTI: HC $3.00/MF $0.65 CSCL 13K

The performance of two jet pumps having low nozzle- to throat-area ratios was evaluated in a water facility and compared to theoretically predicted performance. The purposes of the investigation were to gain a better insight into the flow mechanisms involved in low-area-ratio jet pumps, and to compare the abilities of two existing one-dimensional analyses to predict jet pump performance over a wide range of operating conditions. Two nozzles were evaluated experimentally and the test pump consisted of one of the two nozzles and one test section, the latter having a throat diameter of 1.35 inches (3.43 cm), a throat length of 7.25 diameters, and a diffuser included angle of 8°6' (0.141 rad). The nozzles had exit diameters corresponding to nozzle- to throat-area ratios of 0.066 and 0.197. Each nozzle was operated at several spacings of the nozzle exit upstream from the throat entrance over a range of from 0 to 3 throat diameters. At small nozzle spacings (up to 1 throat diameter) a simple one-dimensional analysis predicted performance quite closely. The theory also demonstrated that low efficiencies exhibited at low ratios of secondary to primary (high pressure) flows are due to inefficient mixing, whereas low efficiencies at high flow ratios are due largely to friction losses. A modified theory, which attempted to account for the effect of the mixing profile in the throat, required more computational effort and did not improve correlation with experimental performance. Author

N68-19307*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

SHAPING OF PRECIPITATION-HARDENING STAINLESS STEELS BY CASTING AND POWDER-METALLURGY

J. G. Kura, V. D. Barth, and H. O. McIntire [1968] 51 p refs Prepared by Army Missile Command and Battelle Mem. Inst.

(NASA Order H-76715; Contract DA-01-021-AMC-11651(Z))

(NASA-SP-5086; RSIC-491) CFSTI: HC $3.00/MF $0.65 CSCL 13H

The state of the art of making shapes of precipitation-hardenable stainless steels by methods other than machining from wrought materials is reviewed. The methods reviewed are casting and powder metallurgy. Of these methods, only casting is extensively practiced. Powder metallurgy is a promising procedure for 17-4 PH stainless, but techniques are not well advanced for handling the grades that contain titanium or aluminum such as PH 15-7 Mo and A-286. Author

N68-19343*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

SURFACE TREATMENTS FOR PRECIPITATION-HARDENING STAINLESS STEELS

[1967] 64 p refs Prepared by Battelle Memorial Inst.

(Contract DA-01-021-AMC-11651(Z))

(NASA-SP-5090; RSIC-595) CFSTI: HC $3.00/MF $0.65 CSCL 13H

In this report, selected surface treatments that are applied to precipitation-hardenable stainless steels are discussed. The treatments covered are hard surfacing, electroplating, electroless plating, carburizing and decarburizing, nitriding, burnishing and other finishing operations, explosive hardening, planishing, and peening. Each treatment is described and its application to the precipitation-hardenable stainless steels is discussed. Reasons for using the treatments are discussed, problem areas are identified, and recommendations for research are made. Author

N68-20056*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

ADHESIVE BONDING OF STAINLESS STEELS INCLUDING PRECIPITATION-HARDENING STAINLESS STEELS

R. E. Keith, M. D. Randall, and R. C. Martin [1966] 125 p Prepared by Battelle Memorial Inst.

(Contract DA-01-021-AMC-11651(Z))

(NASA-SP-5085; RSIC-599) CFSTI: HC $3.00/MF $0.65 CSCL 13H

The state of the art of adhesive bonding of stainless steels and precipitation-hardened stainless steels is given. The advantages and disadvantages of adhesive bonding are discussed along with typical joint designs, surface preparation procedures, and environmental factors that influence choice among the available adhesives and processing techniques. The bonding of stainless steels with organic and inorganic adhesives is discussed in relation to the preparation of the adherend surfaces and joints, the tests and standards for selecting the adhesive, and the testing and inspection of the adhesive bond. B.S.D.

N68-20199*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RESIDUAL STRESS AND SUBSURFACE HARDNESS CHANGES INDUCED DURING ROLLING CONTACT

David W. Reichard, Richard J. Parker, and Erwin V. Zaretsky Washington Apr. 1968 31 p refs

(NASA-TN-D-4456) CFSTI: HC $3.00/MF $0.65 CSCL 13I

Subsurface residual stress measurements were made on SAE 52100 steel inner races from 207-size deep-groove ball bearings in which ΔH (ball hardness minus race hardness) ranged from -1.1 to 3.5 points Rockwell C. Nominal Rockwell C hardness of the inner and outer races was 63. These bearings had been run at an inner-race speed of 2750 rpm and a radial load of 1320 pounds (5874 N) producing maximum Hertz stresses of 352,000 and 336,000 psi (2425×10^6 and 2315×10^6 N/m^2) at the inner and outer races, respectively. The lubricant was a super-refined naphthenic mineral oil. The residual stress measurements were made of various depths below the inner-race running track surface for a total of 19 of these bearings that had been run for nominally 200, 600, and 1600 hours. The measurements indicated that the maximum compressive residual stresses occur in approximately the same ΔH range for which the maximum fatigue lives were observed.

Additionally, no relation between running time and residual stress could be determined from these measurements. Although a subsurface hardness decrease was evident in all cases, no relation between these changes and ΔH or running time could be determined. Author

N68-20325*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
WEAR RATE AND FRICTION COEFFICIENT IN LIQUID NITROGEN AND HYDROGEN OF STEEL SLIDING ON POLYMER LAMINATES (VARIOUS FABRICS AND POLYMERS)
Donald W. Wisander and Robert L. Johnson Washington Apr. 1968 15 p refs
(NASA-TN-D-4463) CFSTI: HC $3.00/MF $0.65 CSCL 11I

The polymers included PTFE (polytetrafluoroethylene), phenolic, epoxy, and melamine; the fabrics included glass, graphite, nylon, and cotton. The reference material used was not a laminate (80% PTFE, 15% glass fiber, and 5% graphite). Wear and friction experiments were conducted with a 3/16-inch- (4.8-mm-) radius hemispherical rider sliding on a flat disk, which was rotated to produce sliding velocities of 2300 feet per minute (701 m/min). The 304 stainless steel riders were under a 1-kilogram load against the polymer laminate disks. The results indicate that the graphite-fabric phenolic laminate is a potentially useful material for sliding contact in liquid nitrogen and that glass-fabric PTFE and graphite-fabric PTFE laminates are potentially useful in both liquid nitrogen and liquid hydrogen. The wear rates and coefficients of friction of 304 stainless-steel riders against the laminates were appreciably lower in liquid nitrogen than in liquid hydrogen Author

N68-20389*# General Electric Co., Schenectady, N. Y.
LEAKAGE TESTING HANDBOOK
J. William Marr Washington NASA Apr. 1968 461 p refs Prepared for JPL
(Contract NAS7-396).
(NASA-CR-952; S-67-1014) CFSTI: HC $3.00/MF $0.65 CSCL 14D

Theory of leakage testing is described; and individual methods of leakage testing, their limitations, sensitivities, and methods of use are delineated. The distinction between leakage measurement and leak location is considered in this handbook that also discusses reasons for leak testing, techniques of using leak testing equipment, flow characteristics encountered in leaks, necessary equipment and safety measures, and standards and calibration. Procedure for writing a leakage specification is given, and a guide is presented for selecting appropriate testing methods. Mass spectrometry, heated anode halogen detection, pressure change procedure, flow measurement, bubble testing, and radioisotope procedures are described. Other techniques considered are the halide torch, sonic detection, light absorption, chemical methods, high voltage discharges, and vacuum gauge responses. Several miscellaneous procedures are noted; and properties of tracer gases and precautions for their use are discussed. M.W.R.

N68-20433*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THERMAL AND MECHANICAL TREATMENT FOR PRECIPITATION-HARDENING STAINLESS STEELS
C. J. Slunder, A. F. Hoenie, and A. M. Hall [1967] 207 p refs Sponsored jointly with AEC Prepared by Battelle Mem. Inst. for Redstone Sci. Inform. Center
(NASA Order H-76715; Contract DA-01-021-AMC-11651(Z))
(NASA-SP-5089; RSIC-600) CFSTI: HC $3.00/MF $0.65 CSCL 13H

The thermal and mechanical treatments employed in the production and fabrication of precipitation-hardenable stainless steels are discussed. Particular emphasis is directed to the interaction of the processing variables and their effects on fabricability and mechanical properties. Equipment and procedures are described as well as problems likely to be encountered and precautions to be observed in processing. Detailed processing information is presented for the precipitation-hardenable stainless steels considered to be applicable for missile and aerospace applications. Author

N68-21226*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
INFLUENCE OF CRYSTAL STRUCTURE, ORIENTATION, AND SOLUBILITY ON ADHESION AND SLIDING FRICTION OF METAL SINGLE CRYSTALS IN VACUUM
Donald H. Buckley Washington Apr. 1968 22 p refs
(NASA-TN-D-4347; ASTM-STP-431) CFSTI: HC $3.00/MF $0.65 CSCL 11F

An investigation was conducted on the relation of friction to the adhesion or cohesion of metals in vacuum. Metal single crystals were used to determine planes, surface energy, work hardening, and crystal structure on friction and adhesion. The following characteristics were examined: (1) atomic plane matching across an interface, (2) the effect of plane atomic density, (3) orientation of coupled metals, (4) mutual solubility, and (5) the effect of crystal structure. The metal couples examined included the copper plane pairs: (100) on (100), (110) on (110), and (111) on (111), all three pairs matched planes and directions; and (110) on (100) and (111) on (100). The (111) plane of copper was also examined in contact with planes (0001) of cobalt, (111) of nickel, and (110) of tungsten. The (0001) plane of cobalt was also studied in contact with itself. The results of this investigation indicate that adhesion is markedly increased by small amounts of unidirectional sliding of the surfaces in contact. The adhesion measurements correlated with the friction coefficients; high friction coefficients were always accompanied by high adhesive forces. Author

N68-21241*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
MACHINING AND GRINDING OF ULTRAHIGH-STRENGTH STEELS AND STAINLESS STEEL ALLOYS
C. T. Olofson, J. A. Gurklis, and F. W. Boulger Redstone Arsenal, Ala. Redstone Sci. Inform. Center [1968] 217 p refs Prepared by Battelle Mem. Inst.
(NASA Order H-76715; Contract DA-01-021-AMC-11651(Z))
(NASA-SP-5084; RSIC-501) CFSTI: HC $3.00/MF $0.65 CSCL 13H

The state of the art of metal-removal operations for stainless and ultrahigh-strength steels is presented. It describes the methods currently employed for conventional machining, grinding, electrolytic, electric-discharge, and chemical-machining processes. The precautions that should be taken to avoid troubles resulting from the characteristics typical of these alloys are pointed out. Nine machining, two grinding, two cutting, and three unconventional metal-removal operations are discussed separately. Other sections discuss the classification of these alloys and their general response to machining variables. Author

N68-21429*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
WELDING OF PRECIPITATION-HARDENING STAINLESS STEELS
J. J. Vagi, R. M. Evans, and D. C. Martin [1968] 194 p refs Prepared by Battelle Memorial Inst.
(Contract DA-01-021-AMC-11651(Z))
(NASA-SP-5087; RSIC-598) CFSTI: HC $3.00/MF $0.65 CSCL 13H

The state of the art of the welding of precipitation-hardening stainless steels is reviewed. Welding preparations, specific welding processes, welding dissimilar metals, and joint quality are discussed. Author

N68-21898*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EVALUATION OF TANTALUM-TO-STAINLESS-STEEL TRANSITION JOINTS

Adolph C. Spagnuolo Washington Apr. 1968 29 p refs

(NASA-TM-X-1540) CFSTI: HC $3.00/MF $0.65 CSCL 13E

Tantalum-to-stainless-steel bimetallic transition joints were tested to determine the overall strength of the brazed joint. Tensile tests were conducted on flat sheet and tubular specimens at elevated temperatures 1350°F and vacuum levels of 10^{-7} to 10^{-6} torr. Studies were also conducted to determine if any unfavorable interdiffusion embrittlement was taking place between the braze material and the parent metals. A 2.5-inch diameter by 0.125-inch wall bimetallic joint was subjected to the temperature 1350°F and pressure 350 psia levels expected in a liquid metal loop including 20 temperature cycles between 600°F and 1350°F. The tests indicated: (1) The parent material in all tensile specimens ruptured first, leaving the brazed area intact. (2) No significant interdiffusion occurred between the braze and the parent metals. (3) The 2.5-inch diameter tube remained leak tight after 150 hours of testing at 1350°F and 350 psia. Ultimate and yield strength data are also included for unalloyed tantalum rods, plate and sheet test specimens at 1350°F at vacuum levels of 10^{-8} to 10^{-7} torr. Author

N68-21965*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTS ON STABILITY OF HERRINGBONE GROOVED GAS-LUBRICATED JOURNAL BEARINGS TO HIGH COMPRESSIBILITY NUMBERS

Robert E. Cunningham, David P. Fleming, and William J. Anderson Washington Apr. 1968 21 p refs

(NASA-TN-D-4440) CFSTI: HC $3.00/MF $0.65 CSCL 13K

Experiments were conducted with six rotors, 1-1/2 inches (3.8 cm) in diameter by 12-1/4 inches (31.1 cm) long and equipped with two herringbone-grooved journals. These rotors were operated in plain cylindrical sleeves to high compressibility numbers with ambient air as a lubricant. Vertical orientation of the rotors without any applied radial load presented a test condition most conducive to existing half-frequency whirl (HFW). These experiments showed that HFW threshold speeds are very much dependent on radial clearance. Five rotors running at clearances from 370 to 500 microinches (9.4 to 12.7 μm) did not whirl up to the limiting speed of the air turbine drive. When the same rotors were operated at clearances ranging from 550 to 710 microinches (14 to 18 μm), HFW was experienced at fairly low speed ranges of from 14,750 to 27,900 rpm. Limited test results comparing a fully grooved with a partially grooved rotor showed the fully grooved rotor to be stable up to 60,830 rpm. The partially grooved rotor having the same operating parameters except for groove length exhibited HFW at 27,900 rpm. Agreement between experimental and theoretical results is generally quite good. Based on these results the theory tends to be somewhat conservative in defining zones of unstable operation. Author

N68-21979*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A REVIEW OF LUBRICATION OF SLIDING AND ROLLING-ELEMENT ELECTRICAL CONTACTS IN VACUUM

John S. Przybyszewski Washington Apr. 1968 33 p refs

(NASA-TN-D-4476) CFSTI: HC $3.00/MF $0.65 CSCL 11H

The operation of sliding- or rolling-element electrical contacts in vacuum presents a problem because of the occurrence of high noise levels, high coefficients of friction and excessive wear rates due to the absence of beneficial surface films. Thin metallic films are seen as a promising method of lubrication. Three methods of thin film deposition and the endurance lives of these films (obtained from friction experiments) are discussed. On the basis of the reviewed experimental data, some conclusions are made regarding the performance of the various electric contact materials and lubricants in vacuum. Author

N68-22778*# National Aeronautics and Space Administration, Washington, D. C.

METHOD OF BRAZING ALUMINUM TO STAINLESS STEEL FOR HIGH-STRESS-FATIGUE APPLICATIONS

D. C. Martin 1968 16 p refs Prepared by Battelle Memorial Inst.

(NASA-SP-5040) CFSTI: HC $3.00/MF $0.65 CSCL 13H

A procedure for minimizing the formation of intermetallic compounds in aluminum-stainless steel joints is discussed that uses a titanium coating on the stainless steel to act as a diffusion barrier. This Ti alloy layer is coated with an aluminum-silicon alloy, and the joint is made by brazing the Al part to the coated stainless steel part. In the case of an age-hardenable Al part, aging takes place after brazing. Applications of the procedure are mentioned; problems of joining Al to iron-base alloys are noted; and diffusion barrier for Ti and Al coatings, brazing, and joint properties are discussed. M.W.R.

N68-22810*# Case Inst. of Tech., Cleveland, Ohio.

A CRITICAL EVALUATION OF THE STATUS AND TRENDS IN HIGH SPEED FLUID FILM LUBRICATION

E. S. Kulinski and S. Ostrach Washington NASA May 1968 25 p refs

(Grant NGR-36-003-004)

(NASA-CR-1058) CFSTI: HC $3.00/MF $0.65 CSCL 11H

High speed lubrication (also denoted as turbulent and superlaminar lubrication) and relevant parts of the fluid mechanics literature are reviewed. It is contended on the basis of this review that existing turbulent journal bearing calculations are predicted on an unrealistic characterization of the lubricant film. Furthermore, an order-of-magnitude argument is presented which indicates that the neglect of inertial terms in the governing equations of turbulent lubrication is incorrect. It is concluded that fundamental investigations on the structure of high speed lubricant films must precede the formulation of an adequate theory, and the nature of these investigations is discussed. Author

N68-23356*# Chrysler Corp., Huntsville, Ala.

DESIGN HANDBOOK UMBILICAL LOCKING MECHANISM DEVELOPMENT PROGRAM

David L. Cusick Washington NASA May 1968 72 p

(Contract NAS8-20649)

(NASA-CR-1021) CFSTI: HC $3.00/MF $0.65 CSCL 13E

This handbook presents the techniques, developed in an intensive testing program, for use in designing ball-lock mechanisms for use on space vehicle umbilicals. In addition to the general design of this locking device and its component parts, this handbook covers the effects of component surface conditioning, temperatures from ambient to minus 196 degrees Centigrade (°C), materials and material hardness, and forces on the locking device up to 5000 pounds. Author

N68-23900*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE RELEASE OF HYDROGEN ON BALL MILLING CHROMIUM IN WATER

Alan Arias Washington May 1968 23 p refs

(NASA-TN-D-4569) CFSTI: HC $3.00/MF $0.65 CSCL 13H

During the ball milling process, chromium powder reacted with the water used as the grinding medium, and hydrogen was evolved. A film composed of Cr_2O_3 and CrO_2 formed on the powder surface during this reaction. This film was calculated to be about 6.7 Å (0.00067 μm) thick. Although the specific surface area of the powder continuously increases, a large proportion of the particles also became welded to each other during the milling process. The welding sandwiched the oxide films between the powder particles. For this reason, the ratio of oxide formed to measured surface (and apparent thickness of the film) increase with ball-milling time. Author

N68-24142*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FRICTION AND WEAR IN CRYOGENIC LIQUIDS FOR COMPOSITES OF PHENOLIC AND OF POLYTETRAFLUOROETHYLENE OF VARIOUS PARTICLE SIZES AND CONCENTRATIONS

Donald W. Wisander, Lawrence P. Ludwig, and Robert L. Johnson Washington May 1968 17 p refs

(NASA-TN-D-4565) CFSTI: HC$3.00/MF$0.65 CSCL 11D

Experiments conducted with phenolic-PTFE (polytetrafluoroethylene) composites sliding against 440-C steel in liquid nitrogen and in liquid hydrogen showed that lubricating properties of phenolic can be improved by the addition of as little as 15 weight percent of PTFE. Experiments further showed that 15 weight percent PTFE of the 0.2- to 8-micron particle size gave the best results in both liquid nitrogen and in liquid hydrogen. Compressive-modulus and shear-strength tests at room temperature and in liquid nitrogen indicated that these properties were reduced by a factor of 2 to 3 by the addition of 15 weight percent PTFE. Author

N68-24456*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COOLING STUDIES WITH 40-MILLIMETER-BORE BALL BEARINGS USING LOW FLOW RATES OF 60°R (33°K) HYDROGEN GAS

David E. Brewe, Harold H. Coe, and Herbert W. Scibbe Washington Jun. 1968 27 p refs

(NASA-TN-D-4616) CFSTI: HC$3.00/MF$0.65 CSCL 13I

Experiments and analyses were performed to determine ball bearing cooling requirments at shaft speeds to 35,000 rpm and thrust loads to 400 pounds (1780 N). A bronze-filled polytetrafluoroethylene retainer was used to lubricate the bearings. Bearing outer-race temperature varied as the inverse of hydrogen gas flow rate through the bearing. From this inverse relation, a minimum flow equation was developed for the range of bearing operating conditions. The minimum flow rate required for bearing cooling was more sensitive to speed than to load increases. Film transfer to the inner-race grooves and retainer wear are indicated and discussed. Author

N68-25042*# Mechanical Technology, Inc., Latham, N. Y. Pratt and Whitney Aircraft, East Hartford, Conn.

RESEARCH AND DEVELOPMENT OF HIGH PERFORMANCE AXIAL-FLOW TURBOMACHINERY. VOLUME 2: DESIGN OF GAS BEARINGS

P. W. Curwen Washington NASA May 1968 332 p refs Prepared for Pratt and Whitney Aircraft

(Contract NAS3-4179)

(NASA-CR-801) CFSTI: HC$3.00/MF$0.65 CSCL 13I

Three variations of a basic gas-bearing rotor-support system have been designed, built, and tested for the NASA Brayton cycle axial-flow turbocompressor. The designs were experimentally evaluated in a full-scale rotor-bearing system test rig. All three bearing system designs performed satisfactorily and successfully passed the required acceptance tests. The final design represents a minimum bearing-friction-loss design consistent with whirl-free operation of the rotor. Following acceptance testing of the initial gas-bearing rotor-support system, an attempt was made to attain a 61% reduction in total journal bearing friction loss by modifying the bearings to operate at larger clearances. Upon test of the modified design, a low-frequency, stable rotor-whirl phenomenon was observed in the turbine bearing as the clearance was being increased to the larger value. Until the whirl phenomenon is better understood, it is recommended that the diametral clearances of the journal bearings be maintained at $\leq$0.00135 inches. This will assure whirl-free operation of the rotor. At these clearances, the final design represents a 34.3% reduction in total journal bearing friction loss relative to the initial design. Author

N68-28241*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OPERATION OF A LIQUID FLUORINE PUMP IN CAVITATING FLOW AT AN INDUCER TIP SPEED OF 188 FEET PER SECOND (57.3 M/SEC)

Walter M. Osborn Washington Jun. 1968 15 p refs

(NASA-TM-X-1573) CFSTI: HC$3.00/MF$0.65 CSCL 13K

A combination cavitating inducer and main-stage impeller was operated in liquid fluorine for 36 minutes. The inducer tip relative flow velocity was approximately 188 feet per second. Both noncavitating and cavitating pump performance are presented. For approximately 18 minutes the inducer was operating with moderate to heavy cavitation. No cavitation damage was experienced. Titanium carbide cermet with nickel binder and aluminum oxide performed adequately as seal materials. Author

N68-28249*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

THE USE OF THE ELECTRON PROBE MICROANALYZER IN MATERIALS RESEARCH AND DEVELOPMENT

Lawrence Kobren Washington Jun. 1968 25 p refs

(NASA-TN-D-4526) CFSTI: HC$3.00/MF$0.65 CSCL 14B

The electron probe microanalyzer, a versatile tool for the analysis of areas as small as one micron in diameter, has been used at Goddard Space Flight Center in applications ranging from materials research to analysis of failures in mechanical parts. Methods of using the probe and representative results obtained are illustrated by several examples that include bonding of thermoelectric materials, alloy development, and analysis of materials failures. Author

N68-28258*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF BALL-RACE CONFORMITY ON SPINNING FRICTION

Marshall W. Dietrich, Richard J. Parker, and Erwin V. Zaretsky Washington Jul. 1968 19 p refs

(NASA-TN-D-4669) CFSTI: HC$3.00/MF$0.65 CSCL 13I

Tests were conducted in the NASA spinning friction apparatus with SAE 52100 steel specimens with ball-groove conformities of infinity (ball on a flat), 60, 55, and 51 percent. The coefficient of spinning friction decreased with increasing maximum Hertz stress to a minimum value of approximately 0.05. For a constant stress, the coefficient of spinning friction increased with decreasing conformity (increasing percent conformity). Spinning torque increased with increasing stress for each conformity tested. For a given stress, spinning torque decreased with decreasing conformity. Author

N68-28260*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF CRYSTAL TRANSFORMATION AND ATOMIC ORDERING ON FRICTION AND WEAR OF TWO COBALT-BASE ALLOYS IN VACUUM

William A. Brainard and Donald H. Buckley Washington Jul. 1968 19 p refs

(NASA-TN-D-4668) CFSTI: HC$3.00/MF$0.65 CSCL 20K

The effect of crystal and order-disorder tranformations on friction and wear for Be–Co and FeCo alloys were studied in sliding friction experiments in vacuum at elevated temperatures. The results show that friction increases fourfold for the beryllium–cobalt alloy during tranformation and that friction remains high until the reverse or cooling transformation occurs. The friction and wear of Be–Co are markedly superior to 440-C stainless steel. The order-disorder transformation in FeCo increases friction by a factor of 30 and also significantly increases wear. Increased sliding speed and loading affect the transformation. The friction behavior during heating is in good agreement with the type of order-temperature relation in FeCo. Author

N68-28766*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY EVALUATION OF GREASES TO 316°C AND SOLID LUBRICANTS TO 816°C IN BALL BEARINGS
Harold E. Sliney and Robert L. Johnson Washington NASA Jul. 1968 21 p refs
(NASA-TN-D-4652) CFSTI: HC$3.00/MF$0.65 CSCL 11H

A special apparatus designed for the evaluation of high-temperature lubricants in 20-mm-bore ball bearings is described. The results of bearing runs at temperatures up to 1500°F in air are reported. At 450° and 600°F, a fluorocarbon grease lubricated the 440-C steel bearings for longer times than did polyphenyl ether and silicone greases thickened with dyes and/or MoS_2. Cobalt alloy ball bearings, lubricated either with barium fluoride–calcium fluoride coatings bonded to the cages or with porous metal cages impregnated with these fluorides, ran successfully at 1200° and 1500°F under a thrust load of 30 lb and at a shaft speed of 5000 rpm. Author

N68-28871*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FRICTION AND WEAR UNDER FRETTING CONDITIONS OF MATERIALS FOR USE AS WIRE FRICTION DAMPERS OF COMPRESSOR BLADE VIBRATION
Max A. Swikert and Robert L. Johnson Washington Jul. 1968 17 p refs
(NASA-TN-D-4630) CFSTI: HC$3.00/MF$0.65 CSCL 13I

Friction dampers are required to reduce the magnitude of vibrational stresses in high aspect ratio blading of compressors for advanced aircraft turbine engines. Fretting is a common problem with all types of friction dampers. Fretting experiments with simulated wire lace blade damping were conducted with Inconel 600. Experiments were run with or without oxide coatings in contact with maraging steel. Although two methods were used to form the oxide, high friction and low wear occurred with both. Further wear experimentation with oxidized material rubbing against itself showed that friction and wear were decreased by operation at a higher temperature (500°F). Author

N68-29918*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INFLUENCE OF SURFACE ACTIVE AGENTS ON FRICTION, DEFORMATION, AND FRACTURE OF LITHIUM FLUORIDE
Donald H. Buckley Washington Aug. 1964 29 p refs
(NASA-TN-D-4716) CFSTI: HC$3.00/MF$0.65 CSCL 11H

Sliding friction experiments were conducted with lithium fluoride crystals in various environments. These included air, water, hexadecane without and with various organic acids, and a paraffinic oil containing oleic acid. Sliding was on the (001) plane in the [100] direction at a speed of 0.005 millimeter per second and under loads of 5 to 200 grams on a millimeter-diameter sapphire rider which contacted the lithium fluoride flat. The results indicate that the presence of surfactants influences deformation and fracture in lithium fluoride. Crystals deform plastically more readily with an adsorbed organic acid than without it; this is the Rehbinder effect. Friction coefficient was influenced by the presence of the acid, its chain length, and its concentration. Author

N68-31478*# Research Triangle Inst., Durham, N. C.
PRACTICAL RELIABILITY. VOLUME 1: PARAMETER VARIATIONS ANALYSIS
Washington NASA Jul. 1968 92 p refs (Contract NASw-1448)
(NASA-CR-1126) CSCL 14D

Concepts such as model, randomness, statistical ignorance, and statistical independence are explored and explained. The effects of variations of parameters can be evaluated by changing components in a physical model or by creating a conceptual/mathematical model of the system and then analyzing it. There are only a very few basic techniques for analysis of mathematical models and these are rather extensively treated. The uses to which these models and their analyses may be put are many and only a few of these are treated such as sensitivity and worst-case analyses, and calculation where extreme extrapolation is necessary. There is a brief discussion of the sources and uses of variations data both in purchased and in manufactured items. A series of appendices gives some mathematical details, thus saving constant reference to other books. Author

N68-31522*# National Aeronautics and Space Administration, Washington, D. C.
LUBRICATION, CORROSION AND WEAR. A CONTINUING BIBLIOGRAPHY WITH INDEXES
Jul. 1968 240 p refs
(NASA-SP-7020(02)) CFSTI: HC$3.00/MF$0.65 CSCL 11F

This publication is the second supplement to the continuing bibliography *Lubrication, Corrosion and Wear*. It contains references to reports and journal articles on lubricating systems, design and performance of bearings; special applications of lubricants, e.g., as heat transfer and anticorrosion agents; stress corrosion and fatigue cracking in metals and alloys; friction and wear characteristics of materials; and corrosion types and techniques for corrosion prevention. In addition, references describing the instrumentation and methods for the testing of lubricants are included. Author

N68-31979*# Research Triangle Inst., Durham, N. C.
PRACTICAL RELIABILITY. VOLUME 4: PREDICTION
C. A. Krohn et al Washington NASA Aug. 1968 168 p refs
(Contract NASw-1448)
(NASA-CR-1129) CFSTI: HC$3.00/MF$0.65 CSCL 14D

The features and techniques of reliability prediction are identified and brought together in this report. Part I is largely qualitative discussion concerned with introduction and perspective. Contents include discussion and opinions on the role of reliability prediction, on perspective features, e.g. program phase and hardware level, on the relation to other analyses, and on the problems. Part II is concerned with reliability measures or definitions concerning single items, including data sources. Part III is devoted to the reliability prediction techniques which are suitable for general use and to classical reliability models. This material is scattered throughout the references; the treatment here mainly identifies approaches and relates them, with reliance on the references. Included for multi-item models are logic, lifetime, environment and bound-crossing topics. The remaining Part IV is concerned with concepts related to the detailed treatment of failure modes without independence assumptions. This is food-for-thought material from the results of research on reliability prediction techniques. This material in Part IV, in general, is not suited for widespread application. The Appendix presents a ready reference on some basic probability laws and on various probability distributions. Author

N68-31980*# Research Triangle Inst., Durham, N. C.
PRACTICAL RELIABILITY VOLUME 5: PARTS
B. M. Berry Washington NASA Jul. 1968 78 p refs
(Contract NASw-1448)
(NASA-CR-1130) CFSTI: HC$3.00/MF$0.65 CSCL 14D

Parts reliability and associated problems are discussed. This includes those functions—selections, specification, verification, review processes, and data sources—which are involved in a successful parts program. Some of the costs associated with these functions are discussed and an attempt is made to define an ideal data bank. Author

N68-32760*# Research Triangle Inst., Durham, N. C.
PRACTICAL RELIABILITY. VOLUME 2: COMPUTATION
Washington NASA Aug. 1968 138 p refs
(Contract NASw-1448)
(NASA-CR-1127) CFSTI: HC$3.00/MF$0.65 CSCL 14D

This report places in perspective the role of automatic digital computations in design for reliability. It is intended for the design engineer, the systems engineer, and the test engineer as well as

the reliability specialist. The degree of detail with which the various topics are treated is sufficient to enable the engineer not previously familiar with the subject to properly select and use the methods presented. The report first briefly describes the computer, how it is used, and some of the mathematical problem types that are amenable to computer solution. The orientation to reliability is then provided in a brief perspective of reliability tasks and the relation of the computer to them. Later sections treat specific reliability tasks and explore the mathematical methods related to them and how the computer is used to implement them. Some specific computer programs are identified and their uses illustrated by examples. Parameter variation analysis and reliability prediction are treated. The last section treats some recent developments in communicating with the computer which make it more suitable to engineering and reliability applications. Author

N68-32779*# Research Triangle Inst., Durham, N. C.
PRACTICAL RELIABILITY. VOLUME 3: TESTING
Washington NASA Aug. 1968 298 p refs
(Contract NASw-1448)
(NASA-CR-1128) CFSTI: HC $3.00/MF $0.65 CSCL 14D

Testing is discussed from an engineering viewpoint. The subject is structured in terms of basic test types, basic problem types amenable to treatment by the basic test types, and applications of testing in hardware programs. The emphasis is on basic principles and practical problems in implementing them. Generally, the discussion emphasizes testing for reliability rather than reliability testing in the formal sense. Part I is devoted to concepts, definitions and general procedures. In particular, a section on test classifications considers the many ways of viewing tests and some of the prevalent confusion in terminology is resolved. Parts II and III collectively treat the basic test and problem types. The manner of separating these discussions into the two parts serves to highlight an important consideration in testing which is often overlooked, viz., whether or not aging is important. Part IV contains discussions on several subjects including nondestructive testing, environmental testing, and accelerated testing which are common to several or all of the basic test types. Part V surveys the major applications of testing in hardware programs and draws special attention to applications associated with reliability. An Appendix contains discussions of the mathematical topics pertinent to testing. Author

N68-32977*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXTRUSION OF 1/2 AND 3/8-INCH-DIAMETER THIN-WALL TUNGSTEN TUBING IN LENGTHS NEAR 10 FEET
Charles Blankenship and Charles A. Gyorgak Washington Aug. 1968 15 p refs
(NASA-TM-X-1638) CFSTI: HC $3.00/MF $0.65 CSCL 13H

Thin-wall tungsten tubing was extruded in lengths of 7.5 to 10.6 feet (2.3 to 3.2 m) using the floating mandrel technique. Tubing diameters were either 1/2 or 3/8 inch (1.27 or 0.95 cm), and nominal wall thicknesses were 0.020 inch (0.05 cm). In most of the tubes, variations in diameter and wall thickness over a length of 8 to 10 feet (2.5 to 3 m) were less than 0.020 and 0.008 inch (0.05 and 0.02 cm), respectively. Feasibility of warm drawing (1300° F or 700° C) the extruded tubing was demonstrated. Drawing greatly improved tubing surface finish and dimensional tolerances. Author

N68-33227*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INFLUENCE OF CHEMISORBED FILMS OF VARIOUS GASES ON ADHESION AND FRICTION OF TUNGSTEN IN VACUUM
Donald H. Buckley Washington Sep. 1968 25 p refs
(NASA-TN-D-4694) CFSTI: HC $3.00/MF $0.65 CSCL 11H

An investigation was conducted to determine the effect of various adsorbed gaseous species on the adhesion and friction of tungsten. Experiments were conducted in a vacuum of 10^{-10} (1.33×10^{-8} N/m^2) with a hemispherical rider specimen ((100) tungsten) contacting a flat. The atomic planes of tungsten examined on the flat included the (100), (110), and the (210). The gases adsorbed to these tungsten surfaces included hydrogen, oxygen, carbon dioxide, hydrogen sulfide, and a homologous series of hydrocarbons (methane through decane), as well as ethylene and acetylene. The results of the study indicate that the presence of any gas, even hydrogen, on the tungsten surface will reduce adhesion and friction. Less than a monolayer of oxygen adsorbed on tungsten is sufficient to reduce appreciably the friction of tungsten crystals. For hydrocarbons, an increase in chain length (methane through decane) resulted in a progressive decrease in friction. Furthermore, with ethane, ethylene, and acetylene, friction decreased with increasing bond saturation. Author

N68-36075*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FATIGUE LIFE OF 120 mm BORE BALL BEARINGS AT 600°F WITH FLUOROCARBON, POLYPHENYL ETHER, AND SYNTHETIC PARAFFINIC BASE LUBRICANTS
Eric N. Bamberger (G.E., Cincinnati), Edwin V. Zaretsky, and William J. Anderson Washington Oct. 1968 27 p refs
(NASA-TN-D-4850) CFSTI: HC $3.00/MF $0.65 CSCL 13I

Groups of 120-mm bore angular-contact ball bearings made from AISI M-50 steel were fatigue tested at a temperature of 600°F and a speed of 12,000 rpm with a synthetic paraffinic oil, a fluorocarbon, and a 5P4E polyphenyl ether. Under a low oxygen environment, the synthetic paraffinic oil and the fluorocarbon gave bearing lives approximately 14 and 3 times AFBMA-predicted (catalog) life, respectively. With the polyphenyl ether, bearing life was less than AFBMA-predicted (catalog) life in an air environment. For the synthetic paraffinic oil and the fluorocarbon, bearing fatigue was subsurface initiated. For the polyphenyl ether, bearing failure was mainly from surface distress, wear, and superficial pitting. Author

N68-36098*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INCOMPRESSIBLY LUBRICATED RAYLEIGH STEP JOURNAL BEARING. 1: ZERO-ORDER PERTURBATION SOLUTION
Bernard J. Hamrock and William J. Anderson Washington Oct. 1968 33 p refs
(NASA-TN-D-4839) CFSTI: HC $3.00/MF $0.65 CSCL 13I

A theoretical analysis of the pressure distribution, load capacity, load angle, and friction force for a single-step concentric journal bearing is performed. The resulting expressions were evaluated on a digital computer. The maximum load capacity is obtained when the ratio of the step clearance to ridge clearance is 1.7 and the ratio of the angle subtended by the ridge to the angle subtended by the pad is 0.35. Finally, for relatively small radius-to-length ratios, the load capacity of the stepped journal, while concentric, is higher than the load capacity of a finite-length Sommerfeld bearing operating with an eccentricity ratio of 0.1. Author

N68-37214*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CRITICAL SPEED ANALYSIS OF RIGID ROTORS ON FLEXIBLE FOUNDATIONS
Richard H. Cavicchi Washington Oct. 1968 47 p refs
(NASA-TN-D-4858) CFSTI: HC $3.00/MF $0.65 CSCL 13I

A critical speed analysis of undamped rigid rotors on flexible foundations reveals four conical mode solutions comprising forward and backward precession. There is also a two solution bouncing mode set dependent only on foundation to rotor mass and spring constant ratios. Although analysis of a firm foundation model omits two of the four conical mode solutions, close agreement exists

between the two corresponding solutions. The flexible foundation analysis reduces to a simple firm foundation result when the foundation to rotor spring constant ratio is zero or infinite. Only three calculations are needed in this range to cover all intermediate values. Author

N68-37239*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE ROLE OF CHEMICAL REACTIONS IN THE MECHANISM OF COMMINUTION OF DUCTILE METALS INTO ULTRAFINE POWDERS BY GRINDING

Alan Arias Washington Oct. 1968 32 p refs

(NASA-TN-D-4862) CFSTI: HC$3.00/MF$0.65 CSCL 13H

On grinding in pure water, zirconium, tantalum, iron, and stainless-steel powders were extensively comminuted and simultaneously oxidized with hydrogen release, whereas nickel, copper, and silver powders did not react with water and their particle sizes increase. On grinding nickel, copper, and silver in water pressurized with oxygen, nickel and copper became extensively comminuted and were oxidized, whereas silver did not react with oxygen and its particle size increased. From these results and other considerations, it is hypothesized that for extensive comminution of ductile metals and alloys to occur on grinding they must react with the grinding media. Author

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MASERS

Includes applications of masers and lasers. For basic research see: 26 Physics, Solid-State.

N68-10467*# TRW Systems, Redondo Beach, Calif.
PARTICLE ACCELERATION BY EVAPORATION PRESSURE
R. F. Wuerker Washington NASA Nov. 1967 104 p refs
(Contract NAS9-5113)
(NASA-CR-927; TRW-04848-6001-R0-000) CFSTI: HC $3.00/MF $0.65 CSCL 20E

Accelerating 100 micron sized particles to meteoric velocities of 20 km/sec was studied via focused radiation from a high intensity pulsed solid state laser system. The Q-switched mode gave the highest peak power and permitted operation at the threshold of material yield strength. A computation method developed for computing effective exhaust velocity directly from experimental values of initial mass, final mass, and terminal velocity of the particles was used to predict, via the rocket equation, the ratio of the amount of mass which would have to be ablated to take a given particle from rest to the 20 km/sec velocity. Titanium had an effective exhaust velocity of 4 to 6 km/sec, and from this an initial to final mass ratio of 0.0358 was computed. In other words, 96.4% of the original particles would have to be burned away to bring the remaining mass to the 20 km/sec velocity. Iron had an effective exhaust velocity of 5 km/sec. Although the effective exhaust velocities obtained were not large enough to accelerate matter to terminal velocities of 20 km/sec, the laser ablation approach appeared to be feasible for generating particles with velocities of about 10 km/sec. M.W.R.

N68-14070*# Sylvania Electric Products, Inc., Mountain View, Calif.
STUDY OF VIBRATION MEASUREMENT BY LASER METHODS
Gail A. Massey Washington NASA Jan. 1968 74 p refs
(Contract NAS2-3643)
(NASA-CR-985) CFSTI: HC $3.00/MF $0.65 CSCL 20E

Described are techniques for using laser radiation to detect and measure vibration of mechanical structures. Two methods were developed analytically and experimentally. One of these methods, the intermediate frequency optical heterodyne system, provides quantitative data about the motion of a particular very small area on the mechanical structure. The other method is a qualitative interference technique for observing the vibrational mode patterns, so that the number of points to be measured by other methods can be reduced. A breadboard optical heterodyne system was built, and detection of audio frequency vibrations at levels from one centimeter to less than 0.1 micron peak-to-peak has been achieved with a variety of surface materials. The performance of this system using two different types of demodulation circuits was investigated. A model structure was fabricated for tests involving comparisons of the qualitative and quantitative methods. It has been shown that a very good knowledge of the vibrational modes can be obtained using the two methods in combination. The qualitative interference method also has been extended to include the measurement of axes of rotation. Author

N68-29438*# National Aeronautics and Space Administration, Washington, D. C.
LASERS AND MASERS A Continuing Bibliography with Indexes, Apr.–Dec. 1967
Jun. 1968 366 p refs 3d Suppl. to NASA-SP-7009; See N65-25599
(NASA-SP-7009(03)) CFSTI: HC $3.00/MF $0.65 CSCL 20E

Bibliographic citations and informative abstracts are presented on all major studies associated with the research and development of lasers and masers. Emphasis is placed on laser and maser applications as they relate to ranging and communications systems, astronomy and optics, and metalworking. Fundamental studies of the physical and electronic properties, and the functioning and performance of lasers and masers are also cited. Subject and personal author indexes are included. Author

N68-33635*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
MICROWAVE PUMP REQUIREMENTS FOR FIELD OPERATIONAL BROADBAND RUTILE TRAVELING-WAVE MASERS
L. E. Rouzer Washington Sep. 1968 12 p refs
(NASA-TN-D-4764) CFSTI: HC $3.00/MF $0.65 CSCL 20E

This paper discusses microwave pump sources available for use in a field operational, rutile, broadband, traveling wave maser for the Applications Technology Satellite (ATS) program. Included is a brief resume of the current solid state microwave pump sources, klystrons, and the Hughes and OKI backward wave oscillators. The spin Hamiltonian for iron-doped rutile is given; its solution yields a pump frequency of 54.7 GHz and pump bandwidth of 500 MHz for a 4.065- to 4.195-GHz signal frequency. The suitability of the OKI backward wave oscillator for the application here considered has been determined; it is simple and comparatively inexpensive to operate in the field. The solid state modulator circuit capable of sweeping the OKI backward wave oscillator over 500 MHz is described; and the pump package, which maintains the tube temperature at 130°F (well within the operating range required by the tube) is discussed. Author

N68-35099*# Tennessee Univ., Tullahoma. Space Inst.
APPLICATION OF NEGATIVE FEEDBACK TO REDUCTION OF GLOW DISCHARGE NOISE
C. W. Bray, F. M. Shofner, and T. B. Carlson Washington NASA Sep. 1968 23 p refs
(Grants NGR-43-001-021; NSF GK-1638)
(NASA-CR-1173) CFSTI: HC $3.00/MF $0.65 CSCL 20F

Several researchers have studied the problem of discharge current modulation noise in the output radiation intensity of a d–c excited He–Ne laser. Work presented herein uses an analog circuit to demonstrate the feasibility of using negative feedback to reduce the discharge current noise and thereby reduce noise in the output radiation intensity. Author

N68-35175*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.
SURVEY OF CO_2 LASER DEVELOPMENT FOR SPACE APPLICATIONS
Thomas R. Lawrence Washington Sep. 1968 51 p refs
(NASA-TN-D-4794) CFSTI: HC $3.00/MF $0.65 CSCL 20E

This report presents the status of CO_2 laser development. The first application of a CO_2 laser is expected to be in the development and testing of an optical communication link from a synchronous orbit to Earth using heterodyne detection. The

transmitter for this link will be a small, low-powered, space-qualified CO_2 laser with stable, single frequency, single mode operation, and dependable, long operating life. In this report, the brief history of CO_2 laser development is surveyed and a simplified qualitative discussion of the CO_2 laser and the various additives is presented. Then the current level of development is compared to what is desired. It is found that the CO_2 laser is especially suited for single frequency operation; stable, single frequency CO_2 lasers have been built and tested in heterodyne communication systems in the laboratory. Many of the requirements for space qualification can be met by proper design. Author

N68-35593*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STUDY OF PLASMA DIAGNOSTICS USING LASER INTERFEROMETRY WITH EMPHASIS ON ITS APPLICATION TO CESIUM PLASMAS

Richard B. Lancashire Washington Sep. 1968 21 p refs
(NASA-TM-X-1652) CFSTI: HC$3.00/MF$0.65 CSCL 20I

A review of the background and current development of gas-laser diagnostics is presented. Included is a résumé of the plasma refractive index and the experimental techniques of the three-mirror laser interferometer and the laser heterodyne system. Sensitivity of the two techniques to electron and neutral-particle densities is covered with emphasis placed on the application of the techniques to a cesium plasma contained in a thermionic diode. The spatial resolution of the techniques as applied to a cesium diode is also presented. Author

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MATERIALS, METALLIC

Includes cermets; corrosion; physical and mechanical properties of materials; metallurgy; and applications as structural materials. For basic research see: 06 Chemistry. For related information see also: 18 Materials, Nonmetallic; and 32 Structural Mechanics.

N68-10051*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ELECTRON MICROSCOPY TECHNIQUE FOR DETERMINATION OF DISPERSOID DISTRIBUTION IN POWDER BLENDS
Bruno C. Buzek Washington NASA Nov. 1967 11 p refs
(NASA-TM-X-1468) CFSTI: HC $3.00/MF $0.65 CSCL 11F

The ability to clearly observe and distinguish between oxide and metal particles in a starting powder blend and to determine the initial distribution of the oxide prior to consolidation enables predictions to be made about the final distribution of the oxide particles in a fully consolidated product. A new electron-microscope specimen-preparation technique was developed to aid in making these predictions. This procedure makes it possible to ascertain the size and the degree of agglomeration of the oxide particles, unobstructed by the presence of the metal-matrix particles, before the compaction and sintering of the powder blend. The initial powder blend is envoloped with a thin layer of carbon, and the metal phase is leached out. The retained particles reveal the state of the dispersoid phase after the blending operation. Nickel, tungsten, chromium, and nichrome, each blended with thoria or alumina, were investigated using this technique. A good correlation exists between the dispersoid distribution in the initial blend and the state of agglomeration in the final sintered product. If small oxide particles were well distributed in the initial powder blend, they remained in the final product. If the small oxide particles were clustered in the original powder blend, they appeard as large particles similar in size to the initial clusters after consolidation.
Author

N68-10104*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF COVER GAS PRESSURES ON ACCELERATED CAVITATION DAMAGE IN SODIUM
Stanley G. Young and James R. Johnston Washington NASA Nov. 1967 24 p refs
(NASA-TN-D-4235) CSCL 11F

An investigation was made to study the effect of pressure on the resistance to cavitation damage of materials under consideration for components of liquid–metal power conversion systems. A vibratory apparatus was used to subject three materials, AISI 316 stainless steel, L-605, and Stellite 6B to accelerated cavitation damage in sodium at 800°F (700°K). Argon cover gas was used to maintain pressures up to 4 atmospheres (4×10^5 N/m^2) during test. Volume loss and volume-loss rate measurements were used to compare the effects of pressure on the degree of damage. Metallographic studies were conducted to determine the nature of damage. Increasing cover-gas pressure significantly increased cavitation damage to all materials for all exposure times. The materials ranked in the same order with respect to resistance to cavitation damage at all pressures; Stellite 6B was most resistant, L-605 intermediate, and AISI 316 stainless steel least resistant. The steady-state volume-loss rate based on total specimen area increased linearly with cover-gas pressure. When the volume-loss rate data were normalized to include only the heavily damaged area of the specimens, the steady-state volume-loss rate increased as a power function of pressure. Metallographic examination of axially sectioned specimens revealed undercutting and transgranular cracking as well as subsurface deformation for all materials.
Author

N68-10498*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DETERMINATION OF ELECTRIC POTENTIAL ACROSS THE OXIDE SCALE DURING OXIDATION OF TANTALUM, NIOBIUM, AND MAGNESIUM
I. Zaplatynsky Washington Nov. 1967 9 p refs
(NASA-TN-D-4240) CFSTI: HC $3.00/MF $0.65 CSCL 11F

According to Hauffe's theoretical treatment of the oxidation of metals, the oxide-gas interface is electrically negative with respect to the oxide-metal interface. The potential difference is considered to be one of the driving forces for oxidation. Experimental evidence, presented here, does not support this assumption. The polarity of measured potential is reversed and has a retarding effect on oxidation. The magnitude of the potential and its temperature dependence were determined for tantalum, niobium, and magnesium during oxidation in air. The magnitude of the potential does not depend upon oxide thickness. Features of the potential-temperature curves for tantalum and niobium correspond to significant changes in the oxidation rates of both metals.
Author

N68-11511*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CORROSION PRODUCT OF THE TANTALUM–INTERSTITIAL OXYGEN–POTASSIUM SYSTEM AT 1800°F(1255°K)
C. William Hickam, Jr. Washington Dec. 1967 12 prefs
(NASA-TN-D-4213) CFSTI: HC $3.00/MF $0.65 CSCL 11F

Described herein are the isolation and identification of the corrosion product formed by the exposure of oxygen-doped tantalum to potassium. The corrosion of tantalum by liquid potassium appears to be quantitatively dependent on the oxygen impurity content and to occur by the formation of a ternary oxide. When tantalum containing oxygen in the range of 1600 to 3800 ppm is exposed to potassium at 1800°F (1255°K), depletion of oxygen from tantalum occurs and the hygroscopic potassium tantalate K_3TaO_4 is isolated as the reaction product. These results imply that the total amount of "oxygen-effect" corrosion can be predicted when the total amount of interstitial oxygen in tantalum is known (i.e., oxygen in solution in the metal initially plus oxygen that enters the metal from the environment during the life of the system). Since oxygen-effect corrosion is the most serious type of corrosion encountered by tantalum alloys in contact with potassium at elevated temperatures, the present results are significant for the design and operation of advanced space power systems.
Author

N68-11522*# Lockheed-California Co., Burbank.
STRESS CORROSION OF TITANIUM ALLOYS UNDER SIMULATED SUPERSONIC FLIGHT CONDITIONS
K. E. Weber and A. O. Davis Washington NASA Dec. 1967 77 p refs
(Contract NAS1-6361)
(NASA-CR-981) CFSTI: HC$3.00/MF$0.65 CSCL 11F

The effects of high altitude supersonic air flow on the titanium hot salt cracking process were studied. Two different types of self-stressed specimens were utilized in these tests; one type was developed by Lockheed and the other by NASA Langley. Specimens were prepared from both the Ti–8Al–1Mo–1V duplex annealed and the Ti–6Al–4V mill annealed alloys. Cracking data from specimens exposed in the wind tunnel were compared to similar data obtained from ordinary laboratory oven tests. The tests demonstrated that the air flow and reduced pressure conditions characteristic of high altitude supersonic flight environments do not eliminate hot salt cracking in these titanium alloys at the test temperatures used in this program. However, cracking in supersonic environments was generally less severe than in laboratory oven environments. As might be expected, some of the salt coating was removed from the specimens by the action of the high velocity air stream, and evidence of a correlation between salt removal and cracking damage was indicated. Author

N68-11637* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FATIGUE OF LIQUID ROCKET ENGINE METALS AT CRYOGENIC TEMPERATURES TO −452°F (4°K)
Alfred J. Nachtigall, Stanley J. Klima, and John C. Freche Washington Dec. 1967 54 p refs
(NASA-TN-D-4274) CFSTI: $3.00 CSCL 11F

Axial tensile fatigue behavior of four candidate alloys for liquid rocket engines was investigated for smooth and notched (theoretical stress concentration factors $K_t > 17$) sheet specimens at a minimum-to-maximum cyclic stress ratio R of 0.14 in ambient air (70°F, 294°K), liquid nitrogen (−320°F, 77°K), and liquid helium (−452°F, 4°K). The materials tested were 2014-T6 aluminum alloy, Inconel 718, 5 percent aluminum–2.5 percent tin–titanium (5Al–2.5Sn–Ti) alloy, and AISI 301 stainless steel. The fatigue strength of smooth specimens was generally higher than that of notched specimens. Except for AISI 301 stainless steel the fatigue strength of unnotched specimens increased progressively with decreasing test temperature to −452°F (4°K). This trend was also observed for 2014-T6 aluminum alloy and Inconel 718 in the notched condition. In most instances, Inconel 718 and 301 stainless steel had the highest fatigue strength while the 5Al–2.5Sn–titanium and 2014-T6 aluminum alloys ranked third and fourth. The titanium alloy generally had the highest fatigue-strength-to-density ratio at all temperatures. The fatigue notch factor K_f increased with cyclic life for all materials at all test temperatures. Up to 100 cycles, the increase was small, and the fatigue notch factor was essentially equal to the tensile notch factor (ratio of smooth specimen tensile strength to notched specimen tensile strength). Inconel 718 generally had the lowest K_f over the life range considered at all temperatures. Author

N68-11644*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DEPOSITION OF SPUTTERED MOLYBDENUM DISULFIDE FILMS AND FRICTION CHARACTERISTICS OF SUCH FILMS IN VACUUM
Talivaldis Spalvins and Hohn S. Przybyszewski Washington Dec. 1967 14 p refs
(NASA-TN-D-4269) CFSTI: HC$3.00/MF$0.65 CSCL 11H

Physical direct-current sputtering of molybdenum disulfide (MoS_2) is used to apply MoS_2 films as a solid lubricant for rotating and sliding components. This method does not use organic or inorganic binders or the process of burnishing. Friction experiments in vacuum (10^{-11} torr or 1.33×10^{-9} N/m^2) were conducted on these films. The coefficients of friction for the sputtered films were in agreement with the reported values in the literature. Stoichiometric films were obtained, and no dissociation was observed. There is a strong bonding (adherence) between the films and the substrate, as indicated by the long-endurance life of the lubricating films in friction experiments. The sputtered MoS_2 films had an accurate repeatability in terms of stoichiometry, adherence, thickness, and uniformity when the sputtering conditions were kept constant. Author

N68-11912*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CONTROL OF CONTAMINANTS IN LIQUID-METAL SYSTEMS
Sol Gorland and Raymond Bilski Washington NASA Dec. 1967 21 p refs
(NASA-TM-X-1432) CFSTI: HC$3.00/MF$0.65 CSCL 18J

The contaminant controls and cleaning procedures used in the SNAP-8 simulation loop, consisting of two sodium–potassium (NaK) loops and one mercury (Hg) loop, minimized both startup and operational problems. Mercury wetting was induced in the boiler and condenser as determined by progressive improvement in the heat-transfer performance. The degree of wetting is an indication of the system cleanliness. The boiler was conditioned in approximately 250 hours of operation without wetting additives. After 384 hours of operation, analysis of a Hg sample by a distillation method indicated no contamination. Oxide plugging in the NaK loops was minimized using the loop-entry procedures developed in the investigation. No plugs occurred because of changes of repairs that required system entry, and only minor partial plugs occurred in over 1500 hours of operation of the NaK loops. Author

N68-12891*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
STRESS-CORROSION CRACKING OF Ti–6Al–4V TITANIUM ALLOY IN NITROGEN TETROXIDE
W. Barry Lisagor, Charles R. Manning, Jr., and Thomas T. Bales Washington Jan. 1968 33 p refs
(NASA-TN-D-4289) CFSTI: HC$3.00/MF$0.65 CSCL 11F

The stress-corrosion of Ti–6Al–4V titanium alloy in nitrogen tetroxide was investigated by using small laboratory-size self-stressed specimens and tanks. Tests were conducted from 65°F to 165°F (290°K to 345°K) for purposes of determining the time for crack initiation. Stress levels from 25 to 100 ksi (170 to 690 MN/m^2) were investigated and crack initiation was observed at all stress levels in approximately the same time. An excellent correlation was obtained between crack initiation time on laboratory specimens and failure time for tanks. Tests were also conducted on specimens which had been treated in some manner for the prevention of stress-corrosion attack. Organic and metallic coatings investigated proved to be unsatisfactory because of adherence problems or apparent permeation resulting in stress-corrosion attack. Surface treatments including peening techniques proved to be beneficial and glass-bead peening to introduce residual compressive stresses of high magnitude appeared to alleviate the problem entirely for the range of tests conducted. The residual stress level was determined by X-ray diffraction techniques and was found to be in excess of 100 ksi (690 MN/m^2) on the surface. The prevention of stress-corrosion attack by chemical inhibition with 0.78 percent by mass nitric oxide (NO) added to the N_2O_4 was also substantiated by tests conducted at 165°F (345°K) for exposures of 170 hours. The mechanism of prevention remains unknown. Author

N68-14888*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TECHNIQUE FOR RECOVERY OF ALKALI-METAL REACTION PRODUCTS

Randall F. Gahn Washington Jan. 1968 11 p refs

(NASA-TN-D-4310) CFSTI: HC $3.00/MF $0.65 CSCL 07B

A procedure for the isolation and recovery of alkali-metal reaction products in an uncontaminated state is described. Separation of the reaction product from excess alkali metal is accomplished by vacuum distillation. All recovery operations are carried out in high-vacuum or inert gas atmospheres. Two typical examples of the application and reproducibility of the procedure are presented: (1) the recovery of potassium tantalate (K_3TaO_4) from the potassium–tantalum-oxygen reaction, and (2) the recovery of potassium monoxide (K_2O) from the potassium–oxygen reaction. Reaction products are identified by both X-ray diffraction and chemical analysis. Author

N68-15637*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

APPLICATION OF DIRECTIONAL SOLIDIFICATION TO A NASA NICKEL-BASE ALLOY (TAZ-8B)

John C. Freche, William J. Waters, and Richard L. Ashbrook Washington Feb. 1968 22 p refs

(NASA-TN-D-4390) CFSTI: HC $3.00/MF $0.65 CSCL 11F

A nickel-base alloy (TAZ-8B) has been developed which compares favorably in high-temperature strength with known high-strength nickel-base alloys. Although basically a cast material, the alloy also has workability potential. By applying directional solidification techniques, test specimens were produced with a preferred columnar grain orientation. Grain boundaries transverse to the major stress axis were largely eliminated. Substantial increases in ductility, ultimate tensile strength, and stress-rupture life were obtained with the alloy in the directional polycrystalline condition, as compared with the random polycrystalline condition. On the basis of calculated electron vacancy number, TAZ-8B would not be expected to form sigma phase. Only minor decreases in 1400°F (1033°K) ductility were observed after exposure for 1000 hours at 1600°F (1144°K). Tensile elongation decreased from 3.3 to 2.0 percent for the random polycrystalline material and from 6.5 to 6.0 percent for the directional polycrystalline material. The application of directional solidification to TAZ-8B resulted in alloy properties which are of interest for potential advanced gas turbine engine applications. Author

N68-17317*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECTS OF COMPOSITION AND HEAT TREATMENT ON HIGH-TEMPERATURE STRENGTH OF ARC-MELTED TUNGSTEN–HAFNIUM–CARBON ALLOYS

L. S. Rubenstein Washington Feb. 1968 31 p refs

(NASA-TN-D-4379) CFSTI: HC $3.00/MF $0.65 CSCL 11F

The effects of composition, heat treatments, and substructure on the strength and ductility of tungsten–hafnium–carbon (W–Hf–C) alloys were studied. The compositions ranged from 0.23 to 1.76 atomic percent for hafnium and from 0.179 to 0.942 atomic percent for carbon, with carbon to hafnium ratios from 0.17 to 2.80 and calculated amounts of hafnium carbide ranging up to 1.5 volume percent. The high-temperature tensile strengths of swaged, recrystallized, solution-annealed and aged alloys increased with increasing hafnium carbide contents up to approximately 0.5 volume percent, after which further additions caused a slight decrease in strength. The strongest alloys contained equiatomic amounts of carbon and hafnium. The 3500°F (2200°K) tensile strength for swaged material was linearly related to the inverse square root of the cell size. Limited tensile and microstructural studies indicated that the W–Hf–C alloys are heat treatable. The stress for a 3500°F (2200°K), 100-hour rupture life was approximately 14,000 psi (96.5×10^6 N/m^2) in the swaged condition. A solution-annealed and aged specimen tested in 3500°F (2200°K) step-load creep tests required a stress of approximately 20,000 psi (138×10^6 N/m^2) for a minimum creep rate of 6×10^{-7} sec^{-1}, corresponding to an approximate 100-hour rupture life. These W–Hf–C alloys exhibit a sevenfold strength improvement over unalloyed tungsten at 3500°F (2200°K) that is related to the precipitate stabilized, fine dislocation structure formed within the cell boundaries. For high strength applications at 3500°F (2200°K), compositions composed of equiatomic amounts of carbon and hafnium, approximately 0.3 to 0.4 atomic percent, are recommended. Author

N68-17377* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

COATINGS AND SURFACE TREATMENTS FOR LONGTIME PROTECTION OF Ti–8Al–1Mo–1V ALLOY SHEET FROM HOT SALT STRESS CORROSION

Bland A. Stein, H. Benson Dexter, and Dick M. Royster Washington Mar. 1968 51 p refs

(NASA-TN-D-4319) CFSTI: $3.00 CSCL 11F

After longtime exposures at 600°F in air at sea-level atmospheric pressure, the coatings were electroplated nickel with black nickel overcoat for high emittance, electrophoretically deposited aluminum, and a dipped coating of polyimide resin. The surface treatments included a vibratory treatment and glass-bead peening. The study included both residual-stress and self-stressed specimens which were dipped in a 3.4-percent NaCl solution, dried and exposed at 600°F (590°K) in circulating air ovens. Relative deflection measured in room-temperature bend tests or relative shortening measured in compression tests were used as quantitative indicators of stress-corrosion cracking in the specimens. An electron probe microanalyzer was used to determine interdiffusion between coating and substrate. The results indicated that the nickel and aluminum coatings were effective in preventing hot-salt stress corrosion for at least 10,000 hours exposure, whereas the polyimide coating peeled off the surface after 500 hours exposure. The glass-bead-peening process appeared to be effective in preventing or alleviating hot-salt stress corrosion for at least 10,000 hours. The vibratory treatment process proved to be effective in preventing or alleviating hot-salt stress corrosion for exposures of 15,000 hours when specimens were treated for at least 26 hours after fabrication. Author

N68-17591*# Bendix Corp., Detroit, Mich.

OXIDATION RESISTANT MATERIALS FOR TRANSPIRATION COOLED GAS TURBINE BLADES. 1: SHEET SPECIMEN SCREENING TESTS

Fred W. Cole, James B. Padden, and Andrew R. Spencer Washington NASA Feb. 1968 146 p

(Contract NAS3-7269)

(NASA-CR-930) CFSTI: HC $3.00/MF $0.65 CSCL 11F

Twelve alloys were tested in sheet metal form to compare their suitability for use as transpiration cooled gas turbine blade materials. The alloys were N 155, TD nickel, TD nickel-chromium, Bendel 65-35, Chromel A, DH 242, GE 1541, Hoskins 875, RA 333, Hastelloy X, Udimet 500, and Haynes 25. Screening tests consisted of cyclic furnace oxidation at 1400°, 1600°, 1800°, 2000°, 2100°, and 2200°F for 4, 16, 64, 100, 200, 300, 400, 500, and 600 hours exposure time. Total oxidation and spalling were determined for each specimen along with variation in room temperature mechanical properties and microstructure. Electron beam welding feasibility was also investigated. Three best-compromise alloys were selected for later testing as wires to determine suitability for manufacturing space-wound or woven porous transpiration cooling materials. Author

N68-17624*# Westinghouse Electric Corp., Lima, Ohio.
PROPERTIES OF MAGNETIC MATERIALS FOR USE IN HIGH-TEMPERATURE SPACE POWER SYSTEMS
P. E. Kueser, D. M. Pavlovic, D. H. Lane, J. J. Clark, and M. Spewock Washington NASA 1967 325 p refs
(Contract NAS3-4162)
(NASA-SP-3043) GPO: HC$2.25; CFSTI: MF$0.65 CSCL 11F

Test data are given and evaluated for eight magnetic materials that were found suitable for use in high-temperature liquid alkali-metal system applications. In general, the magnetic materials tested can be grouped in three temperature ranges, together with their fields of application: (1) 600° to 800°F: Most materials qualify for this temperature range. However, Cubex alloy (3-1/4% Si–Fe, doubly oriented) is preferred for use in stators at inductions up to 18 kilogauss. H-11 steel (5%Cr, 1%Mo, Fe) and maraging steel (15–18% Ni, 8–9% Co, Fe) are recommended for rotors, and Supermendur (2% V, 49% Co, 49% Fe) in controls using high quality, saturable-core reactors. (2) 800° to 1100°F: Hiperco 27 alloy (27% Co, Fe) is suggested for high inductions and Cubex alloy for inductions up to 15 to 18 kilogauss in stators. In rotors, H-11 steel qualifies for lower temperatures and Nivco alloy (approximately 72% Co, 23% Ni) for the higher temperatures in this range. (3) 1100° to 1400°F: Hiperco 27 alloy is recommended for stators and Nivco alloy for rotors in this temperature range.
Author

N68-17897*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EFFECTS OF LONGTIME ENVIRONMENTAL EXPOSURE ON MECHANICAL PROPERTIES OF SHEET MATERIALS FOR A SUPERSONIC TRANSPORT
Richard A. Pride, Dick M. Royster, Bland A. Stein, and James E. Gardner Washington Mar. 1968 26 p refs Presented at the Met. Soc. Session of the 96th Ann. Meeting of the Am. Inst. of Mining, Met. and Petrol. Engr., Inc., Los Angeles, 19–23 Feb. 1967
(NASA-TN-D-4318) CFSTI: HC$3.00/MF$0.65 CSCL 11F

Studies of the effects of longtime environmental exposure on mechanical properties of supersonic transport sheet materials have been conducted by the Langley Research Center. These materials include titanium alloys, stainless steels, aluminum alloys, and a composite. Titanium alloys and stainless steels have been investigated since 1961, and results have shown that exposures of 30,000 hours at 550°F (561°K) have had little effect on the strength characteristics. Hot-salt stress corrosion occurs in titanium alloys under certain combinations of stress, temperature, and time but does not appear to be a problem at the operating conditions of a Mach 2.7 supersonic transport. Aluminum alloys were investigated to provide materials information for the Mach 2 speed range and have been found to be temperature limited by longtime creep strength. Properties of the polyimide-resin–glass-fiber composite have been determined after 4000 hours exposure. This material appears to be suitable for extended use in a Mach 2.7 supersonic transport.
Author

N68-18145*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DEVELOPMENT OF A COBALT-TUNGSTEN FERROMAGNETIC, HIGH-TEMPERATURE, STRUCTURAL ALLOY
Richard L. Ashbrook, Anthony C. Hoffman, Gary D. Sandrock, and Robert L. Dreshfield Washington Mar. 1968 44 p refs
(NASA-TN-D-4338) CFSTI: HC$3.00/MF$0.65 CSCL 11F

Rotors for space power generators require a compromise between high-temperature strength and magnetic properties. Rotors must withstand high centrifugal stresses at high temperature and develop high induction for small exciting fields. Alloys considered for rotors include maraging steels, H-11 steel, and a cobalt-base alloy, Nivco. This report discusses work to develop alloys with improved high-temperature strength and good high-temperature magnetic properties. Because cobalt has the highest Curie temperature of any metal and is a good base for high-temperature alloys, a NASA superalloy, cobalt–25 tungsten–1 titanium–1/2 zirconium–1/2 carbon was chosen for further study. Modifications of this alloy were screened for maximum magnetic induction B_{max} at a maximum magnetizing force H_{max} of 100 oersteds (7958 A/m) over a range of temperatures. Below 1000°F (538°C), low tungsten alloys show inflections in a plot of B_{max} as a function of temperature due to the instability of the face-centered cubic (fcc) phase. Stability of the fcc increased with increasing tungsten and iron. A preferred alloy, Co–7-1/2W–2-1/2Fe– 1Ti–1/2Zr–1/2C, was evaluated for magnetic and mechanical properties in cast form and for mechanical properties as sheet. After aging at 1700°F (927°C) for 72 hours, this alloy had a coercive force of 10.5 oersteds (835 A/m) at 75°F(24°C), and a B_{max} of 11.5 and 10.3 kilogauss (1.15 and 1.03 T) at 1200° and 1400°F (649° and 760°C), respectively. The stress–rupture life at 1200° to 1400°F (649° to 760°C) was greater than that of the strongest high-temperature commercially available magnetic-structural alloy.
Author

N68-18610*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OXIDE DEFORMATION AND FIBER REINFORCEMENT IN A TUNGSTEN METAL OXIDE COMPOSITE
Charles P. Blankenship Washington Mar. 1968 41 p refs
(NASA-TN-D-4475) CFSTI: HC$3.00/MF$0.65 CSCL 11D

Refractory oxide particles of urania (UO_2) and zirconia (ZrO_2) were added to a tungsten matrix and elongated into fibers by hot extrusion. Extrusion temperatures ranged from 3200° to 4000°F (1760° to 2200°C). The geometry of the oxide fibers appeared to be closest to that of an ellipsoid with the major axis alined in the extrusion direction. Oxide fibering was measured by an average length-to-width ratio of the fibers sectioned parallel to the major axis. The extent of oxide deformation was estimated in terms of strain components. Oxide-matrix deformation characteristics were related to the extrusion parameters by comparing the estimated oxide strain components to those of the composite.
Author

N68-18999*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
USE OF SURFACE REPLICATION, EXTRACTION REPLICATION, AND THIN-FILM ELECTRON MICROSCOPY IN THE STUDY OF DISPERSION-STRENGTHENED MATERIALS
Charles A. Hoffman and Bruno C. Buzek Washington Mar. 1968 25 p refs
(NASA-TN-D-4461) CFSTI: HC$3.00/MF$0.65 CSCL 11F

An investigation was conducted on the relative merits of surface replication, extraction replication, and thin-film methods to evaluate the microstructures of dispersion-strengthened materials. Surface replication gave the best agreement of measured and nominal amounts of oxide whether the oxide was discrete and spheroidal ($Ni+ThO_2$) or plate-like and aggregated ($Al+Al_2O_3$); this method also gave the most satisfactory value of average particle size and average interparticle spacing. Extraction replication was also satisfactory for the former material but not for the latter; its validity was dependent on the shape of the oxide particles and its state of aggregation as well as the effectiveness of the extraction technique. The thin-film method was helpful in verifying the existence of the finer particles but gave considerably greater volume fractions of oxide particles compared to the respective nominal amounts. Particle-size–frequency distributions obtained from each of the three methods when applied to the $Ni+ThO_2$ essentially agreed. Stereoscopic, or three-dimensional, views of thin films gave better indication of the shape of the particles and the spatial relations between particles.
Author

N68-19347*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF SURFACE ROUGHNESS ON THE 0.66-MICRON NORMAL SPECTRAL EMITTANCE OF VAPOR-DEPOSITED RHENIUM FROM 1500°K TO 2100°K

Peter Cipollone Washington Mar. 1968 20 p refs

(NASA-TM-X-1514) CFSTI: HC$3.00/MF$0.65 CSCL 20L

The normal spectral emittance of vapor-deposited rhenium at a 0.66-micron effective wavelength is presented, and the results are compared to previously published data on bar and sheet rhenium. A dependence of the normal spectral emittance on surface roughness is demonstrated quantitatively. Author

N68-21431*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ELECTRON MICROSCOPE TECHNIQUE SUGGESTED TO REVEAL MICROSTRUCTURES OF DISPERSION-STRENGTHENED MATERIALS

Bruno C. Buzek Washington Apr. 1968 9 p refs

(NASA-TM-X-1561) CFSTI: HC$3.00/MF$0.65 CSCL 13H

This report describes a preparation and replication method which has produced consistently good results for a number of materials. To show the effectiveness of the method evolved, measurements of volume percentages of dispersoids were compared with values obtained from chemical analysis. Typical microstructures of differently produced dispersion-strengthened materials are shown. The method that was found to be satisfactory uses conventional metallographic specimen preparation procedures up to the two final steps of polishing. For this final polishing, 3-micron and 1/2-micron diamond polishing compounds are necessary. This produces a flat and distortion-free surface. Etching of the samples should be extremely light. The etchants used depend on sample composition and history. The samples are then cleaned in an ultrasonic bath and further cleaned with plastic by dry stripping. Replication of samples with a conventional two-stage method of plastic–carbon and platinum shadowing follows. A good correlation was obtained between volume percent dispersoid measured on the resulting electron micrographs and the values obtained by chemical analysis. This replication procedure was found satisfactory for use with nickel, tungsten, chromium, cobalt, and their alloys. Author

N68-21654*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MECHANISM AND KINETICS OF CORROSION OF SELECTED IRON AND COBALT ALLOYS IN REFLUXING MERCURY

Louis Rosenblum, Coulson Scheuermann, Charles A. Barrett, and Warren H. Lowdermilk Washington Apr. 1968 54 p refs

(NASA-TN-D-4450) CFSTI: HC$3.00/MF$0.65 CSCL 11F

The cobalt-base HS-25 and H-8187 and the iron-base SICROMO-9M, AM-350, and AM-355 were corrosion tested in boiling mercury in the temperature range of 1000° to 1300°F for times as long as 5000 hours. Metallographic, chemical, and physical analyses were used to determine the extent and the nature of the corrosion. Corrosion mechanism and reaction kinetics were inferred through a comparison of experimental and theoretical kinetic constants. The experimental kinetic constants (i.e., the time-law constant b_r and the activation energy ΔH_i) were obtained from the test data by multiple regression analysis. The theoretical kinetic constants b_i and ΔH_i for each of i steps of proposed corrosion models were obtained from transport theory relations and the pertinent boundary conditions. Changes of mechanism during the progress of corrosion were indicated for all the alloys tested except the AM-350 and AM-355 alloys. The shifts from one corrosion regime to another were associated with changes in the nature and length of the corrosion-affected zone. Three corrosion regimes were characterized, linear I, parabolic, and linear II. The probable rate-determining step in the two linear rate regimes is boundary-layer diffusion. The probable rate-determining step in the parabolic rate regime is liquid diffusion. Author

N68-21768*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CRACK GROWTH IN 2014-T6 ALUMINUM TENSILE AND TANK SPECIMENS CYCLICALLY LOADED AT CRYOGENIC TEMPERATURES

William S. Pierce Washington Apr. 1968 40 p refs

(NASA-TN-D-4541) CFSTI: HC$3.00/MF$0.65 CSCL 11F

The cryogenic low-cycle fatigue crack growth behavior of 2014-T6 aluminum through-notched uniaxial tensile and biaxial pressure vessel specimens was studied. Low-cycle crack growth data were obtained from the notched specimens at −320° and −423°F. Initial notch lengths from 0.125 to 1.0 inch and initial R ratios R_i (minimum to maximum initial stress intensity factor, $K_{min,i}/K_{max,i}$) from 0.07 to 0.36 were studied. The parameters R_i and $K_{max,i}$ appear to be useful for relating crack growth rates in pressure vessels to those in tensile specimens. At −320° and −423°F the crack growth rates were almost equal for the pressure vessel and corresponding tensile specimen provided the R_i and $K_{max,i}$ values were held constant. The slopes of the curves for crack growth rate da/dN as a function of stress intensity factor range ΔK varied from 6 to 13 on a log–log plot. For a given ratio of maximum to critical stress intensity factor, the specimens tested at −423°F had longer lives than those tested at −320°F. Also, specimens run with higher R_i ratios had the longer cyclic lives for a given ratio of maximum to critical stress intensity. For similar values of R_i and $K_{max,i}$ the cyclic lives of tensile and tank specimens were almost equal, with the tensile specimens generally having longer lives. Author

N68-21917*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

DEFORMATION PROCESSING OF PRECIPITATION-HARDENING STAINLESS STEELS

D. E. Strohecker, A. F. Gerds, and F. W. Boulger Redstone Arsenal, Ala. Redstone Sci. Inform. Center [1968] 278 p refs

Prepared by Battelle Mem. Inst. for Army Missile Command

(NASA Order H-76715; Contract DA-01-021-AMC-11651(Z))

(NASA-SP-5088; RSIC-495) CFSTI: HC $3.00/MF $0.65 CSCL 13H

Both primary and secondary fabrication methods for the precipitation-hardenable stainless steels are covered. Methods currently employed for primary fabrication of these alloys include rolling, extrusion, forging, and drawing of tube, rod, and wire. Secondary metalforming operations are those processes that produce finished or semifinished parts from sheet, bar, or tubing using additional metalforming operations. The following secondary forming processes are discussed: brake bending, deep drawing, spinning and shear forming, drop hammer, trapped rubber, stretch, roll forming, dimpling, joggling, and sizing. Equipment and tooling used for the various operations are discussed and illustrated wherever possible. Author

N68-22338*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE EFFECT OF INTERFIBER DISTANCE AND TEMPERATURE ON THE CRITICAL ASPECT RATIO IN COMPOSITES

Robert W. Jech and Robert A. Signorelli Washington May 1968 26 p refs

(NASA-TN-D-4548) CFSTI: HC$3.00/MF$0.65 CSCL 11F

The effect of distance and temperature on the minimum fiber length to diameter ratio in a fiber composite was examined using a modified pullout test. Tungsten-wire–copper, iron-wire–lead, and iron-wire–cadmium specimens were used. Variation of the critical aspect ratio as a function of interfiber distance was determined for the iron–lead and iron–cadmium systems. Critical aspect ratio as a function of temperature was determined for the tungsten–copper system. Reduction of the interfiber distance increased the apparent shear strength of the matrix as indicated by

a reduction of the critical aspect ratio. A rapid increase in the critical aspect ratio was noted at test temperatures in excess of 1000°F (540°C). Author

N68-22884*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TEXTURE STRENGTHENING AND FRACTURE TOUGHNESS OF TITANIUM ALLOY SHEET AT ROOM AND CRYOGENIC TEMPERATURES
Timothy L. Sullivan Washington May 1968 32 p refs
(NASA-TN-D-4444) CFSTI: HC$3.00/MF$0.65 CSCL 11F

Preferred crystallographic orientation or texturing in metallic sheet can, under conditions of biaxial stress, result in strengthening considerably greater than that predicted for an isotropic material. Certain titanium alloys exhibit texturing. After it is rolled into sheet form, titanium alloyed with about 4 percent aluminum gives close to the ideal texture for maximum biaxial strengthening. The commercially available titanium alloy, Ti–5Al-2.5Sn, also exhibits texture strengthening. The effect of texturing on the yield, ultimate, notch, and weld strengths of both Ti-4Al-0.2O and Ti-5Al-2.5Sn extra-low-interstitial grade was determined by testing 0.020-inch-thick sheet in uniaxial and 1 to 2 biaxial stress fields at 20°, 77°, and 294°K. The biaxial test specimens were cylinders 6 inches in diameter and 18 inches long. In addition, plastic Poisson's ratios were determined at the three test temperatures. Author

N68-23560*# Boeing Co., Seattle Wash.
ULTRAVIOLET-PROTON RADIATION EFFECTS ON SOLAR CONCENTRATOR REFLECTIVE SURFACES Final Report, Jun. 1965–Aug. 1967
R. B. Gillette Washington NASA May 1968 146 p refs
(Contract NAS1-5251)
(NASA-CR-1024) CFSTI: HC$3.00/MF$0.65 CSCL 11D

The effects of proton and ultraviolet radiation on the specular and diffuse reflectance of stretch-formed aluminum, electroformed nickel and magnesium substrate solar mirrors were studied in high vacuum at temperatures from −195° to 200° and energies from 2 to 30 keV. Ultraviolet exposures were vacuum deposited Al, which in some cases were overcoated with Si_2O_3 or SiO_2. The most severe mechanism of radiation-induced degradation was found to be proton blistering. Author

N68-24111*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CREEP OF TANTALUM T-222 ALLOY IN ULTRAHIGH VACUUM FOR TIMES UP TO 10,000 HOURS
Robert H. Titran Washington May 1968 18 p refs
(NASA-TN-D-4605) CFSTI: HC$3.00/MF$0.65 CSCL 11F

The long time creep behavior of fine-grained (0.016-mm) Ta-9.11W-1.91Hf-0.01C was determined over the temperature range of 2000° to 2600°F (1093° to 1426°C) and in a vacuum of 10^{-8} torr (1.33×10^{-6} N/cm^2). Creep stresses ranged from 2500 to 20,000 psi (17.5×10^6 to 138×10^6 N/m^2) for test times up to 10,000 hours. At temperatures ranging from 2000° to 2600°F (1093° to 1426°C), stress levels to limit creep to 1 percent in 10,000 hours are 28,000 and 800 psi (193×10^6 and 6×10^6 N/m^2), respectively. The stress dependence of the steady creep rate was 3, and the temperature dependence of steady creep was equivalent to an apparent activation energy of 150 kcal/g-mole (627 450 J/g-mole). Author

N68-24477*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
YIELDING AND FRACTURE IN TUNGSTEN AND TUNGSTEN-RHENIUM ALLOYS
Peter L. Raffo Washington May 1968 36 p refs
(NASA-TN-D-4567) CFSTI: HC$3.00/MF$0.65 CSCL 11F

A study was made of the mechanical properties of vacuum arc-melted tungsten and tungsten–rhenium alloys in the temperature range 77° to 810°K in order to elucidate the mechanism by which rhenium additions lower the ductile-brittle transition temperature of tungsten. The temperature and strain-rate dependence of the yield stress of tungsten is reduced by alloying with rhenium. This is shown to be because of a reduction in the Peierls stress. The reduction in the transition temperature is attributed to the reduced Peierls stress through its effect on the mobility and rate of multiplication of dislocations. Author

N68-24558*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ELECTRICAL AND MECHANICAL PROPERTIES OF A SUPERIOR HIGH-TEMPERATURE COBALT–IRON MAGNETIC MATERIAL
John P. Barranger Washington May 1968 22 p refs
(NASA-TN-D-4551) CFSTI: HC$3.00/MF$0.65 CSCL 11F

The alternating current electrical and mechanical properties of high purity alloys of 9 weight percent iron, the balance being mostly cobalt, were determined at temperatures from 25° to 1000°C. Data are presented for four thicknesses from 0.002 inch (0.005 cm) to 0.012 inch (0.030 cm) and at six frequencies from 60 to 3200 hertz. The results of the measurements and comparisons with a commercial alloy indicate that the material is one of the best magnetic materials for high temperature transformer core applications. Author

N68-25318*# Louisiana State Univ., Baton Rouge.
A STUDY OF SENSITIZATION IN TYPES 301 AND 304L STAINLESS STEELS USING MOESSBAUER SPECTROSCOPY
O. W. Albritton Washington, D. C. NASA Jun. 1968 23 p refs
(Grant NGR-19-001-024)
(NASA-CR-1077) CFSTI: HC$3.00/MF$0.65 CSCL 11F

Mossbauer effect spectroscopy in conjunction with X-ray diffraction techniques were used to study the phenomenon of stainless steel sensitization. A ferromagnetic phase, thought to be pseudomartensite, has been found to exist in sensitized Type 301. Stresses generated in the matrix by morphology changes of the precipitated carbides is deemed responsible for the creation of this phase. No such phase was detected in the Type 304L. It was confirmed that the precipitated carbides were of the complex type. Furthermore, it was established that these carbides are paramagnetic. In the presence of austenite, the Mossbauer peak for the carbides is overshadowed. In single phase materials grain size has no effect on the Mossbauer spectrum. In multiphase materials the peak locations are unaffected by grain size, but quantitative evaluations are influenced. Author

N68-28365*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPILATION OF THERMOPHYSICAL PROPERTIES OF LIQUID LITHIUM
Harry W. Davison Washington Jul. 1968 23 p refs
(NASA-TN-D-4650) CFSTI: HC$3.00/MF$0.65 CSCL 20M

A compilation of properties including density, electrical resistivity, enthalpy, heat capacity, surface tension, thermal conductivity, vapor pressure, viscosity, Prandtl number, and thermal diffusivity is presented for temperatures between the melting point and normal boiling point of lithium. Empirical correlations were obtained by statistically fitting a polynomial to experimental data obtained from the literature. Author

N68-28818*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF 10^{20} NEUTRON PER SQUARE CENTIMETER IRRADIATION ON EMBRITTLEMENT OF POLYCRYSTALLINE TUNGSTEN

Charles L. Younger and Gilbert N. Wrights Washington Jul. 1968 59 p refs
(NASA-TM-D-4661) CFSTI: HC $3.00/MF $0.65 CSCL 11F

The effect of reactor irradiation on embrittlement of polycrystalline tungsten was investigated by comparing ductile-to-brittle transition of unirradiated and irradiated material. Tensile tests were conducted in the range 300° to 700°F (422 to 644 K). Bend tests, conducted at room temperature, provided additional data. Test results show that recrystallized tungsten irradiated with 1×10^{20} fast neutrons per cm^2 is severely embrittled. The ductile-to-brittle transition temperature for the irradiated material increased by at least 300°F (167K), accompanied by an increase in the temperature-dependent yield point stress and decreases in the tensile fracture and extreme fiber bending stresses. The embrittlement appears to be a result of factors which decrease grain boundary strength and inhibit transgranular fracture. Also determined were irradiation effects on specimen dimensions, density, and electrical resistivity. Dimensional and density changes were small, but the electrical resistivity increased linearly with increasing irradiation and reached 87% at the highest irradiation exposure. It may be concluded that irradiation of unalloyed, polycrystalline tungsten with 10^{20} fast neutrons per cm^2 and 10^{21} thermal neutrons per cm^2 produces a very brittle tungsten—1-percent-rhenium alloy with strength greater than that of the starting material, but because of irradiation-induced point defects, dislocation loops, and defect clusters, the grain boundary strength is lower than originally. Author

N68-29379*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
HEAT TREATMENT FOR IMPROVED STRESS-CORROSION RESISTANCE OF 17-7 ph STAINLESS
Carl R. Johnson and John D. Grimsley Washington Jul. 1968 11 p refs
(NASA-TN-D-4673) CFSTI: HC $3.00/MF $0.65 CSCL 11F

This paper discusses stress-corrosion tests given to 17-7 ph stainless steel—previously subjected to different heat treatments—to fit it for the requirements of rocket-driven spacecraft. Two commercial treatments and one experimental treatment are described, and illustrated by micrographs. Author

N68-29954*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SOME OBSERVATIONS CONCERNING THE OXIDATION OF THE COBALT-BASE SUPERALLOY L-605 (HS-25)
James S. Wolf and Gary D. Sandrock Washington Aug. 1968 40 p refs
(NASA-TN-D-4715) CFSTI: HC $3.00/MF $0.65 CSCL 11F

The concentration of the minor alloying elements silicon and manganese were found to strongly affect the oxidation behavior of L-605 in the temperature range 1000° to 1200°C. Silicon is also dominant in determining the post-aging ductility of this alloy. Plots were developed which indicate that it is possible to optimize both oxidation resistance and ductility of L-605 by restricting the silicon and manganese concentrations to the range 0.1 to 0.4 and 1.4 to 1.65 weight percent, respectively. A mechanism compatible with observed weight gains, scale structures, and scale compositions was proposed for the oxidation of L-605 and similar alloys. Author

N68-29987*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH TEMPERATURE CREEP-RUPTURE PROPERTIES OF A TUNGSTEN-URANIUM DIOXIDE CERMET PRODUCED FROM COATED PARTICLES
Robert J. Buzzard Washington Aug. 1968 26 p refs
(NASA-TM-X-1625) CFSTI: HC $3.00/MF $0.65 CSCL 11F

Tungsten-50 volume percent uranium dioxide cermets, produced by roll compaction of tungsten-coated uranium dioxide particles and clad with tungsten, were creep-rupture tested at temperatures of 1080° to 1800°C (1975° to 3272°F) and stresses of 1740 to 14,500 psi (12 to 100 MN/m^2). Rupture life values ranged from 1 to 696 hrs. Additional rupture life values were predicted by use of the Manson–Haferd time-temperature parameter. Isotherms for 0.5 and 1.0 percent creep, and the end of second stage creep, also were constructed by use of this parameter. An attempt was made to describe the role of the UO_2 in the cermet's creep-rupture process. Author

N68-29992*# TRW Equipment Labs., Cleveland, Ohio.
GENERATION OF LONG TIME CREEP DATA OF REFRACTORY ALLOYS AT ELEVATED TEMPERATURES
J. C. Sawyer and E. A. Steigerwald Washington NASA Aug. 1968 197 p refs
(Contract NAS3-2545)
(NASA-CR-1115; TRW-ER-7203) CFSTI: HC $3.00/MF $0.65 CSCL 11F

Creep tests were conducted on selected refractory alloys in a vacuum environment for times between 100 and 15,000 hours. Since the ultimate program goal was to provide design data for space electric power systems, particular emphasis was placed on measuring creep extension below 1%. The resulting data were evaluated in terms of the relative properties of columbium, molybdenum, tantalum, and tungsten-base alloys. In the 1800°F to 2200°F temperature range, the molybdenum-base alloys TZC and TZM possess the best creep properties for potential turbine applications. The variability of the creep properties as a function of heat of material was determined for the T-111 alloy. In addition to comparison of alloy creep properties, chemical analysis, metallography, and tensile test data are presented to characterize each of the materials before and after creep testing. Author

N68-30000*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
HOT-SALT-STRESS-CORROSION CRACKING AND ITS EFFECT ON TENSILE PROPERTIES OF Ti-8Al-1Mo-1V TITANIUM-ALLOY SHEET
Dick M. Royster Washington Aug. 1968 36 p refs
(NASA-TN-D-4674) CFSTI: HC $3.00/MF $0.65 CSCL 11F

The concluding phase of an extensive experimental investigation of hot-salt-stress corrosion of the Ti-8Al-1Mo-1V titanium alloy was conducted on self-stressed and tensile specimens of a 0.050-inch- (1.3-mm) thick Ti-8Al-1Mo-1V titanium-alloy sheet (duplex annealed). The self-stressed specimens, with stresses of 50, 25, and 15 ksi (340, 170, and 100 MN/m^2), were dipped in a 3.4 percent sodium cloride (NaCl) solution and exposed at temperatures from 400° to 600°F (480° to 590°K) for exposures up to 20,000 hours. Stress-corrosion cracking was obtained after approximately 17 hours at 600°F (590°K) for the 50 ksi (340 MN/m^2) stress, but no stress-corrosion cracking was noted at 400°F (480°K) at any stress level investigated. The threshold stresses decrease with an increase in exposure temperature and time. The tensile corrosion specimens were coated with a thin layer of salt (NaCl) and exposed at temperatures from 500° to 600°F (530° to 590°K) at 50 ksi (340 MN/m^2) stress for exposures up to 800 hours to develop and grow stress-corrosion cracks. The presence of stress-corrosion cracks resulted in a large drop in elongation and a moderate decrease in tensile strength. The properties deteriorated more for the transverse specimens than for the longitudinal tensile specimens. The residual tensile properties appeared to be dependent only on the depth of the cracks, regardless of the temperature or time at which the cracks were developed. The stress-corrosion cracks were intergranular, and maximum crack depth could be correlated with exposure time at 550° and 600°F (560° and 590°K). Author

N68-30065*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPATIBILITY OF SEVERAL IRON-BASE, COBALT-BASE, AND NICKEL-BASE ALLOYS WITH REFLUXING POTASSIUM AT 1800°F
John H. Sinclair Aug. 1968 20 p refs
(NASA-TM-X-1617; E-4337) CFSTI: HC $3.00/MF $0.65 CSCL 11F

Capsules of HS-25, Rene 41, Hastelloys N, C, and X, and AISI 318 were corrosion tested with refluxing potassium at 1800°F (982°C) for times up to 2000 hours. The objective was to determine the corrosion resistance of these alloys for possible use in facilities for ground testing of design concepts for space-power systems. Only AISI 318 appeared to be unsuitable from the standpoint of resistance to corrosion by potassium. The materials could arbitrarily be ranked into three groups in descending order of resistance to corrosion: Rene 41 and HS-25; then, Hastelloys N, C, and X (in that order); and finally, AISI 318. Author

N68-30066*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CHROMIUM AND NICKEL POWDERS MADE BY REDUCTION OF THEIR OXIDES WITH MAGNESIUM, LITHIUM, OR SODIUM VAPORS
Alan Arias Aug. 1968 23 p refs
(NASA-TN-D-4714; E-4386) CFSTI: HC $3.00/MF $0.65 CSCL 11F

Chromium powder separable into 0.0068-μm colloidal and 0.16-μm coarse powder fractions was obtained by reduction of Cr_2O_3 with Mg vapor in a vacuum furnace. The coarse powder fraction was calculated to have 8 volume percent residual MgO plus $MgO{\cdot}Cr_2O_3$ dispersoids, probably suitable for dispersion strengthening. Other chromium powders, 0.08- to 0.60-μm particle size and oxygen to surface area ratios of about 0.002 g/m^2, were made by reduction of Cr_2O_3 with Li and Na vapors. Nickel powder, 1.25-μm particle size and with 0.114 percent oxygen, was made by reduction of NiO with Li vapor. Author

N68-30504*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TENSILE PROPERTIES OF TANTALUM AND TUNGSTEN 10-FIBER BUNDLES AT 1000° F (812 K)
Ruluff D. McIntyre Washington Aug. 1968 21 p refs
(NASA-TN-D-4725) CFSTI: HC $3.00/MF $0.65 CSCL 20K

This investigation studied the tensile properties of 10-fiber bundles and related these properties to single-fiber strength. Bundles comprised of both tantalum and tungsten fibers with 20, 50, and 80 percent tungsten fibers were also tested. A statistical study related bundle strengths to single-fiber strengths. Bundles of tungsten fibers were less strong than single fibers tested separately. Bundles of tantalum fibers were as strong as tantalum single fibers. Strength followed the rule of mixtures for bundles containing mixtures of tantalum and tungsten fibers. Author

N68-30605*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUPERPLASTICITY IN TUNGSTEN-RHENIUM ALLOYS
M. Garfinkle, W. R. Witzke, and W. D. Klopp Washington Aug. 1968 22 p refs
(NASA-TN-D-4728) CFSTI: HC $3.00/MF $0.65 CSCL 11F

Electron beam melted tungsten–rhenium alloys containing 20 to 28 atomic percent Re exhibited elongations of over 200 percent in tensile tests at 3630°F. Rapid grain growth rates in these alloys, relative to tungsten–rhenium alloys with lesser Re contents, and continuous recrystallization during tensile testing indicate the occurrence of enhanced diffusion processes. Strain rate sensitivities generally ranged between 0.2 and 0.3 for these alloys, but strain rate sensitivities as high as 0.8 were observed under the special conditions encountered immediately following initial recrystallization. These were well within the range associated with superplastic materials. Author

N68-31517*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STRESS-STRAIN BEHAVIOR OF COLD-WELDED COPPER-COPPER MICROJUNCTIONS IN VACUUM AS DETERMINED FROM ELECTRICAL RESISTANCE MEASUREMENTS
John S. Przybyszewski Washington Aug. 1968 22 p refs
(NASA-TN-D-4743) CFSTI: HC $3.00/MF $0.65 CSCL 11F

True stress-strain curves, developed from contact-resistance measurements between two OFHC copper specimens loaded and unloaded in vacuum, showed that the cold-welded junctions exhibited an amount of ductility generally characteristic of the specimen material. Junction ductility was greater when the experiment was kept vibration free. Deliberate vibration introduced during the loading cycle lowered the junction ductility. The contact-resistance-against-load data also seemed to indicate that impulsive forces could increase the area of contact under fixed load to a point where the contact area might revert to an elastic condition. Author

N68-31605*# National Aeronautics and Space Administration, Washington, D. C.
EFFECTS OF LOW TEMPERATURES ON THE MECHANICAL PROPERTIES OF STRUCTURAL METALS
H. L. Martin, P. C. Miller, A. G. Imgram, (Battelle Mem. Inst., Columbus) and J. E. Campbell (Battelle Mem. Inst., Columbus) 1968 65 p refs Revised
(NASA-SP-5012(01)) GPO: HC $0.50; CFSTI: MF $0.65 CSCL 11F

Industrial applications in aerospace and other fields are noted for cryogenic technology; and mechanical properties of metals at low temperatures are discussed in terms of alloying and welding effects and the fracture of preexisting flaws and notches. Testing procedures are outlined; and data are presented for aluminum, magnesium, nickel, steel, and titanium alloys. Tensile properties are tabulated for a wide variety of these alloys in base and welded forms. Studies indicate that the austenitic stainless steels retain high ductility and toughness at temperatures as low as −423°F. Higher strength with good toughness as low as −320°F can be provided with 9Ni-4Co steels. Use of various aluminum alloys is cited, and toughness values of certain age-hardened Al alloys are found to be marginal at low temperatures. High strength, low density, and corrosion resistance of titanium alloys are noted; as are the high ductilities of nickel alloys. Developments in gas liquefaction and separation, storage and handling of cryogenic fluids, low temperature heat exchange, quick freezing, superconductivity, and low temperature storage and surgical techniques are covered. M.W.R.

N68-33019*# Du Pont de Nemours (E.I.) and Co., Aiken, S. C.
ROLE OF HYDROGEN CHLORIDE IN HOT SALT STRESS CORROSION CRACKING OF TITANIUM ALUMINUM ALLOYS
R. S. Ondrejcin and M. R. Louthan, Jr. Washington NASA Aug. 1968 29 p refs
(NASA Order R-124)
(NASA-CR-1133; DP(NASA)-1130) CFSTI: HC $3.00/MF $0.65 CSCL 11F

The reactions of titanium–aluminum alloys with andydrous HCl gas were studied, and the reaction products were found to be $TiCl_2$, $TiCl_3$, $TiCl_4$, Al_2Cl_6, and H_2. These products are considered to be intermediates in the hot salt stress corrosion cracking of titanium–aluminum alloys. These products are not normally identified because they oxidize and hydrolyze in the presence of oxygen, moisture, and heat. Fractographic examination of Ti–8Al–1Mo–1V specimens cracked by hot salt and HCl showed the same fracture mechanism in both cases–mechanical rupture

accompanied by dislocation movement. It is proposed that stress-sorption is the mechanism of cracking, and that atomic hydrogen is the species sorbed. Author

N68-33278*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INFLUENCE OF CHEMISORBED FILMS ON ADHESION AND FRICTION OF CLEAN IRON
Donald H. Buckely Washington Sep. 1968 14 p refs
(NASA-TN-D-4775) CFSTI: HC$3.00/MF$0.65 CSCL 11F

Studies were conducted in a vacuum of 10^{-10} torr with clean polycrystalline iron and with iron containing various films. Results indicate strong adhesive forces for the clean iron; because of the magnitude of these forces friction could not be measured. These forces were appreciably reduced in the presence of adsorbates. Carbon dioxide dissociated on the surface, resulting in metal oxide and carbon monoxide. Water vapor was more effective in reducing friction than was oxygen of the same exposure. With hydrocarbons, the number of carbon-to -carbon bonds influenced friction and adhesion. Friction decreases with chain length and with the number of carbon-to -carbon bonds for a particular chain length. Author

N68-33335*# Materials Research Corp., Orangeburg, N. Y.
AN ALUMINUM NITRIDE MELTING TECHNIQUE
Walter Class Washington NASA Sep. 1968 49 p refs
(Contract NAS3-10659)
(NASA-CR-1171) CFSTI: HC$3.00/MF0.65 CSCL 13H

Experimental studies were undertaken to evaluate the melting behavior of aluminum nitride and, particularly, to determine if pressures of ≤200 atm were sufficient to suppress the decomposition of AlN at its melting point. To determine this as well as the actual melting point of AlN, crucible melting was accomplished in resistively heated crucibles and arc melting was carried out on a cooled copper hearth to achieve uncontaminated AlN melts. The former method permitted the achievement of pressure stabilized melts; although the graphite, rhenium, and tungsten crucible materials reacted with the AlN to prevent an accurate determination of its melting point. The AlN does, however, appear to melt between 2750 and 2850°C. A nitrogen atmosphere at a pressure of 1500 psi was sufficient to suppress decomposition, although this conclusion can be questioned because of the presence of chemical reaction. M.W.R.

N68-33684*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REFRACTORY METAL FIBER NICKEL BASE ALLOY COMPOSITES FOR USE AT HIGH TEMPERATURES
Donald W. Petrasek, Robert A. Signorelli, and John W. Weeton Washington Sep. 1968 48 p refs Presented at the Soc. of Aerospace Mater. and Process Engr. 12th Natl. Symp. on Advan. in Structural Composites, Anaheim, Calif., 10–12 Oct. 1967
(NASA-TN-D-4787) CFSTI: HC$3.00/MF$0.65 CSCL 11F

The stress rupture properties of several refractory metal fiber–nickel base alloy composites were determined at 2000° and 2200°F. The effect of wire diameter, fiber content, fabrication history and compositions of the matrix and fiber on the stress rupture properties of the composite was determined. The 100-hour stress rupture strength obtained for the strongest composites tested at 2000° and 2200°F was 35,000 and 14,000 psi, respectively. Composite strength was related to the compatibility of the fibers with the matrix materials. Composite rupture strength can be optimized by proper fiber diameter selection. Author

N68-35098*# Bendix Corp., Madison Heights, Mich.
OXIDATION RESISTANT MATERIALS FOR TRANSPIRATION COOLED GAS TURBINE BLADES. 2: WIRE SPECIMEN TESTS
Fred W. Cole, James B. Padden, and Andrew R. Spencer Washington NASA Sep. 1968 125 p ref
(Contract NAS3-7269)
(NASA-CR-1184) CFSTI: HC$3.00/MF$0.65 CSCL 11F

Four alloys were selected on the basis of sheet specimen tests, reported in Summary Report CR-930, and tested in 0.005 inch diameter wire form to determine their suitability for use as transpiration cooled gas turbine blade materials. The alloys were N 155, TD nickel-chromium, DH 242, and Hastelloy X. Tests consisted of cyclic oxidation, continuous oxidation, stress rupture life, and stress-oxidation at 1400, 1600, 1800, and 2000°F, and up to 2100 and 2200°F for some tests. Exposure times ranged up to 100 hours except for cyclic oxidation tests where times were 4, 16, 64, 100, 100, 300, 400, 500 and 600 hours. Total specific oxidation weight gain, oxide spall and penetration, and mechanical properties were determined for each alloy. Metallographic examination showed microstructure and oxidation effects. TD nickel-chromium was superior, except for stress sensitivity resulting in internal oxidation. All alloys were limited to a useful service temperature near 1600–1700°F. Author

N68-35200*# Norton Research Corp., Cambridge, Mass.
MECHANISM OF THE ATMOSPHERIC INTERACTION WITH THE FATIGUE OF METALS
M. J. Hordon and M. A. Wright Washington NASA Sep. 1968 54 p refs
(Contract NASw-1533)
(NASA-CR-1165) CFSTI: HC$3.00/MF$0.65 CSCL 11F

In an investigation of the fatigue properties of aluminum in vacuum, experimental work was directed at cyclic frequency and tensile fatigue effects, and at the defect substructure generated in vacuum by fatigue stressing. The mean fatigue life was observed to depend on the cyclic rate of straining at all pressure levels. However, in the region of the critical pressure zone for fatigue life enhancement, changes in the cyclic frequency were noted to have a major effect on crack propagation. Measurements of the fatigue life under conditions limited to alternating tensile stresses alone showed that fatigue life enhancement or crack growth retardation in vacuum was not dependent on compressive stress distributions or fatigue crack closure. Finally, a well defined correlation was observed between the fatigue properties of aluminum and dislocation substructural distributions revealed by thin film electron microscopy. Author

N68-36076*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CAVITATION DAMAGE OF STAINLESS STEEL, NICKEL, AND AN ALUMINUM ALLOY IN WATER FOR ASTM ROUND ROBIN TESTS
Stanley G. Young Washington Oct. 1968 20 p refs
(NASA-TM-X-1670) CFSTI: HC$3.00/MF$0.65 CSCL 11F

Cavitation damage was determined for AISI type 316-stainless steel, nickel 270, and 6061-T6 aluminum as part of an ASTM round robin test program. A vibratory apparatus was used and tests were conducted in water at 75°F under 1 atmosphere pressure. Volume loss, volume loss rate, and mean depth of penetration were determined, and metallographic studies were made of the damage specimens. Author

N68-36970*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE INFLUENCE OF GASEOUS ENVIRONMENT ON THE SELF-ADHESION OF METALS
William P. Gilbreath Washington Oct. 1968 21 p refs
(NASA-TN-D-4868) CFSTI: HC$3.00/MF$0.65 CSCL 11F

The self-adhesion of metal surfaces was measured in various gases with pressure, exposure duration, and temperature as variables. Aluminum, copper, gold, lead, magnesium, and titanium

were studied in air, argon, carbon monoxide, ethylene, hydrogen, nitrogen, and oxygen. The results showed that loss of adhesion for a particular metal resulted from gas adsorption on its contacting surface and that the effect of environment upon adhesion could be related to the heat of adsorption for the particular metal-gas interaction. Author

N68-37053*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

MECHANICAL PROPERTIES AND COLUMN BEHAVIOR OF THIN WALL BERYLLIUM TUBING

Donald R. Rummler, H. Benson Dexter, George H. Harth, III, and Raymond A. Buchanan Washington Oct. 1968 77 p refs

(NASA-TN-D-4833) CFSTI: HC $3.00/MF $0.65 CSCL 11F

The results of an experimental investigation to determine the mechanical properties and column behavior of commercially produced beryllium tubing at room temperature are presented. The investigation included three types of extruded tubing and one type of plasma-sprayed and sintered tubing. The diameters of the tubes ranged from 0.25 to 0.75 inch (6.35 to 19.05 mm). Wall thickness was either 0.020 or 0.040 inch (0.508 or 1.016 mm). Microhardness measurements and metallurgical studies were performed to characterize the tubing microstructure. On the basis of the results of mechanical-property determinations and column tests, the extruded tubing appeared to be suitable for use in truss-type structures. Column buckling loads could be predicted satisfactorily by using the tangent modulus, derived from compressive stress–strain curves, in the inelastic column-buckling equation. The results also indicated that the reproducibility of the dimensions and the mechanical properties of the extruded beryllium tubing were comparable to that of other aircraft structural materials. Author

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MATERIALS, NONMETALLIC

Includes corrosion; physical and mechanical properties of materials (e.g., plastics); and elastomers, hydraulic fluids, etc. For basic research see: 06 Chemistry. For related information see also: 17 Materials, Metallic; 27 Propellants; and 32 Structural Mechanics.

N68-11978*# Southern Research Inst., Birmingham, Ala.
AN INVESTIGATION OF THE MECHANISMS OF HEAT TRANSFER IN LOW-DENSITY PHENOLIC-NYLON CHARS
E. D. Smyly, C. M. Pyron, Jr. and C. D. Pears Washington NASA Dec. 1967 100 p refs
(Contract NAS1-5448)
(NASA-CR-966) CFSTI: HC$3.00/MF$0.65 CSCL 11I

The thermal conductivities of three phenolic-nylon chars having porosities of 0.79, 0.82, and 0.88 were measured in vacuum, nitrogen, and helium environments. The temperature range covered was from 400°F to 1000°F. The pressure range was from 0.002 to 760 torr. The specimens were obtained from virgin materials with densities of 19 lb/ft^3, 30 lb/ft^3, and 42 lb/ft^3 by charring in a 30 percent nitrogen–70 percent argon plasma for 125 to 180 seconds. The input cold-wall heat flux density was 170 Btu/sec-ft^2. The thermal conductivity increased on changing the environment from vacuum to either nitrogen or helium. The increase was greater than could be accounted for by the simple addition of the thermal conductance of the environmental gas to the thermal conductivity measured in vacuum. This discrepancy was explained as an effect due to the thermal shorting of internal delaminations within the char. A thermal model which takes the delaminations into account was developed and correlated with the data. The correlation allowed the isolation of one important intrinsic property of the char, the thermal conductivity of the matrix, assuming that the model describes the physical situation. Author

N68-16623*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
GLASS-, BORON-, AND GRAPHITE-FILAMENT-WOUND RESIN COMPOSITES AND LINERS FOR CRYOGENIC PRESSURE VESSELS
Morgan P. Hanson Washington Feb. 1968 18 p refs
(NASA-TN-D-4412) CFSTI: HC $3.00/MF $0.65 CSCL 11D

An experimental investigation was conducted to determine the tensile-strength properties of glass, boron, and graphite composites at 75°, −320°, and −423° F. Composite tensile-strength and interlaminar-shear-strength tests were made of rings. Tensile strengths of boron filaments were determined at 75° and −320°F. Strengths of glass composites were about 29 percent higher at cryogenic temperatures than at ambient temperature. Boron and graphite composite strengths were essentially the same in the temperature range investigated. Interlaminar shear strength in glass composites also increased from 75° to −320°F; boron and graphite showed no significant change within the temperature range. Filament translation efficiencies ranged from 58 to 69 percent for the materials investigated. Aluminum-foil liners that were adhesively bonded to the internal surface of glass-filament-wound cylinders withstood pressure cycling to 2.5 percent strain for a cyclic life ranging from 14 to 165 cycles at cryogenic temperatures. Liner failures were associated with buckling of the seam areas. Author

N68-18849*# International Business Machines Corp., Cambridge, Mass.
INVESTIGATION OF REFRACTORY DIELECTRICS FOR INTEGRATED CIRCUITS
V. Y. Doo and D. R. Kerr Washington NASA Mar. 1968 81 p refs
(Contract NAS12-105)
(NASA-CR-995) CFSTI: HC$3.00/MF$0.65 CSCL 20L

Growth parameters for pyrolytic silicon nitride such as nucleation, reactant composition, substrate temperature, substrate preparation, and carrier gas were studied. Measurements were made in MNS (metal-nitride-silicon) and MNOS (metal-nitride-oxide-silicon) samples for surface charge density, electronic leakage and dielectric constant determination. The index of refraction and 48% HF etch rate were also measured. The masking property of silicon nitride for dopants which silicon dioxide fails to mask was investigated. Photolithographic techniques were developed so that conventional photoresist could be used. Silicon nitride together with silicon dioxide was used to passivate silicon integrated circuit transistors and diodes. The integrated circuits were thermally and electrically stressed, and the results on H_{FE} and junction breakdowns changes were recorded. Author

N68-19710*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EXPERIMENTAL AND THEORETICAL INVESTIGATION OF THE ABLATIVE PERFORMANCE OF FIVE PHENOLIC-NYLON-BASED MATERIALS
Allen G. McLain, Kenneth Sutton, and Gerald D. Walberg Washington Apr. 1968 32 p refs
(NASA-TN-D-4374) CFSTI: HC$3.00/MF$0.65 CSCL 11I

Five composite ablation materials which contain various percentages of phenolic resin, powdered nylon, and silica (either as spheres or fibers) were tested in a 20-inch hypersonic arc-heated tunnel. The tests were carried out in air at a stream stagnation enthalpy of 4800 Btu/lbm, a cold-wall aerodynamic heating rate of 119 Btu/ft^2-sec, a stagnation pressure on the model surface of 0.066 atmosphere, and a free-stream Mach number of approximately 5. The data obtained from these tests were used to evaluate the ablative performance of each of the materials and have been compared with theoretical predictions of char-recession rate and (for two of the materials) thermal response. During the tests, char removal was due primarily to oxidation and the char-recession rates were not significantly affected by either mechanical failure of SiO_2–C reactions. The addition of 12.5 percent SiO_2 to the high-density materials produced a significant increase in both char integrity and char-virgin material interface strength but resulted in a decrease in thermal effectiveness. Reasonable agreement between measured and calculated char-recession rates was obtained by assuming chemical equilibrium at the char surface between the pyrolysis gases, the char, and the test stream, with CO as the primary reaction product. Reasonable agreement between measured and calculated thermal response could be obtained only when the char thermal conductivity was assumed to be approximately 1/3 of its measured value. Author

N68-20329*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CRYOGENIC POSITIVE EXPULSION BLADDERS

Raymond F. Lark Washington Apr. 1968 18 p refs Presented at the 1st Ann. Cryog. Polymers Conf., Cleveland, 25–27 Apr. 1967 Sponsored by Case Inst. of Technology
(NASA-TM-X-1555) CFSTI: HC $3.00/MF $0.65 CSCL 21H

The cryogenic flexibility of single and multiple plies of thin polymeric films was experimentally determined at −320° and −423°F. Of the films tested, thin Mylar films of 0.5 mil and less are the most flexible. The relations between cryogenic cycle life and film thickness and also for the number of plies of Mylar film are reported for the same two temperatures. Twist-and-flex cycle life of 0.25-mil Mylar C samples at −423°F ranges from 20 cycles for 1 ply to 400 cycles for 10 plies. Test results for spherical 12-inch diameter multi-ply Mylar, Kapton, and polyethylene film bladders are summarized. Bladder material combinations showing the lowest helium gas porosity after 25 liquid hydrogen positive expulsion cycles are: (1) twelve plies of 0.15-mil Mylar C in combination with 20 plies of 0.1-mil polyethylene film; and (2) ten plies of 0.5-mil Kapton in combination with three plies of 2-mil Nomex-Nylon paper. K.W.

N68-22391*# General Electric Co., Philadelphia, Pa.
COATING SELECTION PROGRAM: THEORY
Frederick A. Costello, Thomas P. Harper, and Barbara Aston Washington NASA Apr. 1968 48 p refs
(Contract NASw-960)
(NASA-CR-1041; Doc.-65SD526) CFSTI: HC $3.00/MF $0.65 CSCL 20M

A rational and direct method has been developed for selecting the optical coating pattern for the external surface of a spacecraft, such that the spacecraft temperatures are as close as possible to the midpoint of their preselected ranges. The temperature control is maintained passively by radiation and conduction, using no active control devices. The complete range in mission environments is considered in the optimization procedure. The selection technique has been programmed for use on the GE 600 Series, IBM 7094, or any other computer that uses the standard IBM Fortran IV system. Author

N68-28264*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
CRITERIA FOR SELECTION OF WIRE INSULATIONS FOR USE IN SPACE APPLICATIONS
Vernon Krueger Washington Jul. 1968 17 p refs
(NASA-TN-D-4553) CFSTI: HC $3.00/MF $0.65 CSCL 11I

The properties of five electrical insulation materials (Teflon TFE, Teflon FEP, Specification 44 outer space insulation, Novathene, and modified Rayolin-N) were compared, to provide a guide for selecting wire insulations in spacecraft. Of all the properties considered, the outgassing characteristics, radiation resistance, and weight of the materials were considered most important for space applications. Also considered were the workability of these insulations and the amount of fabrication deterioration that wires and cables using them can withstand. Author

N68-30597*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
POLYMER-FILM COATING OF MAGNESIUM FOR PARABOLOIDAL MIRRORS
Thaddeus S. Mroz and Robert B. King Washington Aug. 1968 13 p refs
(NASA-TN-D-4734) CFSTI: HC $3.00/MF $0.65 CSCL 11C

A material and a method were determined for coating large mechanically polished magnesium surfaces to provide a high quality surface, acceptable for further coating with vapor-deposited optical films. The coating material was a modified epoxy resin mixture. The application procedure consisted of surface preparation using commercially available chemical cleaning agents, spray application with commercially available equipment, and a carefully programmed curing schedule. Author

N68-33034*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF FILM PROCESSING ON CRYOGENIC PROPERTIES OF POLY(ETHYLENE TEREPHTHALATE)
Roger E. Eckert and Tito T. Serafini Washington Aug. 1968 35 p refs
(NASA-TN-D-4762) CFSTI: HC $3.00/MF $0.65 CSCL 11I

The effects of stretch temperature, heat-set temperature, and time on the cryogenic mechanical properties of PET film were studied by using a two-level factorial experiment. Amorphous PET sheet was oriented at either 85° or 95° C. The levels of heat-set temperature and time investigated were 190° and 210° C and 15 and 120 seconds, respectively. Film crystallinity was determined by the density gradient technique. Tensile properties were measured in liquid nitrogen and in liquid hydrogen. Biaxial burst properties were obtained in liquid nitrogen. The number of flexural cycles to failure in liquid hydrogen and room-temperature gas porosities after 25 such cycles were also determined. Author

N68-35100*# Astro Research Corp., Santa Barbara, Calif.
AN EVALUATION OF BORON-POLYMER FILM LAYER COMPOSITES FOR HIGH-PERFORMANCE STRUCTURES
R. F. Crawford Washington NASA Sep. 1968 40 p refs
(Contract NAS7-427)
(NASA-CR-1114; ARC-R-276) CFSTI: HC $3.00/MF $0.65 CSCL 11I

A composite film of polyimide with boron vacuum-deposited on one side has become available for development as a structural material. The objective of the present investigation has been to evaluate the fabricability, mechanical properties, and structural efficiency potentials of this material for structural composites. Hollow tubular test specimens were readily fabricated by wrapping the composite film over mandrels and bonding layers together with epoxy adhesive. These specimens were then tested under axial and bending loads to determine their stiffness and strength. The most important attribute of this form of composite material is that it is bidirectional, in contrast to filaments, which are unidirectional. Structural efficiency analyses performed in this investigation showed that the potential weight savings offered by this bidirectional attribute can be significant for applications such as facings for sandwich cylinders and plates subjected to inplane compression, where biaxial stiffness benefits structural stability. Author

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MATHEMATICS

Includes calculation methods and theory; and numerical analysis. For applications see: 08 Computers.

N68-10121*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

THE RUNGE–KUTTA EQUATIONS BY QUADRATURE METHODS

Joseph S. Rosen Washington NASA Nov. 1967 16 p refs
(NASA-TR-R-275) CFSTI: HC$3.00/MF$0.65 CSCL 12A

This report gives a basically new approach to the formulation of the classic Runge–Kutta process. Dependence on the tedious Taylor expansions is obviated by a matrix equation which defines the Runge–Kutta equations for any order; furthermore, the elements of these matrices are obtained quite simply. The method of quadratures is used to determine the conditions on the parameters which characterize the process since these parameters determine the order of accuracy of these functions. Author

N68-10355*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

DETERMINATION OF STRESSES IN ELASTIC SOLIDS USING THREE STRESS FUNCTIONS AND THREE EQUATIONS

Robert E. Reed, Jr. Washington NASA Nov. 1967 43 p refs
(NASA-TN-D-4253) CFSTI: HC$3.00/MF$0.65 CSCL 20K

The classical equations of elasticity in terms of the stress components are reduced to a set of three equations in terms of the three Maxwell stress functions and arbitrary functions of integration. The sufficiency of these equations is due to the interrelationships between the six compatibility equations. The difficulty in choosing the arbitrary functions to fit a particular problem accents the advantages of using the inverse method to find solutions. A family of exact solutions is presented for stresses in a rectangular solid with certain applied stresses on two opposite faces, workless boundary conditions on two opposite faces, and the remaining two faces free of applied stress. Author

N68-11109*# Brown Univ., Providence, R. I.

USE OF A TRANSCENDENTAL APPROXIMATION IN TRANSIENT CONDUCTION ANALYSIS

P. D. Richardson and W. W. Smith (Taco, Inc.) Washington NASA Dec. 1967 24 p refs
(Grant NGR-40-002-012)
(NASA-CR-955) CFSTI: HC$3.00/MF$0.65

A particular example of a transient conduction problem with a non-linear boundary condition is considered, for which other solutions have been obtained. This example consists of unsteady one-dimensional conduction in a semi-infinite slab with the boundary condition that the heat flux at the surface is proportional to the n-th power of the surface temperature and with the initial condition that the slab temperature is uniform, forming the reference zero (i.e. the zero of an appropriate empirical temperature scale). Solutions for this form of boundary condition are useful for a variety of problems. One practical problem for which they have been used is transient conduction due to unsteady radiation in an enclosure. Author

N68-11494*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

PRODUCTS OF SOME GENERALIZED FUNCTIONS

Robert C. Costen Washington Nov. 1967 36 p refs
(NASA-TN-D-4244) CFSTI: HC$3.00/MF$0.65 CSCL 12A

The purpose of this report is to define a new class of generalized functions which includes products of all members of the class. Application is made to the families of generalized functions derived from tanh nx (hyperbolic tangent family) and from $ne^{-n^2x^2}$ (Gaussian family), where n is a sequence index and x the independent variable. Elementary uses of the product analysis in physics are also presented. The hyperbolic tangent family of generalized functions has the following features: The Dirac delta functions $\delta_n(x)$ and its derivatives are polynomials in the Heaviside unit step function $H_n(x)$ multiplied by powers of the sequence index n. Conversely, powers of $H_n(x)$ may be expressed as linear sums of $H_n(x)$, $\delta_n(x)$, $\delta'_n(x)$, . . . with coefficients containing powers of n. Products of these generalized functions are similarly expressed either as polynomials in $H_n(x)$ or as linear sums of $H_n(x)$, $\delta_n(x)$, $\delta_n(x)$, ... The Gaussian family of generalized functions has analogous features, but products are not the same in the two families. Author

N68-11639*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MULTIPLE DECISION PROCEDURES FOR ANOVA OF TWO-LEVEL FACTORIAL FIXED-EFFECTS REPLICATION-FREE EXPERIMENTS

Arthur G. Holms and J. N. Berrettoni (Ph.D. Thesis—Western Reserve Univ.) Washington Dec. 1967 46 p refs
(NASA-TN-D-4272) CFSTI: HC$3.00/MF$0.65 CSCL 12A

For expensive areas of experimentation, such as alloy development, pressure vessel burst testing, and high-temperature protective coatings, the appropriate experiments consist of two-level fixed-effects factorial designs without replication. No adequate procedures have been available for the statistical analysis of such experiments. A procedure called "chain pooling" is introduced for testing the significance of terms of a model equation as fitted to the observations from a fractional factorial experiment. The procedure starts with a small group containing only the smallest of the ordered squared coefficients of the model equation in the denominator of a test statistic. Stepwise testing, in the increasing order of succeeding squared coefficients, pools insignificant squares into the denominator of the statistic, which is used for continued testing. Monte Carlo computations were performed to determine the decision error probabilities for many different variations of chain pooling and to compare the relative advantages of the variations for fractional factorial experiments with 2^4, 2^5, and 2^6 treatment combinations. These computations were performed with values of the significant coefficients distributed in such a manner as to contribute to high probabilities of decision errors, so that the recommended procedures are good against the worst possible conditions. Author

N68-14077*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
DEVELOPMENT OF A GENERAL FORMULA EXPANDING THE HIGHER-ORDER DERIVATIVES OF THE FUNCTION TANH Z IN POWERS OF TANH Z AND A-NUMBERS
Hans H. Hosenthien Washington Jan. 1968 13 p refs
(NASA-TN-D-4396) CFSTI: $3.00/MF$0.65 CSCL 12A

A general formula for the rth derivative of the function tanh z with respect to z is developed. This formula is a finite polynominal in powers of tanh z where the coefficients are of simple structure containing A-numbers. The A-numbers, $A_r^{(m)}$, of order m and degree r are introduced as an abbreviation for an expression containing C-numbers which are related to Euler's numbers. A recursion formula the A-numbers and their special properties are derived. The paper contains a tabulation of derivatives of tanh z from the first to the sixth order as well as a table of A-numbers covering all combinations of order and degree from 0 to 10. Author

N68-17334*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
BOUNDS FOR THE EIGENVALUES OF A MATRIX
Kenneth R. Garren Washington Mar. 1968 45 p refs
(NASA-TN-D-4373) CFSTI: HC$3.00/MF$0.65 CSCL 12A

This paper provides a listing of techniques used to determine the eigenvalue bounds of a matrix defined over either the real or complex fields. Theorems concerning the condition of eigenvalues as a function of the related matrix are stated. Known theorems which determine the bounds are derived. Closed-form solutions are expressed in terms of (1) the matrix elements, (2) matrix norms, and (3) vectors and the eigenvalues of related matrices. Extensions of several results are made to infinite matrices. A comparison is made in terms of the relative size of the areas of eigenvalue inclusion for the various solutions. Examples in terms of eigenvalue bounds for particular matrices are given. Author

N68-17532*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
ON THE POINCARE–VON ZEIPEL AND BROWN–SHOOK METHODS OF THE ELIMINATION OF THE SHORT PERIOD TERMS FROM A HAMILTONIAN
P. Musen Washington Mar. 1968 36 p refs
(NASA-TN-D-4399) CFSTI: HC$3.00/MF$0.65 CSCL 12A

A comparison is drawn between the methods of Poincare–von Zeipel and Brown–Shook for the elimination of the short period terms from a Hamiltonian by means of canonical transformations. The general theory is developed, and a table of operators is supplied which serve both to eliminate short period effects of any order and to invert the canonical transformation, i.e., to express the original elements in terms of the elements affected only by the long period perturbations. The generating functions which produce these operators are the Taylor and the Lagrange operators. The Lagrange operator is a generalization of the classical operator to the case of several independent variables. In every attempt to solve the problem of the general perturbations using the electronic machines, the table of differential operators and the recurrence relations between them constitute an essential part of the programming. The elimination of the short period terms seems to be somewhat simpler in the Brown–Shook method than in Poincare–von Zeipel method. Author

N68-18455*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
PLANCK FUNCTIONS AND INTEGRALS—METHODS OF COMPUTATION
Thomas E. Michels Mar. 1968 39 p refs
(NASA-TN-D-4446) CFSTI: HC$3.00/MF$0.65 CSCL 20M

Black-body radiation is investigated with emphasis placed on a solution of the Planck integral, which is suitable for computer and hand calculation. A computer program using this method has been included as well as graphs and tables of Planck functions and Planck integrals, which can be used for a wide range of wave numbers, ν, ($=\lambda^{-1}$), and temperatures, T, in degrees Kelvin. A suitable range is: ν from 0.001 to 300,000 cm^{-1} (λ from 10 meters to 333.3 angstroms) for temperatures between 1°K and 25,000°K. Author

N68-19144*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
A NEW METHOD OF TESTING SMALL SAMPLES FOR GOODNESS OF FIT TO NORMAL POPULATIONS
Peter D. Argentiero and Robert H. Tolson Washington Mar. 1968 319 p refs
(NASA-TN-D-4405) CFSTI: HC$3.00/MF$0.65 CSCL 12A

The frequency function is derived for a normal population with unknown mean and variance and from which has been chosen a sample of specified size with zero mean and a standard deviation of one. Tables of areas and ordinates of this frequency function for sample sizes between 20 and 170 are provided. The existence of such tables provides a method of testing small samples for goodness of fit to normal populations without the necessity of replacing unknown population parameters with maximum likelihood estimates. Therefore, this method is an improvement of the usual method of testing the hypothesis that a sample has been chosen from a normal population with unspecified mean and variance. An example is given to illustrate the use of the tables. Author

N68-21100*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
MULTI-STEP RUNGE–KUTTA METHODS
Joseph S. Rosen Washington Apr. 1968 23 p refs
(NASA-TN-D-4400) CFSTI: HC$3.00/MF$0.65 CSCL 12A

The multi-step methods presented in this report differ from the classic, single-step Runge–Kutta process by utilizing the numerical results of the previous integrations. As developed here, the multi-step process avoids the complex Taylor expansions of the functions involved and instead employs the writer's previously developed method of quadratures. Author

N68-21978*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ON THE CONSTRUCTION OF HIGHLY STABLE, EXPLICIT, NUMERICAL METHODS FOR INTEGRATING COUPLED ORDINARY DIFFERENTIAL EQUATIONS WITH PARASITIC EIGENVALUES
Harvard Lomax Washington Apr. 1968 46 p refs
(NASA-TN-D- 4547) CFSTI: HC$3.00/MF$0.65 CSCL 12A

A theory is developed for constructing explicit numerical methods for integrating coupled nonlinear ordinary differential equations with local eigenvalues that are greatly separated in magnitude. Applications are made to cases in which large negative eigenvalues are combined with small complex ones. The specific methods derived are compared with Runge–Kutta methods. The derived methods are not considered to be optimum and further improvements are anticipated. Author

N68-22809*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
GENERAL LAGRANGIAN INTERPOLATION FORMULAS

C. E. Velez Washington May 1968 17 p refs
(NASA-TN-D-4424) CFSTI: HC $3.00/MF $0.65 CSCL 12A

The development of high-degree interpolation polynomials which use the values of the function and its subsequent derivatives is discussed. It is shown that if data of this type are available, high-accuracy interpolation is possible under the restrictive conditions of large step-sizes and few data values. Author

N68-24141*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A COMPUTER PROGRAM FOR REVERSION OF THE CUMULATIVE BINOMIAL PROBABILITY DISTRIBUTION
Darl D. Bien Washington May 1968 13 p refs
(NASA-TM-X-1592) CFSTI: $3.00 CSCL 12A

A technique for reversion of the cumulative binomial probability distribution and an efficient and rapid computer program using the technique are presented. Reversion of the binomial series is useful in calculating the element success probability in a specified parallel system with redundancy which will yield the specified system success probability (reliability). The program is not limited to reliability problems but can also be used in a variety of scientific and engineering problems involving the reversion of the binomial series. Author

N68-24565*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
THE DISTRIBUTION AND PROPERTIES OF A WEIGHTED SUM OF CHI SQUARES
A. H. Feiveson and F. C. Delaney Washington May 1968 42 p refs
(NASA-TN-D-4575) CFSTI: $3.00 CSCL 12A

A study of some of the properties of a weighted sum of chi-square random variables is presented, including the derivation of approximations to the distribution of this sum and an evaluation of the Welch approximation for the distribution of the test statistic in the Behrens–Fisher problem. The study indicates that if equal sample sizes are selected, the Welch approximation to the Behrens–Fisher problem may be safely used. Author

N68-25841*# Innsbruck Univ. (Austria).
LIE SERIES FOR CELESTIAL MECHANICS, ACCELERATORS, SATELLITE STABILIZATION AND OPTIMIZATION
F. Cap, F. Ehlotzky, D. Floriani, W. Groebner, H. Knapp et al Washington, D. C. NASA May 1968 202 p refs
(Grant NGR-52-046-001)
(NASA-CR-1046) CFSTI: HC $3.00/MF $0.65 CSCL 12A

An overview is presented on some of the research work done in the field of Lie series and their physical, technical, and practical applications. The following problem areas are considered: (1) solution of a system of n-th order differential equations; (2) solution of differential equations resulting from the separation of Laplace equation in various coordinate systems; (3) numerical computation of satellite orbits; (4) calculation of particle orbits in accelerators; (5) optimization problem of soft landing on the moon with fuel minimization; and (6) equations of motion of satellites. An extensive bibliography of work done using Lie series is also included. A.L.

N68-25869*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A LEAST SQUARES METHOD FOR THE REDUCTION OF FREE-OSCILLATION DATA
Phillip R. Wilcox and William L. Crawford Washington Jun. 1968 29 p refs
(NASA-TN-D-4503) CFSTI: HC $3.00/MF $0.65 CSCL 01A

The classical least squares curve fitting method is used to determine the frequency, amplitude, damping ratio, phase angle, and zero offset of both a one- and two-degree-of-freedom system from free oscillation data. The method is applied to a number of experimental transients with good results. Where possible, comparisons are made with the results of other methods. The least-squares method is found to be particularly useful in the analysis of two-degree-of-freedom systems where other techniques are difficult or impossible to apply. Author

N68-27457*# Pittsburgh Univ., Pa.
LYAPUNOV STABILITY FOR PARTIAL DIFFERENTIAL EQUATIONS. PART 1: LYAPUNOV STABILITY THEORY AND THE STABILITY OF SOLUTIONS TO PARTIAL DIFFERENTIAL EQUATIONS. PART 2: CONTRACTION GROUPS AND EQUIVALENT NORMS
Gabe R. Buis, William G. Vogt, and Martin M. Eisen Washington NASA Jun. 1968 127 p refs
(Grant NGR-39-011-039)
(NASA-CR-1100) CFSTI: HC $3.00/MF $0.65 CSCL 12A

CONTENTS:
1. LYAPUNOV STABILITY THEORY AND THE STABILITY OF SOLUTIONS TO PARTIAL DIFFERENTIAL EQUATIONS G. R. Buis p 1–113 refs (See N68-27458 16-19)
2. CONTRACTION GROUPS AND EQUIVALENT NORMS W. G. Vogt, M. M. Eisen, and G. R. Buis p 114–122 refs (See N68-27459 16-19)

N68-28240*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PLOT3D—A PACKAGE OF FORTRAN SUBPROGRAMS TO DRAW THREE-DIMENSIONAL SURFACES
R. Bruce Canright, Jr. and Paul Swigert Washington Jun. 1968 32 p refs
(NASA-TM-X-1598) CFSTI: HC $3.00/MF $0.65 CSCL 12A

PLOT3D is a package of FORTRAN subprograms to draw three-dimensional surfaces of the form $z = f(x,y)$. The function f and the bounding values for x and y are the input to PLOT3D. The surface thus defined by PLOT3D may be drawn after arbitrary rotations. Output is by off-line incremental plotter or on-line microfilm recorder. PLOT3D is completely described along with its limitations, possible future modifications, and poetential uses. Sample output and listings of the subprograms are included. Written entirely in FORTRAN IV, PLOT3D is readily adaptable to other hardware. Author

N68-28281*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ON THE USE OF ALGEBRAIC METHODS IN THE ANALYSIS AND DESIGN OF MODEL-FOLLOWING CONTROL SYSTEMS
Heinz Erzberger Washington Jul. 1968 31 p refs
(NASA-TN-D-4663) CFSTI: HC $3.00/MF $0.65 CSCL 12A

This study gives an analysis of and offers design criteria for three configurations of model following. The three configurations studied are real model following, implicit model following or matching dynamics, and real model following with command inputs. It is assumed that model and plant are described by linear vector differential equations where the equations of the model may be of lower order than those of the plant. Algebraic tests are developed to determine under what conditions a feedback law exists that permits perfect following of the model by the closed-loop plant. The same set of tests is shown to be applicable to both real and implicit model following. This leads to the conclusion that real and implicit model following, although physically different, are

mathematically equivalent if no unknown state disturbances or parameter variations occur during the control interval. However, the condition for perfect following with command inputs to the model contains an additional test not present in the first two configurations. If perfect following was shown to be possible, the control law that achieves it is calculated for the implicit model-following configuration. In the general case, this control law must generate both finite and impulse controls if the model is of lower order than the plant. A simple method of approximating the impulse control law to arbitrary accuracy is also given. The theory is illustrated with three examples, two of which are based on the lateral equation of motion of an aircraft. Author

N68-29275*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
STABLE IMPLICIT AND EXPLICIT NUMERICAL METHODS FOR INTEGRATING QUASI-LINEAR DIFFERENTIAL EQUATIONS WITH PARASITIC-STIFF AND PARASITIC-SADDLE EIGENVALUES
Harvard Lomax Washington Jul. 1968 29 p refs
(NASA-TN-D-4703) CFSTI: HC$3.00/MF$0.65 CSCL 12A

Certain classes of coupled, quasi-linear, ordinary, differential equations contain eigenvalues in their associated matrix which make them difficult to integrate by means of conventional numerical differencing schemes, even when the solutions are continuous and nonsingular. Two classes of such parasitic eigenvalues are defined and general ways in which their effects can be suppressed are discussed. Author

N68-29407*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
OPTIMAL COMPUTING FORMS FOR THE TWO-BODY C AND S SERIES
C. R. Herron, E. R. Lancaster, and W. R. Trebilcock Washington Jul. 1968 20 p refs
(NASA-TN-D-4643) CFSTI: HC$3.00/MF$0.65 CSCL 12A

The recently developed universal form of the two-body problem involves several transcendental functions. Since these functions are evaluated so frequently, it is worthwhile to develop approximations that minimize the number of arithmetical operations required. This paper presents several such approximations, based on theories of Chebyshev and Knuth, with bounds for the errors incurred when using them. Author

N68-30594*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
A VECTOR APPROACH TO THE ALGEBRA OF ROTATIONS WITH APPLICATIONS
Paul B. Davenport Washington Aug. 1968 25 p refs
(NASA-TN-D-4696) CFSTI: HC$3.00/MF$0.65 CSCL 12A

A new type of vector multiplication defines a group (whose elements are vectors) isomorphic to the group of rotations. This allows a vector representation of rotations which has many advantages over the usual matrix or Eulerian angles approach, e.g., this vector representation avoids the need for trigonometric relationships and requires only three independent parameters. Several applications show the simplicity of this vector representation—in particular, an analytic solution to a least squares rotation problem. The differential equations defining the motion of a rigid body are obtained in terms of a vector differential equation. Author

N68-30804*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CALCULATIONS OF CHANDRASEKHAR'S X- AND Y-FUNCTIONS AND THEIR ANALOGS FOR NONCOHERENT ISOTROPIC SCATTERING
Franklyn B. Fuller and B. Jeanne Hyett Washington Aug. 1968 147 p refs
(NASA-TN-D-4712) CFSTI: HC$3.00/MF$0.65 CSCL 12A

Results of calculations of the X- and Y-functions of Chandrasekhar, and of their analogs for noncoherent isotropic scattering are given. In the noncoherent work, a Doppler profile is assumed. The results are presented both as tables and in a convenient graphical form, conducive to understanding the behavior of these complicated functions. Moments of the X- and Y-functions are also presented. The method of calculation is based on reduction to the solution of an initial value problem. A simple analytic approximation derived from this method is briefly discussed. Author

N68-31961*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN EFFICIENT METHOD FOR COMPUTATION OF CHARACTER TABLES OF FINITE GROUPS
Gabriel Allen Washington Aug. 1968 29 p refs
(NASA-TN-D-4763) CFSTI: HC$3.00/MF$0.65 CSCL 12A

A systematic procedure is presented for constructing the character table of a given finite group. The use of this procedure makes the task of computing group character tables more straightforward than previously published procedures. Each step in the construction of the character tables is illustrated by worked out examples. Group tables, character tables, and class algebra tables for many of the common finite groups are included. Author

N68-33245*# National Aeronautics and Space Administration, Washington, D. C.
NUMERICAL ANALYSIS—ABSTRACTS OF PRESENTATIONS
Raymond H. Wilson, Jr., ed. 1968 46 p refs Abstracts of papers presented at a workshop meeting on numerical analysis, held in Washington, D. C., 29–30 Jan. 1968
(NASA-SP-170) CFSTI: HC$3.00/MF$0.65 CSCL 12A

Abstracts are presented for the 34 papers given at a NASA workshop on numerical analysis applications to aerospace and related problems. Included are topics such as the integration of lunar motion, calculation of atmospheric properties, techniques for determining thermal radiation, nonlinear methods in aeroelasticity, and evaluation of the geopotential forces for an orbital ephemeris with given high-order harmonics. Other topics deal with heat transfer of a finned spacecraft cylinder, orbital lifetime predictions, optimization problems, and stress analysis. Papers also consider application of the convolution integral, series representations, Bairstow's method, potential theory, and error bounds for real roots. A Heuristic integration program is discussed as are Frechet and other derivatives in a Banach space, multidimensional integrals, truncation errors, biharmonic analysis, and use of the Householder algorithm for solving linear least squares problems. Nonlinear transformations, a boundary value problem solution, and certification of library subroutines are also treated. M.W.R.

N68-33426*# Pennsylvania State Univ., University Park.
DIFFERENTIAL SYSTEMS
Robert Bradley McNeill Washington NASA Aug. 1968 61 p refs
(Grant NGR-39-009-041)
(NASA-CR-1164) CFSTI: HC$3.00/MF$0.65 CSCL 12A

An attempt is made to secure a comprehensive theory for linear and nonlinear differential systems under most general conditions. A generalized form of Bellman's fundamental lemma and the correct proof of Lagrange's variation of parameters formula is presented. Linear systems were studied with respect to the sets beta and zeta. Here an important necessary and sufficient theorem of Conti was generalized. Moreover, a stronger sufficiency theorem was shown, even though one of the original conditions was

dropped. This allowed an obvious extension to the set zeta, which was unattainable via the original theorem. Nonlinear systems are studied by means of their accompanying integral equations. A converse theorem to a standard result is given. The concept of one vector being bounded with respect to another vector is introduced, and a series of theorems concerning this definition follows. Sharper upper bounds were derived. Finally, Lagrange's variation of parameters formula was extended to a certain class of nonlinear systems. Oscillation theorems are presented in order to strengthen previous derivations. Author

N68-35472*# *TRW Systems Group, Redondo Beach, Calif.*
MATHEMATICAL PROBLEMS OF MODELING STOCHASTIC NONLINEAR DYNAMIC SYSTEMS
Richard E. Mortensen Washington NASA Sep. 1968 53 p refs
(Contract NAS2-4553)
(NASA-CR-1168) CFSTI: HC$3.00/MF$0.65 CSCL 12A

The purpose of this report is to introduce the engineer to the area of stochastic differential equations and to point out some of the mathematical techniques and pitfalls in this area. Topics discussed include continuous-time Markov processes, the Fokker–Planck–Kolmogorov equations, the Ito and Stratonovich stochastic calculi, and the problem of modeling physical systems. Author

N68-36525*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ITERATED COMMUTATORS AND FUNCTIONS OF OPERATORS
Howard C. Volkin Washington Oct. 1968 18 p refs
(NASA-TN-D-4857) CFSTI: HC$3.00/MF$0.65 CSCL 12A

A new method is developed by which certain functions of the noncommuting operators A and B can be expressed in a systematic and efficient way in terms of successively higher commutators of the operators. The procedure is designed primarily for polynomials, exponential functions, and analytic functions of the operator (A + B). The method is related to the ordered-operator calculus of Feynman. Certain commutation properties of the operators A and B are represented by polynomials in A and B called iterated commutators. The functions are converted into equivalent forms involving the iterated commutators. All iterated commutators of degree (j + 1) in A and B are combined in a suitable sum to form a new operator $G_{(j)}$. By working only with the $G_{(j)}$ and their commutators, the calculations are simplified and the results are given in an extremely compact notation. Author

N68-36753*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
CLASSICAL FIFTH-, SIXTH-, SEVENTH-, AND EIGHTH-ORDER RUNGE-KUTTA FORMULAS WITH STEPSIZE CONTROL
Erwin Fehlberg Washington Oct. 1968 87 p refs
(NASA-TR-R-287) CFSTI: HC$3.00/MF$0.65 CSCL 12A

In this paper we shall derive classical Runge–Kutta formulas of the fifth, sixth, seventh, and eighth order including a stepsize control procedure which is again based on a complete coverage of the leading local truncation error term. Naturally, these new formulas require more evaluations per step of the differential equations than the known classical Runge–Kutta formulas without stepsize control procedure. Author

N68-37073*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
A COMBINED NEWTON–RAPHSON AND GRADIENT PARAMETER CORRECTION TECHNIQUE FOR SOLUTION OF OPTIMAL-CONTROL PROBLEMS
Ernest S. Armstrong Washington Oct. 1968 64 p refs
(NASA-TR-R-293) CFSTI: HC$3.00/MF$0.65 CSCL 12A

A parameter correction technique is developed to solve a boundary value problem which frequently occurs in optimal control theory. It is assumed that an indirect optimal control method was applied to a controllable dynamic system with a two point boundary value problem resulting such that the boundary conditions take the form of a set of unknown parameters to be determined to meet an equal number of terminal conditions. The optimal control law is a piecewise continuous function with discontinuities occurring only at the zeros of certain continuous functions. A procedure is developed to improve upon an assumed set of parameters so that, by repetitive use of a correction formula, a monotonic decreasing sequence of values of a positive definite function that measures the terminal errors is produced. The direction of the correction vector is found to lie between the directions given by the gradient and the Newton–Raphson procedures. The procedure is applied to the determination of both planar and non-planar fuel optimal trajectories for a space vehicle which is launched from the surface of the moon and required to rendezvous with a space vehicle in a circular orbit. Author

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METEOROLOGY

Includes climatology; weather forecasting; and visibility studies. For related information see also: 13 Geophysics; and 30 Space Sciences.

N68-10222* National Aeronautics and Space Administration. *Goddard Space Flight Center, Greenbelt, Md.*

AN EVALUATION OF SEA SURFACE TEMPERATURE AS MEASURED BY THE NIMBUS I HIGH RESOLUTION INFRARED RADIOMETER

Lewis J. Allison and James S. Kennedy (USAF) Washington NASA Nov. 1967 27 p refs

(NASA-TN-D-4078) CFSTI: $3.00 CSCL 04B

An analysis of Nimbus I HRIR data over various parts of the world indicated limited success in deriving sea surface temperatures to within 3° to 6°K of aircraft radiation measurements (8-13μ) and synoptic-climatological ship sea surface temperature data. At night, thin clouds which may fill the radiometer's field of view make it difficult to interpret the absolute values of derived sea surface temperature. During the daytime, the HRIR data is unusable for oceanographic temperature analysis because the contamination by reflected solar radiation mixes with the emitted radiation. Future satellite instrumentation, consisting of a HRIR radiometer (10–11μ) when used in conjunction with television data, will delineate cloud free ocean areas and permit the daily derivation of sea surface temperatures from approximately 10 to 30% of the world's oceanic regions. Author

N68-17024*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

WIND VELOCITY PROFILES MEASURED BY THE SMOKE-TRAIL METHOD AT WALLOPS ISLAND, VIRGINIA, 1963 AND 1964

Robert M. Henry and Robert W. Miller Washington Mar. 1968 111 p refs

(NASA-TN-D-4365) CFSTI: HC $3.00/MF $0.65 CSCL 04B

Forty-five detailed profiles were obtained for heights from 0.5 to 30 km. Two second-stage profiles for heights from 39 to 58 km are also included. The profiles cover all seasons, and the characteristics are generally similar to those of previously published smoke-trail profiles. Wind velocities in excess of the 99-percent extreme value are included. Closely spaced soundings show only small variations over horizontal distances of 2 km and time intervals of 1-1/2 hours. Author

N68-18246*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

WIND DATA FROM THE 250-FOOT (76.2-METER) TOWER AT WALLOPS ISLAND, VIRGINIA

James A. Cochrane and Robert M. Henry Washington Mar. 1968 46 p refs

(NASA-TN-D-4395) CFSTI: HC $3.00/MF $0.65 CSCL 04B

A nearly continuous 3-1/2 year sample of low-level wind data has been collected from anemometers mounted at five levels on the 250-foot meteorological tower at Wallops Island, Virginia. Fifteen-minute averages of speed and direction were read out at hourly intervals. The statistical treatment and the homogeneity of the sample are discussed. Two types of statistical information—frequency-distribution data and statistical parameters—were computed from the sample. The frequency-distribution information is of three types: (1) percentage probabilities of being less than or equal to a given value of wind speed; (2) wind-speed limits for selected percentiles; and (3) frequency of speed-direction groups. The tabulation of fundamental statistical parameters provides further information on specific properties of the wind distribution. The parameters are presented for various combinations of hourly, monthly, and annual periods. The statistical data included in this report provide the best available information on the low-level wind environment and should be useful for establishing design criteria and supporting launch operations. Author

N68-19084*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

MEASUREMENTS OF WINDS AND TEMPERATURES AT ALTITUDES UP TO 65 KILOMETERS IN THE SOUTHERN HEMISPHERE

James C. Manning and Lloyd W. Chamberlain (Weather Bur., Wallops Sta., Va.) Washington Mar. 1968 61 p refs

(NASA-TN-D-4429) CFSTI: HC $3.00/MF $0.65 CSCL 04B

Meteorological data from 27 rocketsonde and corresponding radiosonde soundings off the west coast of South America are presented as plots of temperature and wind as functions of altitude. The wind data are shown in plots of west-to-east and south-to-north velocity components. Summary time and space cross sections of the data are also shown. Author

N68-20375*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

INVESTIGATION OF AIR-FLOW VELOCITY BY LASER BACKSCATTER

Kent R. Bourquin and Fred H. Shigemoto Washington Apr. 1968 23 p refs

(NASA-TN-D-4453) CFSTI: HC $3.00/MF $0.65 CSCL 04B

An investigation of laser light backscatter properties from an atmosphere emphasized the effect of frequency shift. The detection scheme described is based on this effect and proved successful in the laboratory determination of flow velocity of a contaminated atmosphere. The results agree well with measurements taken with a hot wire anemometer. This investigation used a continuous wave laser radiating in the visible region. The velocity of an air stream containing a small concentration of contaminants was measured. Using this technique to detect clear air turbulence would require that Mie scattering predominate in the turbulent region. This technique does not presently appear practical for airborne detection of clear air turbulence considering the available laser transmitters and detectors, and the uncertain knowledge of the contaminating particle content in a turbulent region. Author

N68-24020 Federal Aviation Administration, Atlantic City, N. J. National Aviation Facilities Experimental Center.

CLEAR AIR TURBULENCE: A BIBLIOGRAPHY, 1950–1967 Final Report

Dorothy E. Bulford Mar. 1968 82 p refs

(NA-68-17; AD-667731)

Clear air turbulence encounters can occur unexpectedly without any visual evidence or warning. As operations of higher altitude aircraft increase, the phenomenon is encountered more often. Clear air turbulence is defined as all turbulence in the free atmosphere of interest in aerospace operations that is not in or adjacent to visible convective activity (this includes turbulence found in cirrus clouds not in or adjacent to visible convective activity). This bibliography consists of 578 references to technical reports, articles in periodicals, and books published during the past 17 years. References about other forms of turbulence such as that occurring with storms and airplane wake vortices are not included. Author (TAB)

N68-25617*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

SOME METEOROLOGICAL OBSERVATIONS OF THE SOUTHERN HEMISPHERE STRATOSPHERE AND MESOSPHERE

J. S. Theon and J. J. Horvath (Mich. Univ., Ann Arbor) Washington Jun. 1968 12 p refs

(NASA-TN-D-4264) CFSTI: HC $3.00/MF $0.65 CSCL 04B

A sea-going experiment was carried out in 1965 to obtain rocket sounding measurements from the atmosphere of the Southern Hemisphere along the west coast of South America from the equator to 60°S. Results are presented for eight Nike Apache pitot-type tube experiments, which were among the 77 rocket soundings taken. Temperature structures in the Southern Hemisphere stratosphere and mesosphere were somewhat different from their Northern Hemisphere counterparts during the corresponding season; and, especially at temperate latitudes, the Southern Hemisphere upper atmosphere was characterized by a warmer stratopause and a colder mesopause. The geostrophic approximation provided a reasonably accurate means for obtaining winds up to 70 km altitude, and zonal wind patterns in this region were characterized by an easterly core centered at 30 to 35 km above the tropics as well as westerly flow that increased with latitude and altitude to a maximum of 60 km above 60°S. This circulation was associated with the developing winter polar vortex. M.W.R.

N68-25816*# Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

INVESTIGATION OF WARM FOG PROPERTIES AND FOG MODIFICATION CONCEPTS

Warren C. Kocmond and James E. Jiusto Washington, D. C. NASA Jun. 1968 70 p refs

(Contract NASr-156)

(NASA-CR-1071; CAL-RM-1788-P-17) CFSTI: HC $3.00/MF $0.65 CSCL 04B

Analytical and experimental investigations were conducted to examine the concept of modifying fog with hygroscopic material. The results indicate that it is possible to improve visibility in warm fog by seeding with micron-size salt particles (NaCl). The visibility in laboratory fog (produced in a 600 m^3 chamber) was increased by factors of three to ten, with as little as 1.7 mg of NaCl m^{-3} being effective. Only modest reductions (<1%) in ambient relative humidity were involved. Extrapolation of these results suggests that clearing a suitable landing zone for aircraft would not involve prohibitive amounts of seeding material. Recommendations are made for field testing the concept. Laboratory experiments also suggest that the formation of fog can be modified by seeding the atmosphere with salt nuclei prior to fog formation. While visibility improvements of a factor of two were achieved in the laboratory, the concept appears less practical for field use. An improved cloud nucleus chamber of the thermal gradient diffusion type was designed and is described together with results of a third year of observations. A "haze chamber" for measuring the concentrations of large and giant nuclei is discussed. Author

N68-33036*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

TEMPERATURE, PRESSURE, DENSITY, AND WIND MEASUREMENTS IN THE STRATOSPHERE AND MESOSPHERE, 1966

W. S. Smith, J. S. Theon, P. C. Swartz, L. B. Katchen, and J. J. Horvath (Mich. Univ., Ann Arbor) Washington Aug. 1968 94 p refs

(NASA-TR-R-288) CFSTI: HC $3.00/MF $0.65 CSCL 04B

Complete data are presented from a total of 43 rocket-borne experiments conducted at Wallops Island, Virginia; Churchill, Canada; Barrow, Alaska; Natal, Brazil; and Ascension Island in the South Atlantic Ocean during 1966. Temperature, pressure, density, and wind profiles from 39 grenade experiments, and temperature, pressure, and density profiles from four pitot static tube experiments covering the altitude range of approximately 30 to 90 kilometers have been compiled. No attempt has been made to analyze the meteorological significance of these data in this report. Error analyses are included for the results of each of the 39 grenade experiments. Author

N68-37869*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

A SATELLITE VIEW OF TYPHOON MARIE 1966 DEVELOPMENT

G. Warnecke, L. J. Allison, E. R. Kreins (Environ. Tech. Appl. Center) and L. M. McMillin (Allied Res. Assoc., Inc., Concord, Mass.) Nov. 1967 98 p 13 refs

(NASA-TN-D-4757) CFSTI: HC $3.00/MF $0.65 CSCL 04B

A complete documentation of Nimbus II High Resolution Infrared Radiometer data and ESSA-3 photographs is presented for the life-time of Typhoon Marie 1966. Particular emphasis was given to the earliest stages of noticeable storm development. The interpretation of the satellite data in combination with the sparse conventional observations from the central Pacific Ocean revealed meteorological conditions in the development area which are commonly found necessary for tropical storm development. Author

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NAVIGATION

Includes guidance; autopilots; star and planet tracking; inertial platforms; and air traffic control. For related information see also: 07 Communications.

N68-11146* National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.

NUMERICAL STUDIES OF TRANSITIONS BETWEEN THE RESTRICTED PROBLEM OF THREE BODIES AND THE PROBLEM OF TWO FIXED CENTERS AND THE KEPLER PROBLEM

R. F. Hoelker Washington NASA Nov. 1967 33 p refs
(NASA-TM-X-1465) CFSTI: $3.00 CSCL 22C

For the comparison of the trajectories of the two fixed-center problem with those of the restricted problem of three bodies, fields of trajectories are numerically computed for six initial position conditions, all starting on the line of masses and perpendicularly to this line. The transition is studied by varying stepwise, for these fields, the rate of revolution of the primaries from zero to the equilibrium rate of circular motion. For the investigation of the behavior of trajectories in the transition from the Kepler problem to the restricted problem, the Kepler orbits are considered in a coordinate system rotating at the rate determined by the continuation of this system into that of the restricted problem. Transition characteristics are shown on samples of periodic orbits and of trajectory fields. In particular, the continuous transition of a family of Kepler orbits into periodic orbits about the smaller primary as well as about the L_3-libration point is demonstrated. Author

N68-11521*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

MIDCOURSE-GUIDANCE PROCEDURE WITH SINGLE POSITION FIX OBTAINED FROM ONBOARD OPTICAL MEASUREMENTS

Harold A. Hamer, Katherine G. Johnson, and W. Thomas Blackshear Washington NASA Dec. 1967 83 p refs
(NASA-TN-D-4246) CFSTI: HC$3.00/MF$0.65 CSCL 17G

A manual procedure is developed for midcourse-guidance application. The procedure required only limited onboard calculations and leads to guidance predictions sufficiently accurate for emergency or backup operations. Although high accuracy cannot be obtained by manual methods as compared with automatic methods, the accuracy of the present method is shown to be adequate to the point where a terminal guidance system could take over with relatively simple equipment. The method is applied to Earth–Moon trajectories and is studied in detail for an example lunar mission. Basically, the determination of only one position fix is required rather than the determination of a large number of position fixes as is usually required in any manual or automatic procedure. This condition is made possible by use of precalculated data which linearly relate deviations from the nominal trajectory at the time of the position fix to those farther along the trajectory. This procedure is especially important for lunar missions where time is limited for making measurements and calculations prior to the first midcourse maneuver. The effects on aim-point accuracy of measurement errors, maneuver errors, star selection, and linear approximation are discussed. Author

N68-11902*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

FACTORS AFFECTING THE DESIGN AND USE OF A PHOTOGRAPHIC SEXTANT FOR SPACE NAVIGATION

Thomas M. Walsh Washington Dec. 1967 37 p refs
(NASA-TN-D-4285) CFSTI: HC$3.00/MF$0.65 CSCL 17G

A study was made of design and use factors that are pertinent to the fabrication of a photographic instrument for obtaining sextant-type data and for providing target star identification information. The objective was to adapt the highly accurate techniques of astronomical photography and film readout to the space cabin environment. Of all the factors studied, the film was the most critical. Currently available emulsions lack either resolution, speed, or ease of development. Improvements in this area are expected and in the near future there should be no serious obstacles to sextant feasibility. However, current emulsions, if made available on flat glass plates, will suffice for sextant measurements that do not require landmark targets. Five basic sextant configurations are examined and one hardware concept is presented. A photographic sextant should be considered a serious alternative as a navigation instrument with a probable precision of better than 10 seconds of arc, with the added capability of providing data for target star identification. Author

N68-11949*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

PRELIMINARY INFRARED HORIZON PROFILES FROM PROJECT SCANNER

Thomas B. McKee, Ruth I. Whitman, and Richard E. Davis Washington Dec. 1967 25 p refs
(NASA-TM-X-1483) CFSTI: HC$3.00/MF$0.65 CSCL 17G

Measured horizon radiance profiles in spectral bands of 615 cm^{-1} to 715 cm^{-1} (CO_2) and 315 cm^{-1} to 475 cm^{-1} (H_2O) from Project Scanner flight of August 16, 1966, are shown. Excellent agreement between measured and analytically predicted radiance profiles in the CO_2 region verifies the analytical technique to within the experimental accuracy. The agreement of measured with predicted profiles and the lack of dependence on presence of clouds indicate the 615 cm^{-1} to 715 cm^{-1} region is a good candidate for use in attitude determination applications. Horizon profiles in the 315 cm^{-1} to 475 cm^{-1} region show a strong dependence on the presence of clouds which indicates that the spectral region would be a poor one for attitude determination applications. Author

N68-13558* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

NAVIGATOR PERFORMANCE USING A HAND-HELD SEXTANT TO MEASURE THE ANGLE BETWEEN A MOVING FLASHING LIGHT AND A SIMULATED STAR

Bedford A. Lampkin Washington Jan. 1968 41 p refs
(NASA-TN-D-4174) CFSTI: $3.00 17G

The performance of a navigator using a hand-held sextant was investigated. The primary variables were the rate of angular motion of the flashing light and the frequency and on time characteristics of the flashing light. Performance criteria were the standard deviation of the measurement data and the bias of the measured angle compared to the true angle. Measurements were made from a stationary sighting station and from a sighting station simulating spacecraft oscillatory motion. An effective technique was developed for training navigators to measure accurately with a sextant. This technique uses measurement error feedback to the operator subsequent to each measurement to inform him of his

error and to aid him in improving his subsequent measurements. The performance during this experiment indicates that an experienced navigator using a hand-held sextant during rendezvous navigation may obtain data with an accuracy of better than 60 arc seconds. Author

N68-14732*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
A STUDY OF THE EFFECT OF MEASUREMENT ERRORS UPON A RANGE CONTROLLER FOR AN ENTRY VEHICLE
Jack A. White Washington Jan. 1968 32 p refs
(NASA-TN-D-4317) CFSTI: HC$3.00/MF$0.65 CSCL 17G

A study of a range controller for an entry vehicle has been made. Three basic path trajectories to simulate short-range entries, medium-range entries, and long-range entries requiring a skip maneuver were selected for the study. The range controller used a bang–bang control during the initial dive into the atmosphere and during the pull-up phase for medium- or long-range entry. Control during the other phases of the trajectory was achieved by a linear-type controller that is dependent upon the solution of desired altitude as a function of desired range. A random number procedure was used to determine the effect of random errors in measuring the vehicle velocity, altitude, and rate of change of altitude upon the effectiveness of the range controller to control the vehicle to the desired range. Results of this study show that the range controller was able to control the vehicle from the entry point for angular ranges varying from 18° to 250° The controller had about the same sensitivity to measurement errors for medium-range and long-range entries. Author

N68-16836*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
LUNAR MODULE PILOT CONTROL CONSIDERATIONS
Clarke T. Hackler, James R. Brickel, Herbert E. Smith, and Donald C. Cheatham Washington Feb. 1968 46 p refs
(NASA-TN-D-4131) CFSTI: HC$3.00/MF$0.65 CSCL 05H

The role of the pilot in control of the lunar module during the lunar landing mission is discussed. A brief description is given of the lunar module mission phases and the lunar module and its primary and backup guidance, navigation, and control sytems. The pilot interfaces with the control system are also discussed. The various simulation studies and flight tests that have been conducted are reviewed. The reasons for the departure from a near-fuel-optimum trajectory and the several aspects of shaping the trajectory for visibility and other piloting considerations following this departure are analyzed. Finally, the primary areas of pilot control in the various phases are examined in detail and are related to such areas of concern as guidance monitoring, landing site inspection and change, landing, engine shutdown, terminal rendezvous, and docking. Author

N68-18484*# Stanford Research Inst., Menlo Park, Calif.
STUDY AND APPLICATIONS OF RETRODIRECTIVE AND SELF ADAPTIVE ELECTROMAGNETIC-WAVE PHASE CONTROLS TO A MARS PROBE
C. A. Hacking, R. B. Battelle, C. H. Dawson, R. C. Kunzelman, J. A. Martin et al Washington NASA Mar. 1968 231 p refs
(Contract NAS2-2933)
(NASA-CR-977) CFSTI: HC$3.00/MF$0.65 CSCL 17B

A theoretical study has been made of several aspects of communication by means of adaptive antenna techniques, from the earth to an interplanetary vehicle (bus), and between the bus and a smaller vehicle (capsule) launched from the bus to land on a planet. The study has been restricted to some of the antenna problems associated with such a communication system, particularly where the vehicle is spin-stabilized. The environment to be expected near a planet, particularly Mars, and its effects on the operation of an adaptive system is discussed in some detail. Consideration is given to the various phenomena associated with atmospheric entry, including plasma, atmospheric inhomogeneities, voltage breakdown, and so forth. Four separate antenna configurations that might be suitable for use on a spinning vehicle were investigated theoretically. Particular attention was paid to the retrodirective mode of operation. Several computer programs were written to analyze various aspects of these antennas. It is shown that the effect of spectral splitting can probably be made negligible by careful design of the antenna and adaptive circuitry. Author

N68-19061*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SATURN 5 MANUAL BACKUP GUIDANCE AND CONTROL PILOTED SIMULATION STUDY
Richard L. Kurkowski and Gordon H. Hardy Washington Mar. 1968 29 p refs
(NASA-TN-D-4481) CFSTI: HC$3.00/MF$0.65 CSCL 17G

Fixed base simulation studies of manual backup guidance and control for the Saturn V have been conducted. A manual attitude trim control system was devised using the spacecraft inertial platform and command module computer to provide a backup attitude control loop. The guidance loop was provided by the pilot who observed digital displays of trajectory parameters, compared them with nominal values, and input controller commands to bias vehicle attitude. Another backup system called the rate command system fed the pilot controller commands directly to the launch vehicle where they were summed with the launch vehicle rate gyro output. The two backup systems were evaluated first for upper stage guidance and control, from second stage ignition to earth orbit injection. The results indicate that either system could be used effectively to guide the vehicle into earth orbit. Evaluation of these two systems for the first stage flight showed that the rate command system was not suitable because the direct on–off signal from the controller adversely affected the sloshing and bending dynamics of the vehicle. The attitude trim system, however, was suitable for first stage control. Author

N68-19236*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SIMPLE PROCESSORS OF STAR TRACKER COMMANDS FOR STABILIZING AN INERTIALLY ORIENTED SATELLITE
Robert D. Showman, Brian F. Doolin, and G. Michael Sullivan Washington Mar. 1968 66 p refs
(NASA-TN-D-4490) CFSTI: HC$3.00/MF$0.65 CSCL 17G

The study develops processors which convert star tracker gimbal angle measurements to satellite attitude control signals. An exact processor is nonlinear and complex because the gimbal angles vary as the inertial orientation of the vehicle changes. In this paper, approximations to the exact processor are developed which greatly simplify the mechanization and yet allow satisfactory attitude control. Three approximate processors are derived from a perturbation analysis in which only the first-order terms are considered significant. The use of the three processors to derive attitude control signals for an example satellite such as the Orbiting Astronomical Observatory is investigated. Author

N68-21123*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NAVIGATOR PERFORMANCE STUDIES FOR SPACE NAVIGATION USING THE NASA CV-990 RESEARCH AIRCRAFT
Richard A. Acken and Donald W. Smith Washington Apr. 1968 20 p refs
(NASA-TN-D-4449) CFSTI: HC$3.00/MF$0.65 CSCL 17G

Manually operated hand-held sextants are being studied to determine whether they are sufficiently accurate for midcourse navigation phases of manned space flight. Studies carried out on the ground have been extended by using the NASA CV-990 aircraft to provide sighting conditions closely simulating those in spacecraft and to investigate further the measurement error due to lunar irradiance. The results of approximately 1200 measurements

made during nine flights confirm results of simulator and ground-based studies which indicate that, with a hand-held sextant, an astronaut can be expected to make navigational measurements with errors having a standard deviation of approximately ±10 arc seconds. A value for moon irradiance effect of approximately 25 arc seconds was established for the conditions of the experiment using a hand-held sextant. Author

N68-21366*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
SIMULATOR STUDY OF PILOT CONTROL OVER THE LUNAR MODULE DURING ASCENT FROM THE LUNAR SURFACE BY USING VISUAL GUIDANCE CUES
Herman S. Fletcher, L. Keith Barker, and Gary P. Beasley Washington Apr. 1968 33 p refs
(NASA-TM-X-1549) CFSTI: HC$3.00/MF$0.65 CSCL 05H

A fixed-base simulator study was conducted to determine the ability of pilots to use a simple, visually guided piloting procedure to inject the ascent stage of the lunar module into a safe transfer orbit which had an apocynthion altitude of 80 nautical miles (148.16 kilometers). The pilot had control of the thrust along the longitudinal axis by means of an on–off switch and of the vehicle attitude by means of a rate-command or a rate-command–attitude-hold control system. The guidance procedure required the pilot to maintain three consecutive constant angles between the thrust axis and the line of sight to the down-range horizon, and to use an integrating accelerometer to indicate when to change the vehicle pitch attitude and when to terminate the thrust. While the tasks required for a simulated launch and transfer-orbit injection were performed by using visual references for guidance, resulting transfer orbits depended on the thrust alignment with the center of gravity and the type of control system. Appreciable pilot-control problems were created when the rate-command control system was used in combination with thrust misalignment, nonvertical-launch effects were of no consequence and easily controlled, and thrust errors as large as 2 percent did not affect the safety of the ascent. Author

N68-21652*# United Aircraft Corp., Farmington, Conn.
A STUDY OF THE CRITICAL COMPUTATIONAL PROBLEMS ASSOCIATED WITH STRAPDOWN INERTIAL NAVIGATION SYSTEMS
Washington NASA Apr. 1968 217 p refs
(Contract NAS12-91)
(NASA-CR-968; SCR-328-1) CFSTI: HC $3.00/MF $0.65 CSCL 17G

A detailed and comprehensive evaluation of the computational processes of strapdown inertial navigators are reported; the computational requirements and error sources are defined, and analytic models of the computational errors are developed. The analytic computational error models were developed with the aid of detailed digital simulations of the flight environment, the strapdown inertial sensors, the computer hardware and the numerical processes. The strapdown computational processes investigated were the determination of attitude, the resolution of accelerometer data into the inertial frame and the computation of position. Author

N68-21754*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
NAVIGATION AND GUIDANCE ANALYSIS OF A MARS PROBE LAUNCHED FROM A MANNED FLYBY SPACECRAFT
Thomas B. Murtagh, Flora B. Lowes, and Victor R. Bond Washington Apr. 1968 70 p refs
(NASA-TN-D-4512) CFSTI: HC$3.00/MF$0.65 CSCL 17G

This study was initiated with the probe and spacecraft separation at the Mars sphere of influence and was terminated with the probe arrival at a specified entry altitude and the spacecraft arrival at Mars periapsis. The disclosures of the study indicate that the results are decidedly dependent on the initial spacecraft errors at the time of separation and on the system model errors assumed when processing navigation data. Author

N68-23377*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
APPLICATION OF MAXIMUM LIKELIHOOD TECHNIQUES TO THE DESIGN OF OPTIMUM STAR TRACKERS
Edwin C. Foudriat Washington May 1968 28 p refs
(NASA-TN-D-4549) CFSTI: HC$3.00/MF$0.65 CSCL 17G

An analytical method was developed for the design of optimum star trackers. In the method both the measurement procedure and the measurement processing—the estimation of the star parameters from the measurement samples—are optimized. The method for measurement processing is based upon the use of maximum likelihood techniques. The equations to be satisfied for estimation of the position and intensity of a star are given with the assumption that the photoelectrons leaving the cathode obey Poisson statistics. With the properties of the maximum likelihood method and the Cramér–Rao inequality, a technique is developed for optimization of the measurement procedure. General equations are derived for the optimum measurement position on the cathode. The procedure is applied to the design of a slit-type star tracker where it is desired to determine the x position of a star image with a Gaussian intensity distribution. The results indicate the star-tracker slit width should be based upon star image size and be independent of star-to-background intensity ratio. The measurement procedure indicates sample should be made along the limb of the star image. Author

N68-24409*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STABILITY ANALYSIS AND MINIMUM THRUST VECTOR CONTROL REQUIREMENTS OF BOOSTER VEHICLES DURING ATMOSPHERIC FLIGHT
Janos Borsody and Fred Teren Washington May 1968 44 p ref
(NASA-TN-D-4593) CFSTI: HC$3.00/MF$0.65 CSCL 17G

Generalized analytic results are derived to give a complete description of an open-loop minimal control requirement to maintain stability for a rigid-body vehicle configuration. The results are easily applicable to both pitch and yaw control planes at any flight time of interest by computing some vehicle dependent parameters and evaluating the given equations. The results show that, with good control system design, the deflection requirements can be reduced to about 56 percent of trim deflection. At the same time, because of the method of control, the maximum angle of attack and bending moments can also be substantially reduced. Author

N68-24512*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field.
A HAND-HELD SEXTANT QUALIFIED FOR SPACE FLIGHT
Bedford A. Lampkin and Donald W. Smith Washington May 1968 31 p refs
(NASA-TN-D-4585) CFSTI: HC$3.00/MF$0.65 CSCL 17G

A hand-held sextant has been developed and fabricated for use in space navigation. The instrument is space-flight rated. Experienced operators may obtain measurement data having an accuracy of better than 10 seconds of arc. The mechanical, optical, and electrical characteristics of the instrument are described in detail. A synopsis of the results of the environmental tests to which the instrument was subjected and a mechanical error model of the instrument are presented. Measurement data and analysis are presented which indicate the operational accuracy of the sextant. Author

N68-24555*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
STAR TRACKER CALIBRATION
Lawrence T. Draper Washington Jun. 1968 13 p refs
(NASA-TN-D-4594) CFSTI: HC$3.00/MF$0.65 CSCL 17G

Optical star tracker calibrations varied among companies in the industry by as much as 250 percent. A calibration procedure has been developed which relates a standard of spectral irradiance to real stars by laboratory measurements and computations. Initial

results from trackers calibrated for the Aerobee Sounding Rocket Program indicate a calibration accuracy on the order of 15 percent. Author

N68-25103*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

ON BOARD CALCULATIONS OF A TWO IMPULSE ABORT TO A PRESELECTED LANDING SITE

Robert B. Merrick Washington May 1968 27 p refs

(NASA-TN-D-4599) CFSTI: HC$3.00/MF$0.65 CSCL 22C

A two impulse maneuver allows great flexibility in the choice of a landing site. This paper assumes that a nominal two impulse abort trajectory has been selected before flight but that the velocity required to attain that abort trajectory from off nominal conditions will be computed manually on board the spacecraft. The method presented here accomplishes the entire plane change with the first impulse and restricts the application of this impulse to cetain preselected ranges. The basic theory is valid for any transfer, in either planocentric or heliocentric space, between two positions whose inertial coordinates are known at prescribed times. Consequently, the theory would allow the method to be used for computing aborts from inbound trajectories, but reasonable fuel limitations restrict its primary applicability to outbound trajectories. The computational procedure developed obtains three orthogonal components, in inertial axes, of the velocity to be gained for the first impulsive rocket firing and obtains the magnitude of second impulse. It is shown that the method is feasible for manual calculations, using four figure accuracy, with a family of graphs to match the time constraint. Author

N68-28236*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.

NAVIGATION AND GUIDANCE SYSTEMS PERFORMANCE FOR THREE TYPICAL MANNED INTERPLANETARY MISSIONS

Flora B. Lowes and Thomas B. Murtagh Washington Jul. 1968 39 p refs

(NASA-TN-D-4629) CFSTI: HC$3.00/MF$0.65 CSCL 17G

The navigation and guidance systems performance for manned interplanetary flight is evaluated for three representative missions: a 1972 Venus flyby mission, a 1975 Mars flyby mission, and a 1977 Mars orbital mission. The navigation system has both Earth-based radar and onboard tracking capabilities for updating position and velocity estimates for a spacecraft and an unmanned probe. Fixed-time-of-arrival and variable-time-of-arrival guidance logic is used in the guidance system to compute velocity corrections and target dispersions. From the performance evaluation for the three missions considered, arrival accuracies and propellant requirements can be predicted for the spacecraft and probe in the three types of missions presented or in similar interplanetary missions. Author

N68-28262*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

RADIOMETRIC MEASUREMENTS OF THE EARTH'S INFRARED HORIZON FROM THE X-15 IN THREE SPECTRAL INTERVALS

Antony Jalink, Jr., Richard E. Davis, and Dwayne E. Hinton Washington Jul. 1968 59 p refs

(NASA-TN-D-4654) CFSTI: HC$3.00/MF$0.65 CSCL 17G

Experimental data of the earth's horizon in three spectral intervals, 0.8 to 2.8 μm, 10 to 14 μm, and 14 to 20 μm, have been obtained by using the X-15 research airplane. The resolution (field of view) of the data at the tangent point is approximately 2 kilometers, and the spatial position of the horizon profile is known to within 4 kilometers. The 14 to 20 μm interval was shown to be the best spectral interval for horizon sensing because it exhibits the least variance at adequate radiant intensity. The 0.8 to 2.8 μm and 10 to 14 μm spectral intervals do not appear suitable for accurate horizon sensing because they are sensitive to low-altitude meteorological changes. The experimental data obtained verified, within experimental accuracy, the theory used to predict the far infrared radiant energy due to carbon dioxide. The use of theory for spectral regions where high-altitude water-vapor data are required is questionable because no mixing-ratio information is available. The single-scattering theory cannot predict accurately the radiant energy in the near infrared region (<3.0 μm). Author

N68-28361*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

A TECHNIQUE FOR PASSIVE ATTITUDE CONTROL OF SOLAR ORIENTED INTERPLANETARY SPACECRAFT

Vernon K. Merrick, Francis J. Moran, and Bruce E. Tinling Washington Jul. 1968 26 p refs

(NASA-TN-D-4641) CFSTI: HC$3.00/MF$0.65 CSCL 17G

Solar pressure forces can provide restoring torques that aline a specified axis of a suitably shaped spacecraft toward the sun. Implementing a control system that employs these torques requires a means of damping oscillatory motion of the solar pointing axis. This paper examines a passive technique of damping by dissipating the energy of relative motion between a pair of connected bodies. Two systems are studied in which the relative motion occurs about a single hinge. Coupling between the attitude motions is caused by unequal rates of change of solar pressure torque with each independent attitude angle. The performance is compared with that of a third system that uses a two-degrees-of-freedom hinge and has no coupling between the attitude motions. Author

N68-28418*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

ANALYSIS OF A STAR-FIELD MAPPING TECHNIQUE FOR USE IN DETERMINING THE ATTITUDE OF A SPIN-STABILIZED SPACECRAFT

T. M. Walsh and Robert L. Kenimer Washington Jul. 1968 22 p refs Presented at the Aerospace Electrotechnol. Symp. of the Intern. Conf. and Exhibit on Aerospace Electrotechnol., Phoenix, Ariz., 19–25 Apr. 1964

(NASA-TN-D-4637) CFSTI: HC$3.00/MF$0.65 CSCL 17G

In certain space experiments precise knowledge of the orientation of a spin-stabilized spacecraft is required. This requirement has resulted in the development of a unique technique of star mapping herein discussed. The star mapping is accomplished by optically scanning a band of the star field about the vehicle's equator. Determination of the orientation of the vehicle's spin axis and roll angle with respect to the celestial sphere is accomplished by cross correlation of the scanned star map with a known reference map of the celestial sphere. The spinning motion of the vehicle causes star images to pass over a reticle which is configured to generate two groups of coded pulses at the output of the sensor. The amplitudes of the signals out of the optical system will be proportional to the spectral radiance of the scanned stars, and thus classification of stars according to their visual magnitude is possible. The time of the occurrence of the two pulse groups is related to the azimuth angle of the star, and the time separation of the pulse groups is related to the star's evaluation angle. Author

N68-30126*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

THE ORBITAL RECOVERY PROBLEM. PART 1: AN ANALYSIS TECHNIQUE FOR RAPID DETERMINATION OF RETURN OPPORTUNITIES AND LATERAL-RANGE REQUIREMENTS FOR RECALL TO RECOVERY NETWORKS

Paul F. Holloway and E. Brain Pritchard Washington Jun. 1967 43 p refs

(NASA-TR-R-259) CFSTI: HC$3.00/MF$0.65 CSCL 17G

An analysis technique has been developed which makes possible a rapid, accurate solution of the orbital return problem in terms of the determination of recall opportunities and the lateral range requirements associated with these opportunities for the recovery of spacecraft. The methods of application of the analysis

(NASA-CR-95808; RD-2005) CFSTI: HC $3.00/MF $0.65 CSCL 22C

The feasibility of using an electro-optical celestial scanning sensor on board the IMP spacecraft for determination of the spacecraft attitude by utilizing star measurements is discussed. The sensor basically consists of a wide-angle lens with a slit positioned on the focal surface, a photomultiplier detector positioned behind the slit aperture and star signal processing electronics. The sensor, which consists of no moving parts, rotates with the spin stabilized vehicle. After automatic identification of the stars detected, the vehicle attitude is determined by computer solution of the system constraint equations. The study effort was largely devoted to the areas of optical design, electrical design, mechanical design, signal detection analysis, system error analysis, and star identification. A recommended system design is determined. Author

N68-31938*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A CELESTIAL ATTITUDE MEASUREMENT INSTRUMENT FOR PROJECT SCANNER

T. M. Walsh, William C. Dixon, Jr., Dwayne E. Hinton, and James A. Holland Washington Aug. 1968 43 p refs

(NASA-TN-D-4742) CFSTI: HC $3.00/MF $0.65 CSCL 03A

The Project Scanner horizon-definition experiment required independent spacecraft attitude measurements with an accuracy (1σ) of 0.016°. This requirement led to the development of a celestial attitude measurement procedure using a unique star-mapping technique. Successful application of this technique required the detection and identification of stars in a +3 visual magnitude A0 spectral class. Star mapping was accomplished by use of a passive optical instrument consisting of a telescope, a coded reticle, and a photomultiplier. The telescope was mounted with its optical axis normal to the Scanner spacecraft principal spin axis. Spin motion about this axis caused star images to transit the reticle. Each star transit was sensed by the photomultiplier as two sequences of coded pulses that were telemetered to a ground receiving station. The amplitudes of the received pulses were proportional to the photometric magnitude of the stars, and the time separation of two pulse groups generated by a single star transit were related to the elevation angle of the star within the field of view of the telescope. Time separations of pulse groups generated by different stars were related to their azimuth angle separations. Total-angular-separation computations were used to identify the stars. Author

N68-31957*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

ATTITUDE DETERMINATION OF THE SPIN-STABILIZED PROJECT SCANNER SPACECRAFT

T. M. Walsh, Jean C. Keating, and Dwayne E. Hinton Washington Aug. 1968 62 p refs

(NASA-TN-D-4740) CFSTI: HC $3.00/MF $0.65 CSCL 17G

The Scanner experiment required continuous knowledge of the spacecraft celestial attitude with a one-sigma accuracy of 0.016°. The basic measurements used to obtain attitude information were sighting times of stars viewed by the star mapper on the Project Scanner vehicle. Each star sighting produced coded-pulse sequences the amplitudes of which were related to the visual magnitude of the star. The times of occurrences of these pulse sequences were related to the angular separation between a pair of stars. These angular-separation data were used to identify the sighted stars. The right ascension and declination of the identified stars and their transit times were used to identify the values of a set of parameters in an assumed model of the vehicle dynamical equations of motion. These vehicle motion parameters were then used to determine the vehicle celestial attitude as a function of time. A brief discussion of the star mapper is presented and the technique used to detect transit times of stars from the coded signals of the star mapper is described. A complete description of the star identification and parameter identification procedures is presented. Author

N68-33006*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

THE EFFECT OF SOME TELESCOPE FACTORS ON VARIABILITY OF PERFORMANCE IN SEXTANT SIGHTING

Robert J. Randle and Emmett C. Lampkin Washington Sep. 1968 24 p refs

(NASA-TN-D-4781) CFSTI: HC $3.00/MF $0.65 CSCL 17G

The use of a hand-held sextant for the acquisition of navigational information in space flight may be a practical and economical method for providing an emergency or supplemental navigation mode. Telescope objective lens diameter, aperture stop diameter, and magnification effects on the variability of a set of angular measurements made with a conventional marine sextant were investigated. Sighting variability performance improved monotonically with increasing telescope powers. Reductions in objective lens size and aperture size were also associated with improved performance. Subjects varied significantly in their sighting ability; subjects who had the poorest performance were helped most by higher magnifications. Performance changes due to magnification changes were dependent upon the objective lens size used. Performance changes due to changes in objective lens size depended upon the aperture size. Author

N68-33271*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A MANUAL NAVIGATION METHOD FOR EVALUATING TRANSFER ORBITS FOR LUNAR LANDINGS

G. Kimball Miller, Jr. Washington Sep. 1968 41 p refs

(NASA-TN-D-4756) CFSTI: HC $3.00/MF $0.65 CSCL 22C

An analytical investigation has been made of a manual navigation method which permits an astronaut in the lunar-landing module to evaluate his orbit as he transfers from an 80-nautical-mile (148.16-kilometer) altitude circular orbit to a point approximately 50,000 feet (15,240 meters) above the lunar surface. The method can also be used to predict the altitude and velocity components at the point of nominal powered-descent initiation. When the local horizontal is known, the method requires only the astronaut's use of a sextant to measure the elevation angle to the command module and the depression angle to the lunar horizon relative to the local horizontal at a single specified measurement point and four simple guidance charts. The navigation method was evaluated for various off-nominal transfer orbits and measurement errors. It was found that the accuracy of the method was enhanced by choosing the measurement point located as late as possible in the transfer orbit. With the measurement point located 40° prior to the point of nominal powered-descent initiation, the basic navigation method generally predicts the altitude of the landing module at pericenter and at the point of powered-decent initiation to within 2500 feet (762.0 meters). The corresponding predicted velocity components at nominal powered-descent initiation are generally within ±4 feet per second (1.22 meters per second) of the actual values. The prediction error experienced under the influence of selected measurement errors (including an optical determination of the local horizontal) are approximately double those of the basic mehtod. Author

N68-33450*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

INFRARED HORIZON PROFILES FOR SUMMER CONDITIONS FROM PROJECT SCANNER

Thomas B. McKee, Ruth I. Whitman, and Richard E. Davis Washington Aug. 1968 125 p refs

(NASA-TN-D-4741) CFSTI: HC $3.00/MF $0.65 CSCL 17G

Measured horizon radiance profiles in spectral bands of 615 cm^{-1} to 715 cm^{-1} (CO_2) and 315 cm^{-1} to 475 cm^{-1} (H_2O) from Project Scanner flight of August 16, 1966, are shown. Data cover a latitude range from 10°N to 57°N. Excellent agreement between measured and independently analytically predicted radiance profiles in the CO_2 region confirms that the analytical technique is within the experimental accuracy. The

agreement of measured with predicted profiles and the lack of dependence on the presence of clouds indicate that the 615 cm^{-1} to 715 cm^{-1} spectral region is a leading choice for attitude determination applications. Horizon profiles in the 315 cm^{-1} to 475 cm^{-1} spectral region show a strong dependence on the presence of clouds. Mixing ratios of water vapor deduced from the radiance measurements indicate little latitudinal variation and are less than 0.017 g/kg at altitudes between 16 km and 33 km. Author

N68-33456*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

THE EFFECTS OF IRRADIATION AND STAR MAGNITUDE ON SEXTANT SIGHTING PERFORMANCE

Robert J. Randle and Emmett C. Lampkin Washington Sep. 1968 11 p refs

(NASA-TN-D-4780) CFSTI: HC$3.00/MF$0.65 CSCL 17G

A hand-held sextant may provide a practical and economical method of acquiring navigational information in space flight during an emergency or to supplement other navigation measurements. If this mode is chosen for space flight, it is mandatory that the limits of human performance with the sextant be established. The present study was designed to investigate variables which may affect sighting accuracy. Male college students with good visual acuity (Snellen 20/20 or better) and normal color vision were trained to make angle measurements with a marine sextant. The sextant was gimbal mounted and angle readings were recorded with a digital shaft encoder mounted on the shaft of the sextant vernier knob. In measuring the angular subtense of a simulated planetary disk, increases in disk brightness were associated with increases in the measured subtense. Changing the magnitude of the reference star did not significantly affect performance. Author

N68-33756*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LOAD RELIEF AUTOPILOT ANALYSIS TO MINIMIZE LAUNCH VEHICLE PEAK THRUST VECTOR DEFLECTION REQUIREMENTS

Leslie L. Scalzott and Fred Teren Washington Sep. 1968 42 p refs

(NASA-TN-D-4786) CFSTI: HC$3.00/MF$0.65 CSCL 17G

A load relief autopilot design to minimize the maximum thrust vector deflection angle required to maintain vehicle stability during flight through design winds is analyzed. The feedback variables are angle of attack and flight path angle as well as attitude error and rate. A rigid body configuration is assumed, and sensor dynamics are not considered. Deflection angle and attitude error responses are presented for design winds. It is shown that the load relief autopilot analyzed results in a 50 percent decrease in deflection requirements for these winds as compared to a conventional autopilot designed to trim the vehicle. Author

N68-33904*# Systems Technology, Inc., Princeton, N. J.

NEW METHODS IN ADAPTIVE FLIGHT CONTROL

Lee Gregor Hofmann and John J. Best Washington NASA Sep. 1968 43 p refs

(Contract NAS1-6813)

(NASA-CR-1152) CFSTI: HC$3.00/MF$0.65 CSCL 17G

A new approach to the design of adaptive control systems was developed. It is called the adaptive control function approach, and the systems so designed are called adaptive control function systems. This terminology is descriptive of the basic operating principle for these systems. The basic operating principle is that sums of properly modulated, conventional linear feedback and feedforward signals provide the control imputs needed to obtain specified responses in a number or output variables of a linear controlled element. The theoretical development in this report deals with linear, constant coefficient controlled elements only. With this restriction, the number of linearly independent controlled element responses which can be arbitrarily specified is equal to the number of independent control points. These specified responses then determine what the (ideal) control inputs should be. Author

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NUCLEAR ENGINEERING

Includes nuclear reactors and nuclear heat sources used for propulsion and auxiliary power. For basic research see: 24 Physics, Atomic, Molecular, and Nuclear. For related information see also: 03 Auxiliary Systems; and 28 Propulsion Systems.

N68-10133*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SHIELDING REQUIREMENTS FOR THE NASA PLUM BROOK HB-6 BEAMHOLE RADIATION EFFECTS FACILITY

Harvey S. Bloomfield Washington NASA Nov. 1967 23 p refs

(NASA-TM-X-1461) CFSTI: HC$3.00/MF$0.65 CSCL 18F

The calculational methods and results used to design a shield assembly for the Plum Brook Reactor HB-6 beamhole facility are described. The function of this shield assembly is to provide adequate biological protection during reactor operation and to permit personnel access to a test chamber after shutdown. Radiation sources examined during reactor operation were neutrons and gamma rays scattered by an experimental package in the test chamber, direct core radiations, and radiation through rectangular slits which may be formed by misalinement of shield sections. Fission product decay gammas and neutron-induced gamma activity in the test chamber were the important radiation sources investigated after shutdown. The bulk of the calculations was performed by specialized digital computer shielding programs which accounted for considerable detail of the core-beamhole geometry. Calculational results compare favorably with experimental measurements on the final shield assembly. Author

N68-10134*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESIGN AND OPERATION OF A HIGH-TEMPERATURE TUNGSTEN-MESH GAS HEATER

Byron L. Siegel Washington, NASA Nov. 1967 26 p refs

(NASA-TM-X-1466) CFSTI: HC$3.00/MF$0.65 CSCL 18I

A high-temperature electrically heated gas heater was designed and is operational. This heater uses interwound helical tungsten coils as mesh heating elements. The heater has heated 0.450 and 0.69 pound per second of nitrogen to 4530° and 4200°R with average mesh bank surface temperatures as high as 4430° and 4270°R respectively. The design of the heater is described and its advantages are discussed. Problem areas associated with the design of a high-temperature heater, such as flow bypass, are described, and resulting solutions or recommendations are given. Author

N68-10291*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPARISON OF ABSOLUTE CALCULATED AND MEASURED GAMMA AND NEUTRON DOSES IN TUNGSTEN–WATER-MODERATED CRITICAL ASSEMBLY

Paul G. Klann and Walter A. Paulson Washington NASA Nov. 1967 55 p refs

(NASA-TN-D-4223) CFSTI: HC$3.00/MF$0.65 CSCL 18E

The mixed gamma and neutron dose was measured at 60 locations within the Tungsten–Water-Moderated Reactor critical assembly. Graphite wall thimble ionization chambers filled with carbon dioxide and polyethylene wall chambers filled with ethylene were used. The chambers were absolutely calibrated in a bremsstrahlung beam against a secondary calibration standard and in a reactor against a water filled calorimeter. These calibrations were used to obtain gamma and neutron response coefficients for the chambers which permitted partitioning of the measured mixed radiation dose into a gamma dose and a neutron dose. The measured gamma doses were compared with an Athena Monte Carlo calculation. Good agreement was found for the 16 locations compared. The average deviation was 10 percent. In addition, the measured neutron doses were compared with a "first collision" calculation of the dose. The calculated neutron doses were uniformly low with an average deviation from the measurement of 18 percent. Author

N68-10561* Georgia Inst. of Tech., Atlanta.

INVESTIGATION OF RADIANT HEAT TRANSFER TO PARTICLE-SEEDED GASES FOR APPLICATION TO NUCLEAR ROCKET ENGINE DESIGN

Edward Y. H. Keng and Clyde Orr, Jr. Washington NASA Nov. 1967 50 p refs

(Grant NsG-273)

(NASA-CR-953) CFSTI: HC$3.00/MF$0.65 CSCL 21F

The objective of this research is to provide fundamental information on radiant heat transfer to aerosols to aid in the evaluation of various gaseous core nuclear rocket concepts. Both theoretical and experimental investigations have been pursued. View factors have been evaluated for a number of conditions considering a cylindrical geometry for the system, such results being generally applicable to high temperature technology. The experimental results agree well with theoretical predictions. A new aerosol generator has been designed to produce dense yet uniform aerosols, and preparation for the study of particle evaporation or sublimation in an intense radiant field are underway. An electrically heated tungsten furnace for this investigation is being assembled. Author

N68-14585*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PARAMETRIC ANALYSIS OF RADIOISOTOPE CASCADED THERMOELECTRIC GENERATORS

James T. Ward and Robert Ruch Washington Jan. 1968 27 p refs

(NASA-TM-X-1501) CFSTI: HC $3.00/MF $0.65 CSCL 18B

The generator consisted of a high-temperature silicon–germanium first stage and a lower-temperature lead telluride second stage was placed concentrically around a cylindrical fuel block. Heat was rejected from the outer surface of the generator shell; in most cases, fins were required to augment the heat rejection. The Si–Ge hot-junction temperature range was 1089° to 1255°K. The PbTe hot-junction temperature was fixed at 811°K and the PbTe cold-junction temperature varied from 422° to 700°K. The fuel-block length-diameter ratio varied from 0.5 to 10.0. The fuel-block-volume power-density range was 0.5 to 10.0 watts per cm^3. The generator power output was fixed at 250 watts electric. The performance of cascaded generators is also compared with the performance of single-stage Si–Ge generators. The results indicate that the cascaded generator operating at a Si–Ge hot-junction temperature of 1089°K had a minimum specific weight of 220 lbs per kilowatt electric (kW_e) at an efficiency of nearly 7%. For a Si–Ge hot-junction temperature of 1255°K, the minimum specific weight was 170 lbs per kWe with an efficiency of over 8%. The single-stage Si–Ge generator with a hot-junction temperature of 1255°K had a minimum specific weight of 100 lbs per kWe at an efficiency slightly below 6%. Author

N68-14986*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ESTABLISHING ALLOWABLE TEMPERATURE GRADIENTS FOR TUNGSTEN–URANIUM DIOXIDE FUEL ELEMENTS USING EXPERIMENTAL CYCLIC STRAIN DATA

Ivan B. Fiero Washington Jan. 1968 36 p ref

(NASA-TN-D-4279) CFSTI: HC$3.00/MF$0.65 CSCL 18J

To establish allowable limits for temperature difference in tungsten–uranium dioxide fuel elements, experimental thermal strain data were examined. The data were obtained by uniformly heating tungsten and tungsten–uranium dioxide composites for 50 thermal cycles. Since the materials were not cycled to failure, the allowable temperature differences established from the experimental data are not absolute maximum values, but represent design values with which fuel element configurations can be evaluated. These allowable temperature differences are those which would produce thermal strains equivalent to the experimental data. If the strains calculated for a given design are less than the experimental values, the fuel element should operate satisfactorily under the conditions considered. Author

N68-15197*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

ANALYSIS OF URANYL FLUORIDE SOLUTION REACTORS CONTAINING VOIDED TUBES

Wendell Mayo Washington Feb. 1968 26 p refs

(NASA-TN-D-4270) CFSTI: HC$3.00/MF$0.65 CSCL 18L

Critical experiments with fully enriched (93.2 percent uranium 235) uranyl fluoride–water solution reactors that contain arrays of large-diameter void tubes have been analyzed satisfactorily. This study evaluates a calculational method that involves the direct application of widely used multigroup computer programs and techniques to cases of extreme heterogeneous voids. Experimental critical solution heights for cores that contain no void tubes and for 19, 31, and 37 void tubes with a 7.658-centimeter diameter were obtained by using the NASA Zero Power Reactor-II facility. Both unreflected cores and cores radially reflected with 15.24 centimeters of water were considered. The void arrays with triangular lattice pitches of either 9.652 or 10.922 centimeters were centrally located in the 76.2-centimeter-diameter core tank. The critical heights of the voided reactors ranged from 21 to about 84 centimeters. Author

N68-15643*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL DETERMINATION OF NEUTRON FLUXES IN PLUM BROOK REACTOR HB-6 FACILITY WITH USE OF SULFUR PELLETS AND GOLD FOIL

John M. Bozek and Michael P. Godlewski Washington Feb. 1968 23 p refs

(NASA-TM-X-1497) CFSTI: HC$3.00/MF$0.65 CSCL 18M

Fast and thermal neutron fluxes were measured in the test cavity outside the HB-6 beam port in the Plum Brook reactor, with the use of sulfur pellets and gold foils. The dependence of flux on reactor power level, shim-control-rod position, water attenuator tank configuration, position in the test cavity, and perturbations by other experiments was investigated. Based on the measurements taken, the thermal and fast neutron fluxes for any combination of these parameters can be determined. Standard fluxes (which correspond approximately to an average flux in the test cavity at full reactor power) were 1.4×10^{6} neutrons per second per square centimeter (nv) for thermal neutrons ($E\leq0.4$ eV or 0.64×10^{-7} pJ) and 8.2×10^{6} neutrons per second per square centimeter (nv) for fast neutrons ($E\geq2.48$ MeV or 0.396 pJ). The flux errors are estimated at ±38 and ±35 percent for thermal and fast neutrons. Author

N68-15792*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

SMALL HIGH-TEMPERATURE NUCLEAR REACTORS FOR SPACE POWER

Edward Lantz, Wendell Mayo, Robert M. Westfall, and John L. Anderson, Jr. Washington Feb. 1968 19 p refs

(NASA-TN-D-4371) CFSTI: HC$3.00/MF$0.65 CSCL 18L

As a first step in a comparison of the relative performance of nuclear reactors and of other thermal sources for space power systems, criticality calculations were made for small, cylindrical, lithium-cooled reactors which use tungsten as the structural material. The nuclear fuels considered were plutonium-239, uranium-233, and uranium-235. These fuels were assumed to be in the form of pure metals, nitrides, and oxides. The radial neutron reflectors considered were beryllium oxide, molybdenum, and carbon. The calculations revealed that the smallest cores are those fueled with metallic U^{233} and Pu^{239}. These cores can be as small as 11 centimeters in diameter and 30.5 centimeters long; however, at desired operating temperatures these cores would contain molten fuel. The smallest solid fuel core contains uranium-233 nitride ($U^{233}N$) in a core 13.5 centimeters in diameter and 30.5 centimeters long. The reactor diameters increase about 2.5 centimeters when the oxide fuel is used in place of the nitride. Cores fueled with U^{235} are considerably larger than those fueled with U^{233} Author

N68-15855*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NUCLEAR DESIGN DATA FOR EXPERIMENTS TO BE CONDUCTED IN HORIZONTAL THROUGH HOLE 1 OF THE PLUM BROOK REACTOR

Robert G. Rohal, Patrick M. Finnegan, and E. J. Ciesla Washington Feb. 1968 31 p refs

(NASA-TM-X-1509) CFSTI: HC$3.00/MF$0.65 CSCL 18M

Three irradiation facilities have been designed for use in the Horizontal Through Hole 1 (HT-1) of the Plum Brook Reactor (PBR). These facilities are the Inpile Helium-Cooled Loop, the Single-Pass Argon-Cooled Facility, and the Inpile Capsule Facility. Experiments were conducted in HT-1 of the Plum Brook Mockup Reactor (MUR) to provide data for experiments employing these facilities. In these experiments, mockups of the three facilities were used to obtain the following information: (1) the thermal-neutron flux, which ranged from approximately 1×10^{9} to 4×10^{9} neutrons per square centimeter per second per kilowatt of reactor power along the axis of the inpile tubes; (2) the fission power in mockups of flat-plate fuel elements composed of tungsten and approximately 10 to 25 grams of fully enriched uranium, which ranged from approximately 0.04 to 0.10 watt per gram of enriched uranium per kilowatt of reactor power; (3) the gamma heating in the inpile tube structure, which ranged from approximately 0.5×10^{-4} to 1.0×10^{-4} watt per gram per kilowatt of reactor power; (4) the reactivity worth of the mock fuel elements and inpile tubes in both normal and accident conditions, which ranged from −4 to −40 cents, respectively. Author

N68-16056*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CALCULATIONS TO SUPPORT OPERATION OF THE PLUM BROOK REACTOR

Harry J. Reilly, John H. Lynch, and Steven R. Borbash Washington Feb. 1968 25 p refs

(NASA-TM-X-1496) CFSTI: HC$3.00/MF$0.65 CSCL 18I

Several calculations that have aided operation of the Plum Brook Reactor were described. First, a simple mathematical model and the resulting calculations which were done to study fuel utilization are described. A decision to buy 240-gram uranium 235 fuel elements and to use them three times each was made on the basis of the study. The power distribution in the mixed loading is discussed and is observed to be more uniform than that in a uniform fuel loading. Charge life weight factors are then derived; the derivation differs in approach and in results from previous derivations by others. Finally, a "xenon clock" on-line computer program in use at the Reactor is discussed, and an approximation useful for hand calculations of complex histories is derived. Author

N68-16478*# United Aircraft Corp., East Hartford, Conn.
EXPERIMENTAL INVESTIGATION OF FLOW PATTERNS IN RADIAL-OUTFLOW VORTEXES USING A ROTATING-PERIPHERAL-WALL WATER VORTEX TUBE
Arthur Travers Washington NASA Feb. 1968 68 p refs
(Contract NASw-847)
(NASA-CR-991; F-910091-10) CFSTI: HC $3.00/MF $0.65 CSCL 21F

Experiments were conducted to determine whether the turbulence observed in radial outflow vortices is caused by fluid injection at the peripheral wall or by an instability inherent with the flow of fluid radially outward from the centerline of the vortex, to determine criteria for the flow conditions that lead to turbulence, and to determine whether a rotating peripheral wall, a rotating inner porous tube, and rotating endwalls have significant effects on flow patterns. Results indicate that radial outflow vortices are characterized by turbulence with large eddies that convect fluid from the central region of the vortex to near the peripheral wall. These flow patterns exist for both basic and axial flow vortex configurations and for wide ranges of the flow conditions. Laminar flow was encountered only with low rates of radial outflow and low superimposed axial velocities. Rotation of the end walls affected flow patterns in the basic vortex configuration for a limited range of the flow conditions. Rotation of the inner porous tube had no effect. Rotation of the inner porous tube and end walls did not affect the flow patterns in the axial flow vortex configuration. R.N.A.

N68-17022*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL DETERMINATION OF GAMMA EXPOSURE RATE IN PLUM BROOK HB-6 FACILITY
John M. Bozek Washington Feb. 1968 14 p refs
(NASA-TM-X-1490) CFSTI: HC $3.00/MF $0.65 CSCL 18H

The gamma ray exposure rates in the HB-6 beam hole facility of the NASA Plum Brook Reactor were measured with lithium fluoride thermoluminescent dosimeters and argon-filled ion chambers. The exposure rates varied as a function of position in the test cavity and the time of measurement. To define and predict variations of the gamma exposure rate, an empirical relation between a standardized exposure rate and various reactor parameters was formulated. The standardized exposure rate, defined at 60 megawatts of reactor power, median values of reactor parameters, and the center of the radiation beam, were measured to be 7.6×10^4 roentgens per hour (19.6 (C/kg)/hr). Author

N68-17095*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUMMARY OF RADIATION EFFECTS ON THERMIONIC INSULATOR MATERIALS
John T. Mayer Washington Feb. 1968 37 p refs
(NASA-TN-D-4414) CFSTI: HC $3.00/MF $0.65 CSCL 18J

Nuclear thermionic power systems are presently being studied for possible space applications. One of the critical materials in such designs is the metal oxide ceramic used as an electrical insulator and seal between various components. Such materials must withstand high temperatures (1000°C and above) as well as fast neutron doses to 10^{22} neutrons per square centimeter. To gain insight into their behavior in such an environment, a literature survey has been conducted for radiation effects data on the following candidates: beryllia, alumina, thoria, zirconia, and yttria. The properties of interest include dimensional changes, thermal and electrical conductivity, strength, thermal expansion coefficient, elastic modulus, and breakdown voltage. A large amount of data were found on beryllia, but much less work has been done on the other oxides, especially zirconia, thoria, and yttria. Beryllia seemed to be the most promising material, and its radiation stability may be improved by the use of additives and/or fine grained low density material. However, the large gas production rate in beryllia may restrict its use in thermionic systems; the release of a significant amount of helium gas into the interelectrode space may affect converter performance. The most successful tests on beryllia to date showed relatively minor changes after fast neutron doses to 9×10^{21} neutrons per square centimeter at 1000°C. In contrast, high temperature tests of alumina and yttria have resulted in gross fracturing at lower doses. No high temperature, high dose data on thoria or zirconia were found. Author

N68-17131*# United Aircraft Corp., East Hartford, Conn.
EXPLORATORY FLOW AND CONTAINMENT EXPERIMENTS IN A DIRECTED-WALL-JET VORTEX TUBE WITH RADIAL OUTFLOW AND MODERATE SUPERIMPOSED AXIAL FLOWS Fifth Interim Summary Technical Report, Sep. 15, 1965–May 30, 1967
Bruce V. Johnson Washington NASA Feb. 1968 85 p refs
Sponsored in part by AEC
(Contract NASw-847)
(NASA-CR-992; F-910091-11) CFSTI: HC $3.00/MF $0.65 CSCL 21F

The containment characteristics of confined radial-outflow vortexes with superimposed axial flow were studied to determine whether high average simulated-fuel densities and high ratios of simulated propellant-to-fuel flow rates could be obtained. The experiments concentrated on two factors that influence simulated-fuel containment: (1) simulated-propellant injection methods in which the flow is injected from the peripheral wall of an axial-flow vortex tube with both axial and tangential (circumferential) components of velocity, and (2) simulated-fuel injection methods. Compared with the containment times measured with no axial component of injection velocity, improvements in containment time of as much as a factor of three-and-one-half were obtained in this investigation using injection with both axial and tangential components of velocity. However, the maximum containment times that were measured were approximately one to two orders of magnitude less than the value now estimated to be required for an economically practical, open-cycle gaseous-core nuclear rocket. Author

N68-18197*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY CONSIDERATIONS FOR FAST-SPECTRUM, LIQUID-METAL COOLED NUCLEAR REACTOR PROGRAM FOR SPACE-POWER APPLICATIONS
Gerald P. Lahti, Edward Lantz, and John V. Miller Washington, Mar. 1968 49 p refs
(NASA-TN-D-4315) CFSTI: HC $3.00/MF $0.65 CSCL 18L

A preliminary study was made in which reactor size and shield weight requirements were calculated for several compositions of uranium nitride and uranium dioxide fuel materials under various operating conditions. A fast-spectrum, lithium-cooled reactor was selected for the study since it potentially will result in the smallest reactor that is capable of operating at the required temperature levels. In order to determine man-rated shielding requirements, a 2-millirem-per-hour radiation dose at 66 feet was selected as a reasonable value, being of the same order of magnitude as that which would be received from galactic cosmic rays in interplanetary space. Nuclear criticality and the allowable fuel burnup limits essentially determine the required reactor size and resulting weight of the shielding. The importance of the other variables, such as allowable steady-state heat-transfer limits, coolant temperatures, flow rates, and coolant hole sizes, is only secondary in determining the weight of the reactor plus shield. Choice of the proper value for each of these parameters can be based on overall system performance, availability of design data, material limitations, and manufacturing feasibility. It appears that nuclear stability and control, fuel material development, and shielding optimization are areas requiring further study. Author

N68-18243*# United Aircraft Corp., East Hartford, Conn.
CONTAINMENT EXPERIMENTS IN VORTEX TUBES WITH RADIAL OUTFLOW AND LARGE SUPERIMPOSED AXIAL FLOWS

John S. Kendall, Arthur E. Mensing, and Bruce V. Johnson Washington Mar. 1968 92 p refs
(Contract NASw-847)
(NASA-CR-993; F-910091-12) CFSTI: HC $3.00/MF $0.65 CSCL 21F

An experimental investigation was conducted to determine the heavy-gas containment characteristics of radial-outflow vortexes for potential application to a vortex-stabilized, open-cycle gaseous nuclear rocket engine. Tests were conducted in a constant-temperature vortex with Reynolds numbers based on the superimposed axial flow up to those expected in a full-scale engine. Air was employed to simulate the seeded hydrogen propellant and a heavy fluorocarbon was used in most tests to simulate the gaseous nuclear fuel. The effects on heavy-gas containment of changes in the vortex tube length-to-diameter ratio, the light-gas injection geometry and area, the ratio of average heavy-gas density to light-gas density, and the density of the heavy gas at injection were studied. The containment parameters varied significantly only with vortex tube length-to-diameter ratio and the ratio of average heavy-gas density to light-gas density. The results of some tests using helium injected near the centerline of the vortex indicated that the presence of a light gas in the central region of the vortex has a significant favorable effect on containment characteristics. Author

N68-18252*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FEASIBILITY STUDY OF A TUNGSTEN WATER MODERATED NUCLEAR ROCKET. 7: SYSTEM DYNAMICS AND CONTROL ANALYSIS
James R. Mihaloew Washington Mar. 1968 98 p refs
(NASA-TM-X-1426) CFSTI: HC $3.00/MF $0.65 CSCL 21F

A system dynamics and control analysis was performed on several versions of a tungsten water-moderated (TWMR) nuclear rocket system, to determine its overall feasibility and control requirements from chilldown to startup and power range operation. Results of steady-state mapping of the TWMR showed that heat exchanger hydrogen bypass was required to prevent icing in the water-moderator cooling heat exchanger. A comparative system analysis of the several TWMR versions showed that the all-topping cycle version with heat exchanger bypass was substantially superior with respect to system simplicity and flexibility at the design chamber pressure of 600 psia. However, a split-feed cycle version with heat exchanger bypass represented the most promising system because of its superior chamber pressure uprating potential. The control analysis of this version showed that chamber temperature control with a poison insertion–extraction scheme was extremely fast in response, but necessarily discontinuous. Chamber temperature control with heat exchanger bypass was comparatively slow but inherently continuous. A control system based on heat exchanger bypass for primary chamber temperature control and poison reactivity for augmentation was demonstrated satisfactorily over a typical operating cycle. Author

N68-18541*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DETERMINATION OF INTERSECTION OF PARTICLE FLIGHT PATH WITH SURFACE OF HELICAL TUBULAR VOID REGION
Millard L. Wohl and Carl D. Bogart Washington Mar. 1968 25 p refs
(NASA-TN-D-4435) CFSTI: HC $3.00/MF $0.65 CSCL 18F

A method for determining the intersections of a nuclear particle flight path and the wall of a helical tubular duct is presented. FORTRAN listings of computer subroutines which perform the numerical analysis involved are included. The subroutines are useful in any Monte Carlo transport analysis where complex void configurations of helical or pseudohelical geometry are involved. Their immediate purpose in this work is to serve as geometry subroutines to be used in conjunction with 05-R, a Monte Carlo transport code. Author

N68-19146*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NUCLEAR THERMIONIC SPACE POWER SYSTEM CONCEPT EMPLOYING HEAT PIPES
Colin A. Heath and Edward Lantz Washington Mar. 1968 24 p refs
(NASA-TN-D-4299) CFSTI: HC $3.00/MF $0.65 CSCL 18N

A space power system employing out-of-pile thermionic diodes and using concentric heat pipes for both heating and cooling of these diodes has been examined. For an early application, the out-of-pile thermionic diode has some advantages over an in-pile system because it is removed from the reactor environment. Moreover, the heat pipe permits emitter temperatures that are not much less than the temperature of the fuel clad. Laboratory data on the performance of heat pipes has been examined and the results used to estimate reasonable performance levels for thermionic diodes which were consequently incorporated into a small, fast-spectrum nuclear reactor concept. Performance levels and system weights including shield weights, have been estimated from first order calculations. The overall system can have the advantage of the safety inherent in heat pipe redundancy and the improved performance available from components that are removed from the reactor environment. Author

N68-19925*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REACTIVITY EFFECTS CAUSED BY RADIAL POWER FLATTENING IN A SMALL, FAST-SPECTRUM REACTOR
C. L. Whitmarsh, Jr. Washington Apr. 1968 13 p refs
(NASA-TN-D-4459) CFSTI: HC $3.00/MF $0.65 CSCL 18I

The effect on criticality of flattening the radial power distribution in a small, reflector-controlled, fully enriched, fast-spectrum nuclear reactor was calculated. Compared to a uniformly fueled, fully enriched core, a decrease in reactivity occurred from reduced fuel inventory and an increase in reactivity occurred from enhanced reflector worth. Fuel distributions were also calculated to indicate the effects of (1) changing the power ratio of 1.1, and (2) changing the reflector thickness to 7.62 cm. Change (1) resulted in a zoned core with an enrichment variation from 71.3 percent in the central zone to 93.2 percent in the peripheral zone; whereas, for change (2) these values were 67 and 93.2 percent, respectively. The net reactivity loss (fuel loss–reflector worth increase) based on a 93.2 percent enriched uniformly-fueled core was 3 percent for either of these zoned cores. Power distortion in a reactor core is caused by reflector movement required to compensate for reactivity changes over the core lifetime. This effect in zoned cores was observed by calculating power shapes for the initial and the end-of-life reflector configurations for two zoned cores. Author

N68-20355*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ACTIVATION OF SODIUM, LITHIUM, AND POTASSIUM IN COMPACT FAST REACTORS AND ITS EFFECT ON SHIELDING
Leonard Soffer Washington Apr. 1968 23 p refs
(NASA-TM-X-1512) CFSTI: HC $3.00/MF $0.65 CSCL 18J

Neutron activation of sodium (Na), lithium (Li), and potassium (K) used as possible coolants in a "typical" compact fast reactor were analytically investigated. The natural elements, all individual isotopes, and one common eutectic (NaK 78) were examined. Suitable energy dependent neutron fluxes were used in conjunction with activation cross sections to calculate saturated specific activities. Activation cross-section data for the elements studied were compiled and tabulated, and these data are judged to be adequate for engineering calculations. Results show that when zero holdup time is assumed, the best coolants, on the basis of unshielded activation dose rate, are K^{40}, K^{39}, Li^{7}, and natural Li. The worst are K^{41} and Na. Because of low natural abundance, K^{40} is impractical as a reactor coolant. Lithium dose rates are

very sensitive to holdup time beause of the short (0.8 sec) half-lives of the Li products. Holdup of even a few seconds greatly reduces the Li dose rates but not those for any other element. Lithium 7 held up for 8 seconds and gave the lowest activation dose rate of any coolant considered. The unshielded dose rate from the assumed fission product release was the highest of all. It was about two orders of magnitude greater than the zero-holdup Li^7 rate, and about five orders of magnitude greater than the dose rate for Li^7 held up for 8 seconds. Gas evolution resulting from coolant irradiation was also investigated and found to be negligible except for Li^6. Author

N68-21111*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

POSTSHUTDOWN COOLING REQUIREMENTS OF TUNGSTEN WATER-MODERATED NUCLEAR ROCKET

Walter A. Paulson and Ray M. Crawford Washington Apr. 1968 23 p refs

(NASA-TM-X-1568) CFSTI: HC $3.00/MF $0.65 CSCL 21F

The postshutdown cooling requirements were calculated for the tungsten water-moderated reactor concept. The reactor was assumed to have operated at full power for 1 hour. An amount equivalent to 5.25 percent of the hydrogen used during the operation at full power is required to remove the energy generated after shutdown. The postshutdown cooling schedule requires continuous hydrogen flow for the first 1000 seconds followed by 23 pulsed cooling periods. The last hydrogen pulse occurs at 6.1 days after shutdown. The pulse flow rate is 0.3 pound per second (0.136 kg/sec) and the duration of the pulses range from 4250 seconds early in the schedule to 1300 seconds at later times. Author

N68-21124*# United Aircraft Corp., East Hartford, Conn.

OPTICAL ABSORPTION IN FUSED SILICA DURING TRIGA REACTOR PULSE IRRADIATION

R. Gagosz, J. Waters, F. C. Douglas, and M. A. De Crescente Washington NASA Apr. 1968 67 p refs

(Contract NASw-847)

(NASA-CR-1031; F-910485-1) CFSTI: HC $3.00/MF $0.65 CSCL 18J

An experimental investigation was conducted to determine the spectral transmission characteristics of fused silica before, during and after exposure to reactor irradiation pulses. The transmission measurements were carried out at three wavelengths (0.215, 0.625 and 1.0 microns) and at a range of temperatures from ambient to 900°C. Corning 7940 fused silica specimens in a corner cube configuration were mounted next to the reactor core face. Peak neutron and gamma fluxes obtained from this reactor were approximately 5.4×10^{15} n/cm^2-sec and 6.1×10^7 R/sec, respectively. Neutron and gamma doses associated with these pulses were 2.3×10^{14} n/cm^2 and 2.6×10^6 R, respectively. The effective time of the pulse obtained by dividing the total dose by the peak flux was approximately 0.043 sec. The transmission measurements were made immediately before, during and after the reactor pulses to monitor both the creation of irradiation induced absorption and the decay of the induced absorption after the pulse. Author

N68-21705*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HOT ISOSTATIC COMPACTION OF TUNGSTEN–URANIUM DIOXIDE FUELS WITH HIGH-VOLUME FRACTION OF URANIUM DIOXIDE

Paul F. Sikora and Andrew C. Millunzi Washington Apr. 1968 19 p refs

(NASA-TM-X-1563) CFSTI: HC $3.00/MF $0.65 CSCL 18J

Dense (>98 percent of theoretical) tungsten–uranium dioxide cermets containing 30 to 70 volume percent uranium dioxide were fabricated by hot isostatic compaction of tungsten-coated uranium dioxide particles. Both thin plates (0.020-in. or 0.051-cm thick) and small-diameter rods (0.20-in. or 0.51-cm diam) were successfully produced at compaction conditions of 3100°F (1700°C) and 30,000 psi (207 MN/m^2). In addition to volume-fraction loading of uranium dioxide, other variables studied in this program were the effect of (a) fuel particle size in the range of 50- to 110-micron diameter, (b) molybdenum or a molybdenum alloy (TZM) in container assemblies, and (c) compaction schedule and pressure (up to 42,000 psi or 295 MN/m^2). Fully dense cermets were produced with all combinations of the range of variables studied. The surface smoothness of the cermets was affected only by the choice of container materials. Containers produced from TZM resulted in smooth cermet surfaces; however, unalloyed molybdenum containers often resulted in irregular surfaces. The feasibility of applying a thin tungsten cladding to the cermet surfaces as an integral part of the compaction process was also demonstrated. Author

N68-21924*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

APPLICATIONS OF MONTE CARLO ANALYSIS TO TUNGSTEN RESONANCE ABSORPTION

Robert M. Westfall Washington May 1968 47 p refs

(NASA-TN-D-4545) CFSTI: $3.00 CSCL 18F

Calculational procedures for Monte Carlo analyses and tungsten resonance absorption are presented. The widely used flat spatial neutron source assumption is shown to overestimate the effective resonance integral of the large scattering resonance in W^{186} by 21 percent at a surface to mass ratio (S/M) of 0.5 cm^2/g. Resonance overlap in natural W decreases the effective resonance integral by 18 to 7 percent over a S/M range of 0.16 to 4.0 cm^2/g relative to calculations which ignore resonance overlap. Spatial self-shielding in a complex geometric cell is evaluated through comparison of Monte Carlo calculations with exact geometric and homogenized absorber region representations. The code EPIGRAM, which selects energy points for resonance cross sections, is reported. Author

N68-22022*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

GAMMA FLUX AND HEAT DEPOSITION IN PLUM BROOK REACTOR—COMPARISON OF CALCULATION AND EXPERIMENT

Robert J. Bacigalupi and Byron E. Thinger Washington Apr. 1968 24 p refs

(NASA-TM-X-1539) CFSTI: HC $3.00/MF $0.65 CSCL 18M

A computerized point-kernel technique (QAD-P5) was used to calculate a gamma-heating map of a thermionic diode experiment proposed to be irradiated in the Plume Brook reactor core. A replica of the diode was used in the low-power mockup reactor at Plum Brook to generate corresponding gamma-heating maps experimentally using lithium fluoride dosimetry. A detailed comparison of experimental and calculated values generally showed agreement to within ±25 percent. Proper interpretation of the measured values is discussed herein. Author

N68-22038*# United Aircraft Corp., East Hartford, Conn.

STUDIES OF SPECIFIC NUCLEAR LIGHT BULB AND OPEN-CYCLE VORTEX STABILIZED GASEOUS NUCLEAR ROCKET ENGINES

G. H. Mc Lafferty and H. E. Bauer Washington NASA Apr. 1968 102 p refs

(Contract NASw-847)

(NASA-CR-1030; F-910093-37) CFSTI: HC $3.00/MF $0.65 CSCL 21F

Analytical studies were conducted to determine the characteristics of two specific vortex-stabilized gaseous nuclear rocket engines: a nuclear light bulb engine and an open-cycle engine. Both engines are based on the transfer of energy by thermal radiation from gaseous nuclear fuel suspended in a vortex to seeded hydrogen propellant. The two engines differ in that the nuclear light bulb engine employs an internally-cooled transparent wall to separate the fuel-containing vortex region from the propellant region, while the open-cycle engine relies entirely on fluid mechanics

containment for preferential retention of the nuclear fuel. The majority of the work has been directed toward the nuclear light bulb engine, since recent fluid mechanics results indicate that the fuel retention characteristics of an open-cycle vortex-stabilized engine are insufficient to provide economic fuel containment. The nuclear light bulb engine offers the possibility of providing essentially perfect containment of the nuclear fuel. The studies indicate approximate values of the thrust, weight, and specific impulse of both configurations. Author

N68-22088*# United Aircraft Corp., East Hartford, Conn.
EXPERIMENTAL INVESTIGATION OF RADIAL-INFLOW VORTEXES IN JET-INJECTION AND ROTATING PERIPHERAL-WALL WATER VORTEX TUBES
Arthur Travers Washington NASA Apr. 1968 38 p refs
(Contract NASw-847)
(NASA-CR-1028; F-910091-14) CFSTI: HC $3.00/MF $0.65 CSCL 21F

Experiments were conducted in water vortex tubes to determine the effects of peripheral-wall injection area and axial bypass on the flow pattern and location of the radial stagnation surface in radial-inflow vortexes. The particular type of flow pattern investigated contains a central cell region which is bounded on the outside by a radial stagnation surface which appears to be laminar. At the radius of the radial stagnation surface, all radial flow passes through the end wall boundary layers. The flow in the vortex is laminar for radii less than that of the radial stagnation surface and is turbulent at larger radii. Tests were conducted with different combinations of tangential injection and radial Reynolds numbers, different amounts of bypass flow, and different peripheral-wall injection areas. The characteristics of the flow and the radius of the radial stagnation surface were determined from observations and photographs of dye patterns. The results of the experiments were compared with the results of a previous theoretical investigation of confined vortex flows. Author

N68-23481*# United Aircraft Corp., East Hartford, Conn.
OPTICAL ABSORPTION IN TRANSPARENT MATERIALS FOLLOWING HIGH-TEMPERATURE REACTOR IRRADIATION
F. C. Douglas, R. Gagosz, and M. A. DeCrescente Washington NASA May 1968 90 p refs
(Contract NASw-847)
(NASA-CR-1032; F-910485-2) CFSTI: HC $3.00/MF $0.65 CSCL 18M

An experimental investigation was conducted to determine the optical absorption levels induced in fused silica as a result of exposure to nuclear reactor irradiation over a range of fast neutron fluxes, fast neutron doses, and reactor temperatures. Also included in the investigation were a limited number of specimens made from alumina, hot-pressed beryllia, and single crystal beryllia. Measurements of the ultraviolet transmittance spectrum were made prior to the reactor irradiation, after the reactor irradiation, and after a series of cobalt-60 gamma irradiations. Measurements were also made during and after heat treatments at elevated temperatures. The induced absorption coefficients were determined from these measurements at the centers of absorption bands located at 0.215 and 0.163 microns. Author

N68-23894*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REACTIVITY INSERTIONS IN COMPACT REACTOR CORES DUE TO FUEL MOVEMENT
Robert E. Sullivan Washington May 1968 14 p refs
(NASA-TM-X-1587) CFSTI: HC $3.00/MF $0.65 CSCL 18J

The reactivity effect of fuel movement in several compact reactor cores, highly fueled with uranium-233 dioxide was calculated using a computer program to solve the Boltzmann transport equation. Author

N68-24559*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REACTIVITY CONTROL OF FAST-SPECTRUM REACTORS BY REVERSIBLE HYDRIDING OF YTTRIUM ZONES
John L. Anderson, Wendell Mayo, and Edward Lantz Washington Jun. 1968 35 p refs
(NASA-TN-D-4615) CFSTI: HC $3.00/MF $0.65 CSCL 18D

The temperature dependent equilibrium hydrogen content of yttrium hydride above 1173°K is investigated as a means of reactivity control for a cylindrical reactor using zones of hydride in various in core and reflector configurations. The temperature dependence is such that the control system is inherently self-regulating. Severe power peaking, dependent on the hydrogen density, occurs at the hydride core interfaces. Use of auxiliary control for startup reduces the control demand on the variable hydriding system and thus reduces the power peaking. A configuration for which the reactivity control satisfies required core life and power peaking limits is presented. Author

N68-25058*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland Ohio.
AGES OF D(D,N)HE SUP 3 AND T(D,N)HE SUP 4 NEUTRONS IN WATER AND TUNGSTEN-WATER MIXTURES
Roger L. Alexander, Donald F. Shook, and Donald Bogart Washington May 1968 22 p refs
(NASA-TN-D-4581) CFSTI: HC $3.00/MF $0.65 CSCL 18J

Ages for D–D and D–T neutrons were measured. Experimental and calculated ages were in agreement for water, but measured ages exceeded calculated ages for tungsten–water mixtures. The discrepancy increases with an increase in the volume fraction of metallic tungsten in the tungsten–water mixture. The most probable reasons for the discrepancy are incomplete data for the partial inelastic cross sections of the tungsten isotopes and the inadequacy of the evaporation model used to represent inelastic scattering above 1.5 MeV in the GAM II cross section compilation. Author

N68-26764*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
METHOD FOR CALCULATING ALLOWABLE CREEP STRESS IN LINEARLY INCREASING STRESS ENVIRONMENT
Charles L. Whitmarsh, Jr. Washington Jan. 1968 12 p refs
(NASA-TN-D-4352) CFSTI: HC $3.00/MF $0.65 CSCL 18J

An analytical technique was developed to calculate the allowable design stress for a specified creep limit of a material under conditions of linear stress buildup and constant temperature. The analysis utilizes constant-stress creep data in the integration of a stress-dependent creep rate over the material history. Allowable design stress limits for 1-percent creep of refractory metals in the temperature range 800° to 1600°K are increased by 25 to 57 percent when compared with calculations based on the constant end-of-life stress conditions. Author

N68-28304*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AXIAL POWER TAILORING TO OBTAIN CONSTANT FUEL-CENTERLINE TEMPERATURE IN A NUCLEAR REACTOR
Harry W. Davison Washington Jul. 1968 43 p refs
(NASA-TN-D-4658) CFSTI: HC $3.00/MF $0.65 CSCL 18L

The total-power output from a nuclear reactor can be increased by tailoring the axial-power shape if reactor power is limited by fuel-centerline temperature. The potential power gains and the axial-power shape required to obtain a constant fuel-centerline temperature are calculated using steady-state heat-transfer calculations on a long fuel rod cooled externally by forced convection. Steady-state two-group neutron diffusion theory is used to predict the axial-fuel loading required to obtain the desired axial-power shape. Fuel loadings and neutron-flux distributions are presented for various axial-power shapes required in a reflected, water moderated, and cooled reactor. Author

N68-29390*# Florida Univ., Gainesville.
GRAPHITE TRIPLE POINT AND SOLIDUS-LIQUIDUS INTERFACE EXPERIMENTALLY DETERMINED UP TO 1000 ATMOSPHERES
Glen J. Schoessow Washington NASA July 1968 38 p refs (Contract NAS3-10412)
(NASA-CR-1148) CFSTI: HC $3.00/MF $0.65 CSCL 18J

A pressure cell with a resistance heated graphite test specimen in a helium atmosphere was used to experimentally determine the triple point of graphite and the solidus liquidus interface to 1000 atmospheres absolute. Four grades of graphite were tested for triple point pressure and temperature. The triple point pressure was determined to be 103 atmospheres absolute for the four grades. The temperature varied for each grade. The solidus liquidus interface from the triple point to 1000 atmospheres was experimentally determined for one grade of graphite. The melting temperature increased with increasing pressure from 7645°R at 103 atmospheres to 7750°R at 1000 atmospheres absolute based on a linear least squares fit. Author

N68-29950*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NEUTRONIC EFFECTS ON MODERATOR INSERTION IN FAST-SPECTRUM REACTORS
Wendell Mayo Washington Aug. 1968 18 p refs
(NASA-TM-X-1614) CFSTI: HC $3.00/MF $0.65 CSCL 18I

A study of the effects of insertion of yttrium hydride into fast-spectrum reactors was conducted. Large, negative moderator temperature coefficients of reactivity that became more negative with increasing moderation were found. Partial or primary reactor control could be based on this temperature coefficient. An increase in the mean prompt-neutron lifetime and a decrease in the positive reactivity coefficients of volumetric compression were observed whem moderator was added. Moderator addition, however, increases the core size and results in larger fast-neutron fluxes in the reflector, causing increased shield weight for compact nuclear spacepower systems. Author

N68-30516*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CHARACTERISTICS OF A SPACE-POWER NUCLEAR REACTOR WITH CONSIDERATIONS FOR VENTING OR CONTAINING GASEOUS FISSION PRODUCTS
John V. Miller Washington Aug. 1968 57 p refs
(NASA-TM-X-1631) CFSTI: HC $3.00/MF $0.65 CSCL 18L

A study of a fast spectrum, liquid metal cooled reactor in which the gaseous fission products were either completely vented, completely contained, or partially vented from the fuel element, was performed. Although several areas were found in which insufficient data are currently available to accurately analyze the problem, the characteristic behavior of the various concepts was determined using fuel temperature, cladding strain, and nuclear criticality as limiting conditions. The analysis shows that the completely vented reactor is generally smaller than the other concepts. This size advantage decreases as the strength of the cladding increases and as the allowable fuel temperature decreases. Author

N68-30750*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NEUTRONIC CALCULATIONS OF FUEL AND POISON DRUM CONTROL OF REFRACTORY-METAL, FAST-SPECTRUM, SPACE POWER REACTORS
Robert M. Westfall and Wendell Mayo Washington Aug. 1967 24 p refs
(NASA-TN-D-4709) CFSTI: HC $3.00/MF $0.65 CSCL 18L

An analytical procedure was developed to evaluate drum control worths with one-dimensional, radial, discrete ordinate transport calculations. Two types of drum control were evaluated, one with fuel drums containing a heavy-metal reflector material, the other with poison drums containing beryllium oxide and boron carbide. The one-dimensional procedure gave small-core drum control worths which agree with two-dimensional calculations to within 7 percent. The control response curves from two-dimensional calculations agree with $\sin^2(\theta/2)$ curve to within 15 percent. Poison control drum worths are sufficient for 40-centimeter-diameter cores. Fuel control drums are applicable to cores as large as 80 centimeters in diameter. Author

N68-32968*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ELECTRON-BOMBARDMENT FILAMENT DESIGNS FOR HEATING CYLINDRICAL THERMIONIC CONVERTERS
Peter Cipollone Washington Aug. 1968 20 p refs
(NASA-TM-X-1630) CFSTI: HC $3.00/MF $0.65 CSCL 18N

The effect of axially varying the pitch of helical electron-bombardment heaters on the axial distribution of radial heat flux to an internally heated hollow cylinder was investigaged; the cylinder simulating the electron-emitting electrode of a thermionic converter. Measured axial distributions of temperature and corresponding calculated heat fluxes are presented for a series of five variable-pitch filaments and fpr mean emitter-surface temperatures of 1778 to 2038°K. These results are compared to similar data obtained with a uniform-pitch filament. Author

N68-32983*# General Electric Co., Pleasanton, Calif.
THERMAL CONDUCTIVITY OF COATED PARTICLE URANIUM DIOXIDE TUNGSTEN CERMETS
L. N. Grossman Washington NASA Aug. 1968 27 p refs (Contract NAS3-8511)
(NASA-CR-1154) CFSTI: HC $3.00/MF $0.65 CSCL 18J

The thermal conductivity of cermets fabricated by hot-pressing of tungsten (W) coated uranium dioxide (UO_2) was measured. Data obtained from specimens containing nominally 80 and 60 volume percent UO_2 were compared with theoretical predictions based on Bruggman's model. Excellent agreement was found between theory and experiment in the 80 volume percent case in the temperature range of 900 to 1500°C. Less satisfactory agreement was obtained in the 60 volume percent case between 600 and 1700°c; the discrepancies could not be explained. The experimental technique, specimen preparation, experimental results and post-experiment metallography are presented. Author

N68-34087*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY STUDY OF A THERMIONIC REACTOR CORE COMPOSED OF SHORT-LENGTH EXTERNALLY FUELED DIODES
Howard G. Yacobucci Washington Sep. 1968 69 p refs
(NASA-TN-D-4805) CFSTI: HC $3.00/MF $0.65 CSCL 18I

The characteristics of a thermionic reactor-core concept, aimed at incorporation of the best features of several previously proposed concepts, are studied. Optimization of diode dimensions resulted in a reference design for a 211-kW electric core. The design, which employs electrical zoning to reduce the detrimental effect of radial thermal power variation, was analyzed for various electrical failures. Equations were derived for calculating internal resistance losses in diodes that have an electrical conductor in parallel with an electrode. Author

N68-35073*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPARISON OF SMALL WATER-GRAPHITE NUCLEAR ROCKET STAGES WITH CHEMICAL UPPER STAGES FOR UNMANNED MISSIONS
M. Ray Clark, Gary D. Sagerman, and Gerald P. Lahti Washington Sep. 1968 58 p refs
(NASA-TN-D-4827) CFSTI: HC $3.00/MF $0.65 CSCL 21F

Payload performance and the radiation environment characteristics of this small reactor type (200 to 600 MW power)

in a nuclear upper stage are considered. Payload dose criteria indicate that any shielding requirement would be based on propellant heating considerations. Several approaches to propellant heating, including subcooled or slush hydrogen propellant and shielding, are compared. Potential performance gains are outlined for the Saturn 1B and 260-inch solid launch vehicles when employing orbital nuclear start engine firing, optimum nuclear thrust, and subcooled hydrogen propellant. Payload sensitivity to the nuclear-stage jettison weight and to the shielding approach to propellant heating is illustrated. Author

N68-35153*# General Electric Co., Cincinnati, Ohio.
CB-1ZR SODIUM THERMAL CONVECTION LOOP
E. E. Hoffman and J. Holowach Washington NASA Sep. 1968 135 p refs
(Contract NAS3-2547)
(NASA-CR-1097; R67SD3014) CFSTI: HC $3.00/MF $0.65 CSCL 20M

A sodium thermal convection loop constructed of Cb-1Zr was tested for 1000 hours at temperatures up to 2380°F. The purpose of the experiment was to evaluate several of the components selected for subsequent use in a two-loop Cb-1Zr facility in which liquid sodium was to circulate in a primary loop and potassium was to circulate in a two-phase secondary loop. In general, the components tested performed satisfactorily. No significant corrosion of the Cb-1Zr by the high temperature sodium was observed and the level of the vacuum environment maintained during the experiment prevented deleterious contamination of the Cb-1Zr tubing. The results of chemical analysis indicated a migration of the oxygen in the Cb-1Zr tubing from the hottest regions of the loop to the cooler regions. Author

N68-35826*# United Aircraft Corp., East Hartford, Conn.
OPTICAL ABSORPTION AND FLUORESCENCE IN FUSED SILICA DURING TRIGA PULSE IRRADIATION
R. Gagosz and J. Waters Washington NASA Sep. 1968 43 p refs
(Contract NASw-847)
(NASA-CR-1191; G-910485-3) CFSTI: HC $3.00/MF $0.65 CSCL 18J

An experimental investigation was conducted at the Mark II pulse reactor to determine the spectral transmission characteristics during and after an irradiation pulse and to determine the cause of the apparent increase in transmission during the pulse and the apparent decrease of trnasmission after the pulse which had been observed in the previous test program. A total of 91 experiments were performed on six specimens at a range of temperatures from 500 to 900C. Transmission measurements were made at two wavelengths, 2150 and 3021 Angstroms. Corning 7940 fused silica specimens in a corner cube configuration were mounted next to the reactor core face at the internal end of a reactor beam port. Peak neutron and gamma fluxes obtained from this reactor were approximately $5=4 \times 10^{15}$ n/cm^2-sec and 6.1×10^7 R/sec, respectively. Neutron and gamma doses associated with these pulses were 2.3×10^{-14} n/cm^2 and 2.0×10^6R, respectively. In addition to the transmittance tests, bypass and optical instrumentation tests were conducted to examine the influence of the optical instrumentation tests were conducted to examine the influence of the optical alignment parameters upon system operation. Fluorescent test were also conducted to obtain an applicable correction to the transmittance runs. Author

N68-36055*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH POWER KINETICS OF A TWO DIMENSIONAL CIRCULATING LIQUID METAL FUEL REACTOR
Michael J. Kolar Washington Oct. 1968 54 p refs
(NASA-TN-D-4840) CFSTI: HC $3.00/MF $0.65 CSCL 18K

A two dimensional model of a single channel unreflected circulating fuel reactor is used to investigate the effect of a radial temperature distribution on the neutron kinetics. A slug flow model with no delayed neutrons is used. The effects of a nonuniform radial heat source distribution and radial heat transfer are taken into account. Results show that radial heat transfer has little effect on the kinetics. Furthermore, if changes in multiplication are not too large, the flux and radial temperature distribution maintain their steady state shapes throughout the transient. For certain combinations of the physical parameters, resonances can occur in the time dependent flux and temperature. These resonances can be predicted by either a line reactor model or a two dimensional reactor model; however, a two dimensional model is necessary to predict the value of the steady state flux and temperature following a transient. Author

N68-36615*# United Aircraft Corp., East Hartford, Conn.
EXPERIMENTAL STUDY OF MULTI-COMPONENT COAXIAL-FLOW JETS IN SHORT CHAMBERS
Bruce V. Johnson Washington NASA Oct. 1968 84 p refs
(Contract NASw-847)
(NASA-CR-1190; G-910091-16) CFSTI: HC $3.00/MF $0.65 CSCL 21F

Fluid mechanics experiments were performed to obtain information applicable to an open cycle, coaxial flow, gaseous nuclear rocket engine. In this engine concept, gaseous nuclear fuel and a surrounding stream of seeded hydrogen propellant pass coaxially through a reactor chamber. The flow was simulated in the present experiments by multicomponent, constant temperature, coaxial flow jets in short chambers. The flow was studied using flow visualization techniques and concentration measurements. Author

N68-37209*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
VERY HIGH BURNUP VAPOR TRANSPORT FUEL PIN CONCEPT FOR LONG LIFE NUCLEAR REACTORS
Frank E. Rom, Patrick M. Finnegan, and Glen E. McDonald Washington Oct. 1968 33 p refs
(NASA-TN-D-4860) CFSTI: HC $3.00/MF $0.65 CSCL 18I

A very-high-burnup, vapor-transport fuel-pin concept is presented. Sample calculations using the design charts given in the report show that fission densities in the range of 10^{20} to 10^{21} fissions per cubic centimeter are conservatively predicted. The fuel within the pin can be operated at sufficiently high inside surface temperatures so that fuel redistribution will occur by design. This feature accommodates and relieves the adverse effects of nonuniform power distribution, hot spots, and nonuniform burnup. Changes in reactor reactivity due to high burnup are minimized with the vapor-transport fuel-pin concept. Author

N68-37260*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
GAMMA HEATING IN THIN HEAVY-ELEMENT ABSORBERS
John H. Lynch, Richard J. Crum, and Harry J. Reilly Washington Oct. 1968 20 p refs
(NASA-TM-X-1680) CFSTI: HC $3.00/MF $0.65 CSCL 18K

The ratio of gamma heating per gram of tungsten to gamma heating per gram of water was calculated for the case of a thin tungsten detector in a water shield. One dimensional transport theory calculations were used to obtain response polynomials which predict this ratio as a function of source energy, shield thickness, and detector thickness. Electron transport effects were also examined. Useful results are presented in the form of graphs. Author

N68-37927*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF TURBULENT MIXING ON AVERAGE FUEL TEMPERATURES IN A GAS-CORE NUCLEAR ROCKET ENGINE

Albert F. Kascak and Annie J. Easley Washington Nov. 1968 28 p refs

(NASA-TN-D-4882) CFSTI: HC $3.00/MF $0.65 CSCL 21F

A heat transfer analysis was made for a coaxial flow nuclear rocket. The analysis considers one-dimensional radial transfer of heat, by both radiation and turbulent mixing from a centrally located fissioning gas to a coaxially flowing propellant. The results compare the effective thermal conductivities for radiation and turbulent mixing. Also included are typical radial-temperature profiles at various axial locations and average fuel temperatures showing the effect of neglecting turbulent mixing. Turbulent mixing had a large effect on local temperature in regions where the fuel density was smallest. Therefore, the effect of turbulent mixing on the average fuel temperature was small. Author

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PHYSICS, GENERAL

Includes acoustics, cryogenics, mechanics, and optics. For astrophysics see: 30 Space Sciences. For geophysics and related information see also: 13 Geophysics, 20 Meteorology, and 29 Space Radiation.

N68-10354*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

OPTICAL ALIGNMENT OF SILICON CRYSTALS

Felix E. Geiger and Sidney Brashears (Electro-Mech. Res., Inc.) Washington NASA Nov. 1967 11 p refs

(NASA-TN-D-4187) CFSTI: HC $3.00/MF $0.65 CSCL 20L

The principles of optical alignment of crystals, specifically silicon, are discussed. A relatively simple apparatus is described which allows crystal orientation to within ±2° or better, depending on the crystal plane. Data are presented and optical reflection patterns are given which identify not only the usually given {100}, {110}, and {111} planes but also the {311} and {122} planes. The usefulness of the latter two is pointed out when crystal orientations in more than one direction are required. The relationship between reflectograms and stereographic projection of crystal planes, and the latter's use for identifying optical reflections, are pointed out. An Appendix gives some useful hints on cutting such crystal wafers as required in solar cell and transistor technology, and in the measurement of Hall effect, resistance, and electron spin resonance. Author

N68-10674* Mississippi State Univ., State College.

MICROWAVE SPECTROSCOPY OF MOLECULES: BIBLIOGRAPHY, 1964–1966

Gordon E. Jones, B. Wayne Castleman, and Rudolph G. Oswald Washington NASA Nov. 1967 42 p refs

(Grant NGR-25-001-008)

(NASA-CR-951) CFSTI: $3.00 CSCL 07D

A bibliography is presented on the various studies pertaining to the adaptation of microwave spectroscopy to the problem of detecting and identifying contaminants in the atmosphere of closed space capsules. Emphasis is placed on the microwave measurement of gases, and the listings are grouped according to inorganic molecules and organic molecules. M.G.J.

N68-13115*# Lockheed Missiles and Space Co., Palo Alto, Calif.

DESIGN AND CONSTRUCTION OF AN ENGINEERING MODEL SOLID CRYOGEN REFRIGERATOR FOR INFRARED DETECTOR COOLING AT 50°K

R. P. Caren and R. M. Coston Washington NASA Jan. 1968 65 p refs

(Contract NAS5-9549)

(NASA-CR-988) CFSTI: HC $3.00/MF $0.65 CSCL 13A

Structural and thermal design evaluations for a spaceborne sublimating solid cryogenic refrigerator resulted in the development of a prototype stacked unit that uses two cylindrical cryogen containers and a common vacuum space. The argon and carbon dioxide containers keep infrared detector operating temperature down to about 52°K. The refrigerator is able to remain unvented and in solid state during spacecraft boost phase, as well as for several days of a hold phase before the temperature rises markedly. G.G.

N68-15950*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.

SUBCRITICAL CRYOGENIC STORAGE DEVELOPMENT AND FLIGHT TEST

R. K. Allgeier Washington Feb. 1968 92 p refs

(NASA-TN-D-4293) CFSTI: HC $3.00/MF $0.65 CSCL 20M

A subcritical cryogenic nitrogen system was aboard Apollo-Saturn flight 203 on July 5, 1966. This flight completed development of this particular sub-critical system. This paper contains the development history, ground-test results, and flight-test results of a sub-critical cryogenic storage system which is designed to supply warm vapor regardless of the liquid orientation. A two-phase development program resulted in delivery of ground-test units and flight units. The successful flight test culminated development efforts with this subcritical system and demonstrated its feasibility. Author

N68-21444*# Michigan Univ., Ann Arbor. Dept. of Electrical Engineering.

ELECTROMAGNETISM IN MOVING, CONDUCTING MEDIA

Rudolph M. Kalafus (Ph.D. Thesis) Washington NASA Apr. 1968 95 p refs

(Grant NGR-23-005-107)

(NASA-CR-1025; Rept.-7322-3-T) CFSTI: HC $3.00/MF $0.65 CSCL 20C

Based on Minkowski's theory of the electrodynamics of moving bodies, the present work is concerned with the systematic solution of problems involving sources placed in a uniformly moving, conducting medium. In order to accomplish this it is first necessary to examine the two differing forms of Ohm's law for moving media that are found in the literature. It is concluded here that the two forms are equivalent and interchangeable, and that their apparent difference arises out of different definitions of conduction and convection currents. Another difficulty which is encountered when dealing with conducting media is related to the relaxation phenomenon. The total charge and current densities cannot be independently specified, but must be consistent with the relaxation phenomenon; for non-conducting media only the equation of continuity must be met. A scheme is developed here which involves a separation of currents and charges into source and response terms. The source terms can be specified independently, but the total charge must be consistent with Maxwell's equations. Vector and scalar potentials are developed from the field quantities, and partial differential equations for the potentials are derived for two classes of problems: static charge sources, and harmonic current sources. For unbounded regions potential solutions are found by the method of Green's functions, which satisfy the same differential equations. The differential equations are solved by transform methods, and the Green's functions are found in closed form. The medium is assumed to have constant scalar parameters of permittivity, permeability, and conductivity. The results are valid for all values of conductivity and frequency, and for relativistic velocities. Author

N68-24146*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

A THEORETICAL APPROACH TO THE DETERMINATION OF MAGNETIC TORQUES BY NEAR FIELD MEASUREMENT

J. C. Boyle, J. Greyerbiehl, and E. J. Mosher Washington May 1968 22 p refs

(NASA-TN-D-4485) CFSTI: HC $3.00/MF $0.65 CSCL 20C

Using the concept of stress in the medium as postulated by Faraday and developed mathematically by Maxwell and Jeans, equations are derived for the torque on a magnetic object immersed in an arbitrary magnetic field. The calculation requires a knowledge of the magnetic intensity vector over any closed surface which encompasses the magnetic object of interest. Torque equations are derived for the case where the closed surface is a sphere of arbitrary radius and also where the closed surface is a right circular cylinder. The validity of the equations is tested by applying them to a simple intensity distribution (that of a theoretical dipole) where the resultant torque is known a priori. There is also a discussion of permanent versus induced moments and a technique which can be used to separately identify these components based on near field information. Author

N68-25868*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

OPTICALLY INDUCED FREE-CARRIER LIGHT MODULATOR

C. Gruber and W. E. Richards Washington Jun. 1968 18 p refs

(NASA-TN-D-4608) CFSTI: HC $3.00/MF $0.65 CSCL 20F

Laser modulators for optical communications systems have recently been the subject of great effort especially in visible or near-infrared regions. The availability of optical sources in these regions, where excellent atmospheric transmission "windows" exist, has prompted attempts to extend the previously developed modulation techniques to longer wavelengths. Existing devices have other disadvantages such as excessive drive power requirements for high-frequency/wide-bandwidth operation, multicomponent optical configurations, inability to modulate at high optical power levels, and (with one or two exceptions) low modulation index. The present paper describes an optical modulation technique that should be able to overcome many of these difficulties and, in addition, provide complete electrical isolation of the modulation element. In addition the technique can be used over a broad range of infrared wavelengths determined solely by the optical transmission characteristics of the modulator material. In brief, this technique uses optically generated free electrons (and/or holes) in a bulk semiconductor in order to change its transmission characteristics. Apart from its construction in suitable semiconducting material, the modulator requires an easily modulated optical pump signal. Author

N68-28259*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AN EXPLANATION OF FITZGERALD'S AUDIOFREQUENCY RESONANCES AND SOUND BEAMS

Donald R. Behrendt and James P. Cusick Washington Jun. 1968 12 p refs

(NASA-TN-D-4625) CFSTI: HC $3.00/MF $0.65 CSCL 20A

Fitzgerald's method is used to investigate the origin of his audiofrequency resonant phenomena. The source of the phenomena is shown from experiment to arise from the stiffness of the sample-shaker interface and not from a process associated with the interior of the sample, as proposed by Fitzgerald. The resonance effects are explained in terms of conventional elastic theory. Author

N68-30596*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MEASUREMENT OF THE TRANSMISSIVITY OF A CARBON-PARTICLE-SEEDED NITROGEN JET

Chester D. Lanzo Washington Aug. 1968 18 p refs

(NASA-TN-D-4722) CFSTI: HC $3.00/MF $0.65 CSCL 20F

An experiment was conducted to measure the transmissivity of a flowing steam of nitrogen gas that had been seeded with nominal 0.009-micron carbon particles. The seed density and light-beam wavelength were the variables of the experiment. Seed density was varied from 10^{-5} to 10^{-4} g/cm^3. Wavelength was varied from 200 millimicrons to 3500 millimicrons. The results are presented as a ratio of transmitted to incident light intensity, and as an absorption cross section. Scattering is assumed to be unimportant. The experimental results show that the absorption cross section decreases as the seed density increases. This is attributed to particle agglomeration. The measurements also show that, for all practical purposes, the absorption cross section is independent of wavelength for wavelengths from 200 to 3500 millimicrons. Author

N68-36460*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.

MATHEMATICAL DETERMINATION OF GEOMETRICAL IMAGE ABERRATIONS IN SINGLE AND DOUBLE MIRROR SYSTEMS

Martin G. Hurwitz and Hubert F. A. Tschunko Washington Oct. 1968 25 p refs

(NASA-TN-D-4692) CFSTI: HC $3.00/MF $0.65 CSCL 20F

The mathematical analyses to determine the image aberrations of single and double mirror systems are presented. The single mirrors, spherical and paraboloidal, are considered. Then, double mirror systems with paraboloidal primary and hyperboloidal secondary are considered, along with higher aspherics of the secondary and tolerances in the relative positions of the mirrors. This investigation is a first step in the evaluation of the imaging performance of single and double mirror systems. The general analysis available in the literature is not applicable without development for the special requirements of the present cast. This special raytracing is the prerequisite needed later for the Fourier transformations which serve to derive the image performance data necessary to the determination of wave optical aberrations. Author

N68-36470*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

EFFECTS OF EDGE CONSTRAINTS ON OPTICAL QUALITIES OF A SPACECRAFT WINDOW

David N. Warner, Jr. and Thomas M. Walsh Washington Oct. 1968 37 p refs

(NASA-TN-D-4845) CFSTI: HC $3.00/MF $0.65 CSCL 22C

Some effects of edge constraints on optical qualities of Gemini spacecraft windows were determined experimentally. Frames approaching theoretical fixed-edge and free-edge constraints were designed and constructed for the investigation. Gemini window frames were also used so that the idealized frames could be compared to an operational window frame. Direct measurements were made of the flatness and wedge angle of the windowpanes, the resolution loss through the window, the angular deviation of a line of sight, and the distortion of a flat wave front traveling through the window assembly. Space pressure differentials were applied to the window to bow the panes and simulate the effect of the space environment. Tests showed that edge constraints on spacecraft windows significantly affect their optical qualities. The qualities become irregular, particularly at high incidence angles, as the panes are distorted in the simulated space environment. Although the clamped edge frames did not provide a strictly theoretical fixed-edge condition, they did allow less surface deflection, less angular deviation to the line of sight, and less distortion to a plane wave front. Author

N68-37792*# Israel Program for Scientific Translations, Ltd., *Jerusalem.*

ANALYTICAL MECHANICS. STABILITY OF MOTION. CELESTIAL BALLISTICS [ANALITICHESKAYA MEKHANIKA, USTOICHIVOST' DVIZHENIYA, NEBESNAYA BALLISTIKA]

A. I. Lur'e, ed. et al 1968 262 p 454 refs Transl. into ENGLISH of the "Proc. of the 2nd All-Union Conf. on Theoret. and Appl. Mech., Pt. 1" Moscow, Izd. Nauka, 1965 Conf. held at Moscow, 29 Jan.–5 Feb. 1964 Sponsored jointly by NASA and NSF (NASA-TT-F-503; TT-68-50305) CFSTI: HC $3.00/MF $0.65 CSCL 20

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PHYSICS, ATOMIC, MOLECULAR, AND NUCLEAR

Includes atomic, molecular and nuclear physics. For applications see: 22 Nuclear Engineering. For related information see also: 29 Space Radiation.

N68-11037*# New York Univ., N. Y.
QUANTUM MECHANICAL STUDY OF MOLECULES TRANSITION PROBABILITIES, EINSTEIN A COEFFICIENTS AND OSCILLATOR STRENGTHS OF SOME BAND SYSTEMS OF DIATOMIC MOLECULES
D. C. Jain and R. C. Sahni Washington NASA Dec. 1967 45 p refs
(Grant NsG-76)
(NASA-CR-975) CFSTI: HC$3.00/MF$0.65 CSCL 20H

The Franck–Condon factors and r-centroids based on the Rydberg–Klein–Rees potential energy curves, have been presented for some band systems of the CO^+, N_2, N_2 and RbH molecules. The variation of the electronic transition moment with the internuclear distance, $R_e(r)$, has been determined by the r-centroid procedure for the band systems for which the experimental data on the relative intensity distribution is available. The absolute band strengths, Einstein A coefficients and oscillator strengths have been obtained for some band systems by employing the expression for the electric dipole transition moment, $R_e(r)$, and the lifetimes of the excited states. The influence of the vibration–rotation interaction on the transition probabilities of the band system of the RbH molecule was studied and it was found that for this and certain other similar band systems, the vibration–rotation interaction must be included in the theoretical interpretation of the results. The importance and possible applications of these results is also described. Author

N68-11074*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SCATTERING OF 42-MEV (6.7-PJ) ALPHA PARTICLES FROM EVEN ISOTOPES OF CADMIUM
Norton Baron, Regis F. Leonard, and William M. Stewart Washington Nov. 1967 19 p refs
(NASA-TN-D-4256) CFSTI: HC$3.00/MF$0.65 CSCL 20H

Angular distributions were measured for the elastic and inelastic scattering of 42 MeV (6.7-pJ) alpha particles from isotopically enriched targets of cadmium 110, 112, 114, and 116. In each isotope, five excited states were seen and their excitation energies were determined to ±30 keV (±4.8 fJ). Angular distributions for three of these states were measured over the angular range 30° to 65° Their relative phases and excitation energies indicate that these states are the first 2^+, the 3^-, and the two phonon 2^+. It is suggested that the two other excited states result from a quadrupole-octupole two-phonon transition. A tentative spin assignment of 5^- was made for one of them. Elastic angular distributions were analysed using the optical model with a four parameter Woods-Saxon potential. Excellent fits have been obtained for the elastic scattering. Inelastic scattering has been analyzed using a distorted wave Born approximation calculation. These calculated inelastic angular distributions agree very well with the experimentally measured cross sections for scattering to one phonon states, and allow determination of deformation parameters which are in satisfactory agreement with those obtained elsewhere. Author

N68-11634*# Research Systems, Inc., Lexington, Mass.
A STUDY OF TRACE CONTAMINANT IDENTIFICATION BY MICROWAVE DOUBLE RESONANCE SPECTROSCOPY
Richard J. Volpicelli, Otto L. Stiefvater, and George W. Flynn Washington NASA Dec. 1967 99 p refs
(Contract NAS1-6308)
(NASA-CR-967) CFSTI: $3.00 CSCL 07D

A microwave double resonance spectrometer has been assembled that operates with pump frequencies between 12 GHz and 18 GHz and signal frequencies between 26.5 GHz and 40 GHz. The absorption cell consists of a coiled 100 ft section of X-band guide. Modulation of the double resonance phenomenon is achieved through frequency modulation of the pump radiation, the modulation frequency being 100 KHz. For each of the five molecules ($CH_3CH_2COH_1$) $CH_3CH_2CH_2Cl$, CH_3CH_2COOH, $(CH_3)_2S$, and CH_2Cl_2, one or two double resonance connections were selected and suitable for the identification of these compounds. The amplitude of the double resonance signals was studied as a function of the sample pressure for both pure samples and samples diluted in air. In typical cases double resonance signals could be observed in the pressure range from 1 μHg to ≈ 100 μHg. The smallest detectable amount of a gas contaminant was of the order of ≈ .3%. In mixtures of several gases with rich microwave spectra the double resonance technique affords a rapid and extremely specific method for identifying individual components, and there is no ambiguity due to interference from neighboring and/or overlapping lines with only one double resonance connection required to identify the compound from which it arises. Author

N68-11903*# New York Univ., N. Y.
QUANTUM MECHANICAL STUDY OF MOLECULES: EIGENVALUES AND EIGENVECTORS OF REAL SYMMETRIC MATRICES
G. R. Verma, C. D. La Budde, and R. C. Sahni Washington NASA Dec. 1967 48 p refs
(Grant NsG-76)
(NASA-CR-983) CFSTI: HC$3.00/MF$0.65 CSCL 20J

In this report, three general classes of methods for calculating the eigenvalues and eigenvectors of real symmetric matrices arising in quantum mechanical calculations are described: the Sturm sequence methods, the orthogonal reduction methods, and the step by step methods. The advantages and limitations of each method are pointed out. The report also includes the discussion of various methods of reducing real symmetric matrices to more compact convenient forms. Methods of reduction to tridiagonal form, and deflation of matrices to smaller order are described. Author

N68-15328*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXCITED STATES OF XENON 128
Glenn M. Julian, S. Jha (Western Reserve Univ.), and A. S. Johnston (Carnegie Inst. of Tech.) Washington Feb. 1968 19 p refs Submitted for publication
(NASA-TN-D-4305) CFSTI: HC$3.00/MF$0.65 CSCL 20H

Gamma rays accompanying the decay of 25 minute iodine 128 (^{128}I) and 3 minute cesium 128 (^{128}Cs) have been studied with 8- and 30-cubic centimeter lithium-drifted germanium spectrometers. Coincidences between gamma rays were studied using two 7.6 by 7.6 centimeter thallium-activated sodium iodide scintillators. A level scheme of Xenon 128 (^{128}Xe) has been constructed with levels at 443.2 (2^+), 969.6 (2^+), 1583.1 (0^+, 1^+, 2^+), 2275.2, 2484.3, 2600.5, 2841.1, and 2862.8 keV. According to the hydrodynamical model, the near-spherical even–even nucleus ^{128}Xe could be expected to have a close-lying $0^+=2^+-4^+$ "vibrational triplet" at about twice the energy of the first excited state. Population of the 0^+ and 2^+ members of such a triplet would be allowed in the decay of 1^+ ^{128}I

and 1^+ ^{128}Cs. A 2^+ level of ^{128}Xe at about twice the energy of the first excited state had been found in previous investigations. In the present study a search was made for the predicted 0^+ triplet member. No evidence has been found for the existence of such a level. Author

N68-15638*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A SEARCH FOR UNBOUND HELIUM 3 LEVELS WITH ISOBARIC SPIN 1/2

Robert E. Warner (Oberlin Coll.), John S. Vincent, and Edmund T. Boschitz Washington Feb. 1968 14 p refs

(NASA-TN-D-4377) CFSTI: HC $3.00/MF $0.65 CSCL 20H

An attempt was made to excite the unbound $T=1/2$ states in helium 3 by (α–He^3) inelastic scattering. No states in He^3 between 3- and 13-MeV excitation were found. The shape of the inelastic alpha particle spectrum was calculated with the assumption that phase space alone determines the shape. Precise fits to the observed spectra were not obtained, but the similarity between calculated and observed spectra gave evidence that a broad maximum in the 17.5° spectrum was caused by phase space rather than a level in He^3. Other calculations with Baldin's formalism showed that no enhancement of the inelastic cross section near 8-MeV excitation in He^3 should be expected. Author

N68-17898*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EXPERIMENTAL STUDY OF TRANSMISSION AND BACKSCATTER OF 0.075 TO 1.0 MeV ELECTRONS BY ALUMINUM AND STAINLESS STEEL

William E. Miller and Herbert D. Hendricks Washington Mar. 1968 22 p refs

(NASA-TN-D-4363) CFSTI: HC $3.00/MF $0.65 CSCL 18F

An experimental study of the transmission and backscatter coefficients for aluminum and stainless steel irradiated with 75-keV to 1-MeV electrons at normal and 45° incidence is reported. The transmission coefficients were greater and the backscatter coefficients were smaller at normal beam incidence than they were at 45° beam incidence for both materials. In all cases the aluminum had higher transmission coefficients and lower backscatter coefficients than did stainless steel. It was determined that the transmission and backscatter coefficients for both aluminum and stainless steel were independent of the number of layers of foils used to attain a given thickness. The ratio of the thickness for maximum backscatter to the extrapolated range was found to be nearly a constant for each material. Transmission curves independent of energy were constructed for aluminum and stainless steel for normal and 45° beam incidence. Author

N68-18118*# Geophysics Corp. of America, Bedford, Mass.

STUDIES OF PHOTOABSORPTION BY ATOMIC HYDROGEN, OXYGEN, AND NITROGEN

R. B. Cairns and James A. R. Samson Washington Mar. 1968 119 p refs

(Contract NASw-1283)

(NASA-CR-998; GCA-TR-67-2-N) CFSTI: HC $3.00/MF $0.65 CSCL 20H

This report contains an account of experiments made to study the photoabsorption properties of atomic hydrogen, oxygen, and nitrogen. The ultimate objective was the quantitative measurement of atomic photoionization cross sections. The results of the experiments have been combined with recent theoretical estimates of the cross sections and information from spectroscopic studies. Author

N68-18254*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OPERATIONAL AMPLIFIERS FOR USE IN NUCLEAR SPECTROSCOPY

Theodore E. Fessler Washington Mar. 1968 28 p refs

(NASA-TN-D-4349) CFSTI: HC $3.00/MF $0.65 CSCL 18D

The design of pulse amplifier systems for use in nuclear research can be greatly simplified by the use of fast operational amplifiers. This report treats the design and use of operational amplifiers in circuits with rise times as low as 10 nanoseconds. A specific amplifier circuit is used to illustrate real amplifier performance. Phase-compensation methods and their relation to open-loop amplifier properties are described. Some closed-loop amplifier circuits are used to demonstrate practical phase compensation. Author

N68-18949*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

A CRITICAL EVALUATION OF THE USE OF ULTRASONIC ABSORPTION FOR DETERMINING HIGH-TEMPERATURE GAS PROPERTIES

Warren F. Ahtye Washington Mar. 1968 70 p refs

(NASA-TN-D-4433) CFSTI: HC $3.00/MF $0.65 CSCL 20M

The usefulness of ultrasonic absorption for determining the values of high-temperature gas properties has been examined critically. The sources of ultrasonic absorption considered are: viscosity and thermal conductivity (classical absorption), thermal radiation, and relaxation effects due to dissociation, ionization, and electronic excitation by atomic collisions. The absorption values for argon and nitrogen were calculated in an attempt to explain the large disparity between classical values and those measured by Carnevale in a series of electric arc experiments. Ultrasonic absorption in oxygen and in hydrogen was also examined. The calculations show that it is possible to measure the transport coefficients of argon and hydrogen for two states. The transport coefficients of nitrogen and oxygen cannot be measured with any degree of accuracy at any temperature. The calculations show that the ultrasonic absorption associated with thermal radiation is so minute that the absorption technique is incapable of measuring total radiative intensities of atmospheric gases even at temperatures sufficiently high that single ionization occurs. It is shown that most of the anomalous absorption in nitrogen can be attributed to collisional excitation of the bound electrons in nitrogen atoms, but only if a high collisional efficiency exists. Author

N68-21227*# Tennessee Univ., Tullahoma. Space Inst.

MIE-SCATTERING FUNCTION

F. Shahrokhi and P. Wolf Washington NASA Apr. 1968 17 p refs

(Grant NGR-43-001-021)

(NASA-CR-1022) CFSTI: HC $3.00/MF $0.65 CSCL 20H

For a comparison between experimental results and Mie-scattering theory, a series of calculations was made to find the normalized scattering function $f(\theta)$ from the tables of Legendre-polynomials by G. C. Clark and S. W. Churchill and from tables of scattering coefficients made by C. M. Chu, G. C. Clark, and S. W. Churchill. Author

N68-21949*# General Electric Co., Philadelphia, Pa.

THE ROLE OF ENERGY IN DEFORMATION

I. J. Gruntfest Washington Apr. 1968 31 p refs

(Contract NASw-1190)

(NASA-CR-1039) CFSTI: HC $3.00/MF $0.65 CSCL 20L

This report is a review of exploratory analytical studies of the influence of energy conservation on the mechanical behavior of a variety of materials in diverse test situations. The results are presented and discussed so to display their physical implications rather than the details of their development. The work is generally complementary to the existing body of theory relating to mechanical behavior. However, consideration of the necessary coupling between the thermal and mechanical fields in deforming materials does suggest some new approaches to the problems of

fracture in solids and flow stability in fluids. Some insights into the role of microstructure in determining the behavior of solids are also suggested. The methods, some of which involve the use of electric analogs of the mechanical system, show how necking, yield and plastic flow may arise. In addition, scale effects are introduced which are likely to be of interest in geophysical phenomena. Author

N68-23893*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CALCULATION OF CAPTURE CROSS SECTIONS FOR ION POLAR MOLECULE COLLISIONS INVOLVING METHYL CYANIDE

John V. Dugan, Jr., James H. Rice, and John L. Magee (Notre Dame, Univ.) Washington May 1968 19 p refs

(NASA-TM-X-1586) CFSTI: HC$3.00/MF$0.65 CSCL 07E

The cross sections (CS) for capture collisions between the symmetric top molecule CH_3CN and molecular ions are calculated numerically. These ion-molecule collisions were studied experimentally and have large reaction CS, Q_R. Calculations are done to study the role of the added degree of rotational freedom by comparing capture CS for tops with linear molecules. The monoenergetic CS $\sigma_c(\epsilon_1)$ (where ϵ_1 is the ion energy and T_R is the top rotational temperature) are less than the maximum classical CS σ_{max}, but much larger than Langevin CS σ_L. The integrated σ_c, Q_c, agree well with Q_R for the collisions studied. The σ_c values for CH_3CN are nearly independent of target geometry. Author

N68-24661*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INELASTIC SCATTERING FORM FACTORS USING PROJECTED HARTREE–FOCK WAVE FUNCTIONS

Richard C. Braley and William F. Ford Washington May 1968 28 p refs

(NASA-TN-D-4566) CFSTI: HC$3.00/MF$0.65 CSCL 20H

The theory of inelastic scattering is formulated, using detailed nuclear wave functions which are obtained from nuclear structure calculations. The inelastic scattering is assumed to proceed through a direct reaction, and nuclear states are obtained by projecting states of good (J^2,J_z) from a variational Hartree–Fock wave function. General expressions for transition amplitudes and the nuclear form factors are derived, and the form factors for inelastic proton scattering are presented. These form factors are compared with those based on the shell model and macroscopic collective model. It is concluded that the restrictions imposed in the Hartree–Fock model must be relaxed if the model is to give the correct order of magnitude for reaction cross sections. Author

N68-28250*# Northrop Corp., Hawthorne, Calif. Corporate Labs.

STUDY ON A TECHNIQUE FOR DETECTING PHOTONS IN THE 100–1000 Å WAVELENGTH REGION Final Report, 15 Apr. 1965–15 Oct. 1967

O. P. Rustgi Washington NASA Jun. 1968 136 p refs

(Contract NAS12-3)

(NASA-CR-1096) CFSTI: HC$3.00/MF$0.65 CSCL 20H

A general survey of the various modes of interaction of electromagnetic radiation in the 100–1000 Å region with matter was conducted. These interactions were analyzed in terms of photon efficiency, wavelength cut-off, minimum photon flux required for detection of these effects, ease of wavelength resolution through selective detection, and ease of fabrication and calibration of resultant detectors. The transmittance of thin films and photoionization in gases are selected as the possible interactions resulting in selective detectors. Thin films of aluminum, bismuth, indium, titanium, and tin are prepared and supported on mosaic glass. Techniques are developed to seal the mosaic glass with a film to the metallic plate. This plate is then used as a filter as well as a window for a rare gas ion chamber to form the resultant selective detector. Spectral response characteristics of selective detectors using (1) bismuth film with neon, argon, and krypton; (2) indium film with argon, krypton, and xenon; and (3) titanium film with argon, neon, and helium are presented with emphasis on selectivity of response. Author

N68-28265*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COUPLED-CHANNELS METHOD FOR REARRANGEMENT COLLISIONS

Howard C. Volkin Washington Jul. 1968 70 p refs

(NASA-TN-D-4633) CFSTI: HC$3.00/MF$0.65 CSCL 20H

The classification and construction of open-channel projection operators for a given rearrangement collision are developed from the unifying viewpoint of their projective spaces in the total Hilbert space of the system. The representative case of the pickup or stripping process is treated. The open-channel projection operators are constructed from the channel-subspace projectors with the help of generalized channel transformation functions. Various projection operators that can be obtained in closed form are identified. The use of the projection operators to obtain coupled equations describing the reaction is discussed, including their application to generalized potential models. Author

N68-29375*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

GAMMA RAY ANGULAR CORRELATIONS FOLLOWING INELASTIC SCATTERING OF 42-MeV ALPHA PARTICLES FROM MAGNESIUM 24

Regis F. Leonard, William M. Stewart, Norton Baron, and Richard C. Braley Washington Jul. 1968 28 p refs

(NASA-TN-D-4683) CFSTI: HC$3.00/MF$0.65 CSCL 20H

The angular correlation between inelastically scattered 42-MeV alpha particles and gamma rays emitted in the subsequent nuclear decay has been studied for the 1.37-MeV state of magnesium 24. The symmetry angle of the gamma distribution and the magnitude of the anisotropy of the gamma distribution have been measured for alpha scattering angles between 30° and 76°. The results are compared with the distorted-wave predictions and with the adiabatic and Wills-Cramer models. Observed symmetry angles do not display the large excursions away from the adiabatic line which were seen in earlier work on magnesium 24 at lower energies and more forward angles. Author

N68-29520*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

A NUMERICAL LEAST-SQUARE METHOD FOR RESOLVING COMPLEX PULSE HEIGHT SPECTRA

J. I. Trombka and R. L. Schmadebeck Washington 1968 175 p refs

(NASA-SP-3044) GPO: HC$1.50; CFSTI: MF$0.65 CSCL 20H

A least square analysis method is presented for determining the differential energy spectrum from a measurement of the pulse height spectrum. Consideration is given to an empirical matrix inversion method which allows for calculating the relative intensity of the statistical variance based on counting statistics of the correlation between library components and the fit chi-square. In order to obtain a unique solution and a non-oscillating solution, physical constraints are included either as an iterative search mode for nonegativity or a component subtraction mode in the computer program. An assessment is made of the nonlinearities in the pulse height scale that can be attributed to gain shift and zero drift. A method for background subtraction and the use of the background as a library component in the least square analysis were considered. The details of the structure of the computer programs, the FORTRAN statement of the program, data for use in the program, and typical computer outputs are presented. B.S.D.

N68-30001*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FISSION NEUTRON ATTENUATION IN LITHIUM-6, NATURAL LITHIUM HYDRIDE, AND TUNGSTEN
Gerald P. Lahti Washington Aug. 1968 24 p refs
(NASA-TN-D-4684) CFSTI: HC$3.00/MF$0.65 CSCL 18G

A fission-spectrum neutron-dose-rate-attenuation curve was computed by the discrete-ordinates method for Li^6H and natural LiH for penetration depths up to 139.5 cm. Results were compared with a recent Monte Carlo calculation for natural LiH. A single value for an energy-independent-neutron-removal cross section for Li^6 and natural Li in LiH was deduced for use in an Albert–Welton dose-attenuation kernel but is accurate for only a given range of penetration. The validity of fast-neutron-removal theory was demonstrated for the cases of W followed by LiH. From this penetration data, a neutron-removal cross section for W was calculated. Author

N68-33763*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MEASUREMENT OF THE B 10 (n, α) Li 7, Li 7* RELATIVE CROSS SECTIONS IN THE keV REGION
Donald Bogart and Lowell L. Nichols (Batelle-Northwest) Washington Sep. 1968 25 p refs
(NASA-TN-D-4783) CFSTI: HC$3.00/MF$0.65 CSCL 20H

Relative cross sections for $^{10}B(n,\alpha)^7Li$, $^7Li^*$ were obtained from measurements of the counting ratios of a $^{10}BF_3$ proportional counter and a precision long counter used to monitor relative neutron fluxes. Monoenergetic neutrons were produced by a Van de Graaff accelerator in the energy region from 30 to 800 keV. When the relative cross sections are normalized to a 1/v variation below 80 keV, the data lie above a 1/v line from 80 to 550 keV indicating departures of 15 percent at 140 keV and 20 percent at 220 keV. Recommended cross sections for $^{10}B(n,\alpha)^7Li$, $^7Li^*$ up to 1 MeV are obtained from recently available measurements and the known levels in ^{11}B. Author

N68-34175*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ADSORPTION-DESORPTION BEHAVIOR OF HOMOGENEOUS AND HETEROGENEOUS METAL SURFACES
Thaine W. Reynolds Washington Sep. 1968 46 p refs
(NASA-TN-D-4789) CFSTI: HC$3.00/MF$0.65 CSCL 20L

Energy distribution relations which describe the desorption behavior from heterogeneous surfaces are presented. A graphical method of obtaining these is described, and the results are compared with a more exact computer-determined solution. Adsorption isotherms representing equilibrium coverage for the systems H_2–W, CO–W, N_2–W, CO–Mo, and N_2–Mo are presented covering a pressure range from 10^{-12} to 1 torr, a fractional surface coverage from 0.02 to 0.98, and for the appropriate temperature range in each case. Author

N68-35535*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
TABLES OF ENERGY AND ANGULAR DISTRIBUTIONS OF THICK TARGET BREMSSTRAHLUNG IN METALS
Clemans A. Powell, Jr. Washington Oct. 1968 35 p refs
(NASA-TN-D-4755) CFSTI: HC$3.00/MF$0.65 CSCL 20H

Calculations are made for the angular and energy distributions of bremsstrahlung produced in thick elemental metallic targets by normally incident monoenergetic fluxes of electrons with energies of 0.50, 0.75, 1.00, 2.00, and 3.00 MeV. Results are given for magnesium, aluminum, titanium, manganese, iron, nickel, copper, tungsten, gold, and lead. The target thickness was chosen to be the mean range of the electrons in the particular target material for the electron energy of interest. The theoretical analysis of these data is based on the approximation of a thick target by a series of thin slabs each of which is considered to be a thin target for bremsstrahlung production, and includes the following secondary processes: (1) the effect of multiple electron scatterings, (2) electron backscatter out of the target, (3) electron-electron bremsstrahlung, and (4) the absorption and buildup of photons in the target. Results are compared with experimental thick target bremsstrahlung data for aluminum and iron. Although the agreement is good, the predicted values tend to overestimate the experimental data for low photon energies and underestimate for higher photon energies. The discrepancy between the predicted and experimental values increases with increasing angular displacement from the incident electron direction and with increasing atomic number of the target material. Author

N68-36070*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EXPERIMENTAL INVESTIGATION AND ANALYSIS OF DIELECTRIC BREAKDOWNS INDUCED BY ELECTRON IRRADIATION IN POLYMER FILMS
George M. Storti Washington Oct. 1968 35 p refs
(NASA-TN-D-4810) CFSTI: HC$3.00/MF$0.65 CSCL 20L

The phenomenon of dielectric breakdowns caused by electron irradiation was investigated in several polymeric materials. The frequency of occurrence of the breakdowns (as measured by the number of breakdowns occurring for a given fluence of electrons) was dependent on factors such as the electron kinetic energy, electron flux, sample radiation history, and sample temperature. Also, some materials (for example, Teflon) were found to be more susceptible to the dielectric breakdowns than others (for example, polyethylene). These results were interpreted in terms of a modified band model for organic insulators. This modified band model successfully explained many of the experimental observations. Consequently, relative depths of electron traps in some of the materials were surmised from the experimental data. Author

N68-37240*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE EXCITATION SPECTRUM FOR A BOSE GAS WITH REPULSIVE AND ATTRACTIVE INTERACTIONS
Gerald V. Brown Washington Oct. 1968 69 p refs
(NASA-TN-D-4838) CFSTI: HC$3.00/MF$0.65 CSCL 20H

The correct qualitative features of the helium II elementary excitation spectrum are derived microscopically for a realistic interatomic potential. The strong repulsive core is included by using a reaction matrix in the Hamiltonian. The attractive well is successfully included by assuming a generalized Bose–Einstein condensation. The pair Hamiltonian is diagonalized by the thermodynamically equivalent Hamiltonian method. Numerically solutions yield spectra with phonon and roton regions. The spectrum energies are too high for the Yntema–Schneider potential. Another potential, constructed to fit virial coefficient data classically, gives better results. Spectra are presented for a series of attractive well strengths. Author

N68-37708*# Ling-Temco-Vought, Inc., Dallas, Tex. Nuclear Science Group.
INVESTIGATION OF ELECTRON INTERACTION IN MATTER Final Report, 9 Feb. 1967–9 Feb. 1968
Washington NASA Oct. 1968 338 p 14 refs
(Contract NAS8-21055)
(NASA-CR-1194; Rept.-0-7100/8R-2) CFSTI: HC $3.00/MF $0.65 CSCL 20H

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1. MEASUREMENT OF ELECTRON SCATTERING IN ALUMINUM AT 1.0 MeV FOR NON-NORMAL INCIDENCE D. H. Rester and W. J. Rainwater, Jr. p 3-241 refs (See N68-37709 24-24)

2. ELECTRON-BREMSSTRAHLUNG CROSS SECTION

MEASUREMENTS AT INCIDENT ELECTRON ENERGIES OF 0.2, 1.0, 1.7, AND 2.5 MeV D. H. Rester and W. E. Dance p 243-282 refs (See N68-37710 24-24)

3. ELECTRON BREMSSTRAHLUNG PRODUCED IN THICK TARGETS AT INCIDENT ELECTRON ENERGIES OF 0.2, 1.0, 2.0, AND 2.8 MeV W. E. Dance and D. H. Rester p 284-330 refs (See N68-37711 24-24)

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PHYSICS, PLASMA

Includes magnetohydrodynamics. For applications see: 28 Propulsion Systems.

N68-11404*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
POWER TRANSFER TO ION CYCLOTRON WAVES IN A TWO ION SPECIES PLASMA
Donald R. Sigman and John J. Reinmann Washington Dec. 1967 13 p refs
(NASA-TM-X-1481) CFSTI: HC$3.00/MF$0.65 CSCL 20K

Calculations were made on the efficiency of using a Stix coil to transfer power to waves near the ion cyclotron frequencies of a cold, collisionless plasma consisting of two ion species. The mass ratio m_b/m_a of the ion species was 2, and the frequency region near and between the cyclotron frequencies (Ω_{ia} and Ω_{ib}) of each ion species was investigated. For wave frequencies ω less than Ω_{ib}, only the usual ion cyclotron resonance absorption peak is obtained. For $\Omega_{ia}>\omega>\Omega_{ib}$, two absorption peaks are obtained. The additional peak corresponds to power absorbed by fast wave modes associated with the heavier species. The wave set up nearer the cyclotron frequency of the lighter ion Ω_{ia} is a left-polarized wave, and power is absorbed primarily by modes whose wavelengths, which are parallel to the static magnetic field, are near the wavelength of the Stix coil. The second absorption peak occurs at lower frequencies where the power is absorbed by the right-polarized fast wave modes associated with the heavier species. There is a sharp cutoff on the low frequency side of this second absorption peak. Author

N68-14078*# Catholic Univ. of America, Washington, D. C.
MAGNETOHYDRODYNAMIC FLOWS OVER A ROTATING DISK
Hsien-ping Pao Washington NASA Jan. 1968 25 p refs
(Grant NsG-586)
(NASA-CR-989) CFSTI: HC$3.00/MF$0.65 CSCL 20I

The flow of an incompressible viscous electrically conducting fluid over a rotating disk is investigated. In addition, a circular magnetic field is also imposed at the disk. One physical interest in this flow lies in the possibility of using such a magnetic field to shield a rotating body from excessive heating. Similarity assumptions lead to a reduction of the governing equations to a set of ordinary differential equations. These are integrated numerically. Some approximate solutions are also obtained. The role of the magnetic field here is to thicken the flow boundary layer and to reduce the strength of the axial flow field. That means, the magnetic field has a diffusing and stiffening effect upon the flow field. As a consequence, the frictional moment at the disk is reduced. For sufficiently large values of the applied magnetic field, the boundary layer separates from the surface of the disk. Author

N68-15747*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ELECTRICAL PROPERTIES OF XENON-FILLED THERMIONIC DIODES IN RADIATION FIELD OF A NUCLEAR REACTOR
Ralph Forman Washington Feb. 1968 17 p refs
(NASA-TN-D-4368) CFSTI: HC$3.00/MF$0.65 CSCL 18I

Experimental data on nuclear-irradiated xenon-gas-filled thermionic diodes are presented. The characteristic curves for the irradiated diodes were studied as a function of xenon pressure (4 to 300 torr (5×10^2 to 4×10^4 N/m^2)), nuclear radiation intensity (gamma dose rate 10^8 to 6×10^8 rads/hr (10^6 to 6×10^6 J/(kg)(hr))), emitter temperature (1000° to 1200°C), and electrode spacing (0.025 to 0.75 cm). Some interesting breakdown pehnomena occurred at voltages much lower than the first excitation potential. Some of the breakdown effects showed characteristics similar to those obtained in low-temperature cesium thermionic converters. There are regions corresponding to the unignited mode, preignition, and the ignited mode. In some cases, depending on the choice of radiation intensity, xenon pressure, and interelectrode spacing, these breakdown modes occur at applied voltages as low as 1 volt. Author

N68-16286*# National Aeronautics and Space Administration, Washington, D. C.
MOTION OF CONDUCTING BODIES IN A MAGNETIC FIELD
Ya. Ya. Liyelpeter, ed. Feb. 1968 152 p refs Transl. into ENGLISH of the book "Dvizheniye Provodyashchikh Tel v Magnitnom Pole" Riga, Izd. Zinatne, 1966
(NASA-TT-F-460) CFSTI: HC$3.00/MF$0.65 CSCL 20I

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1. STATE OF THE THEORY OF MAGNETOHYDODYNAMIC INDUCTION MACHINES WITH WORKING MEDIA OF LIQUID METAL Ya. Ya. Liyelpeter p 1–12 refs (See N68-16287 07-25)
2. ELECTROMAGNETIC PROCESSES IN AN IDEAL, INDUCTION MHD MACHINE A. K. Veze and L. Ya. Ulmanis p 13–37 refs (See N68-16288 07-25)
3. HIGHER SPATIAL HARMONICS OF THE MAGNETIC FIELD OF AN INDUCTION MHD MACHINE Yu. Ya. Mikel'son p 38–57 refs (See N68-16289 07-25)
4. TRANSVERSE EDGE EFFECT IN PLANE INDUCTION MAGNETOHYDRODYNAMIC MACHINES A. Ya. Vilnitis p 58–85 refs (See N68-16290 07-25)
5. LONGITUDINAL EDGE EFFECT IN LINEAR INDUCTION MHD MACHINES Ya. Ya. Valdmanis p 85–98 refs (See N68-16291 07-25)
6. PONDEROMOTIVE FORCES ACTING UPON CONDUCTIVE BODIES IN THE TRAVELING MAGNETIC FIELD OF A CYLINDRICAL INDUCTOR Yu. K. Krumin' p 99–121 refs (See N68-16292 07-25)
7. THEORY FOR THE PROPAGATION OF PULSED ELECTROMAGNETIC FIELDS IN MOVING CONDUCTIVE MEDIA G. Ya. Sermons p 121–147 refs (See N68-16293 07-25)

N68-16700*# National Aeronautics and Space Administration, Washington, D. C.
MAGNETOBREMS (SYNCHROTRON) EMISSION AND REABSORPTION [O MAGNITOTORMOYNOM (SINKHROTRONNOM)]
V. L. Ginzburg, V. N. Sazonov, and S. I. Syrovatskiy Feb. 1968 41 p refs Transl. into ENGLISH from Preprint No. 83 of Lebedev Phys. Inst. (Moscow), 1967
(NASA-TT-F-521) CFSTI: HC$3.00/MF$0.65 CSCL 20I

The problem of magnetic-acceleration (synchrotron) emission at helical motion of relativistic electrons emitting from a source with relativistic velocity is discussed and mathematically formulated. Problems of reabsorption of magnetobrems emission, with respect to radio emission by quasars, are reviewed, followed by a study of the motion of particles in a magnetic field in the presence of

losses. Special emphasis is placed on this motion for particle aggregates of high energy density and the resultant changes in the magnetic field, with formulas for the change in energy of the particle group. Errors in formulas and conclusions by other authors are analyzed. Author

N68-17070*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CORRELATION OF TRANSIENT SPECTRA WITH PERFORMANCE IN COAXIAL PLASMA GUNS

Charles J. Michels and Henry J. Hettel Washington Feb. 1968 32 p refs

(NASA-TN-D-4385) CFSTI: HC$3.00/MF$0.65 CSCL 20I

The time-varying spectra of an argon plasma in a coaxial gun were measured. Two gun geometries were investigated, both with argon propellant. The transient spectra were obtained by viewing the plasma spectra in the exit plane of a polychromator with an electronic image converter camera used as a streak camera. Frame and streak camera views and magnetic probes were also used to study the discharges occurring in the guns. The transient spectrum of each gun was completely different. The geometry which exhibits relatively clean argon spectra showed good performance. It operated internally crowbarred. The performance correlates well with both earlier theory and experiments and extends previous data. In contrast, the geometry which exhibited contaminant spectra showed poorer performance which does not agree with theory or past experimental data. This geometry operated in the multiple-moving-discharges mode. The discharge spectra showed no argon lines, and the contaminant lines were those from a pyrex gas baffle just upstream of the gas ports. The influence of the gas baffle on performance accounts for discrepancies with earlier data (both experimental and theoretical). The two different geometries of the guns served to demonstrate the usefulness of transient spectra diagnostics as an added tool in ascertaining when theory can correctly be applied to a given gun. A description of a two-channel transient voltage digitizer is given. The digitizer is used to record dynamically gun voltage and current at the rate of 5 million samples per second. It digitizes these samples and punches them on paper tape for data reduction by a conventional high-speed computer Author

N68-18485*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ENHANCEMENT OF ION CYCLOTRON WAVES IN HYDROGEN HELIUM MIXTURES

Henry J. Hettel, Roman Krawec, George M. Prok, and Clyde C. Swett Washington Mar. 1968 35 p refs

(NASA-TN-D-4271) CFSTI: HC$3.00/MF$0.65 CSCL 20I

The admixture of helium to a hydrogen plasma atmosphere has increased the radiofrequency power absorption in the ion-cyclotron mode. Measurements of power absorption, plasma radius, electron density, and magnetic flux density at the peak power point were obtained as a function of plasma composition. A relation was derived involving these experimental parameters and the ion density. It is shown that the observed power enhancement can be explained if it is assumed that the metastable states of the helium atoms react with hydrogen atoms and molecules to increase the plasma ion density. Author

N68-18614*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.

A STUDY OF THE POSSIBLE USES OF PLASMA FOR MILLIMETER WAVE GENERATION

Robert E. McIntosh Washington Mar. 1968 28 p refs

(NASA-TN-D-4309) CFSTI: HC$3.00/MF$0.65 CSCL 20I

The millimeter wave portion of the frequency spectrum has not been utilized in communication systems because of a lack of practical, high-power mm wave generators. As conventional tube design techniques have been only moderately successful in extending the microwave power frequency frontier, a number of novel approaches for obtaining mm wave sources have been suggested. Two of these methods rely on the use of a gaseous plasma and are described in this technical note. The electron beam-plasma interaction and the plasma multiplier have been investigated during the last decade in the hope that one or the other might have some application at mm wavelengths. So far the expectations for these devices have not been realized because of many unresolved engineering problems. This report describes the major difficulties that must be overcome before further development in this area can proceed, and it attempts to evaluate the potential of both devices. Author

N68-20296*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A COAXIAL-FLOW-STABILIZED ARC

Chester D. Lanzo Washington Apr. 1968 20 p refs

(NASA-TN-D-4517) CFSTI: HC$3.00/MF$0.65 CSCL 20I

This report describes and evaluates a new experimental coaxial-flow-stabilized ac arc facility and presents the results of a study of the general characteristics of an ac arc which has been stabilized or held in place by the action of the coaxial flow of two different gases. The arc is maintained in a central jet of axially flowing argon, between an upstream and a downstream electrode. An outer stream of gas flows coaxially around the center argon jet. Both nitrogen and helium were used in the outer stream. Tests were conducted to determine qualitatively the effect of varying the relative velocities of the inner and outer gas streams. These tests were conducted at a chamber pressure of 8 to 25 psia (55×10^3 to 172×10^3 N/m^{2}abs) and arc lengths of 1 to 12 inches (2.54 to 30.5 cm). Frequency was varied from 12 to 22 cps (12 to 22 Hz). Current levels of 500 to 1000 amperes were run. Visual observations were made, and voltage and current measurements were recorded. In addition, individual frames from a high-speed motion-picture film were examined. These data indicate that the coaxial, two-gas flow pattern causes stable arc operation and that the arc behavior is relatively insensitive to changes in the velocity of either gas stream. Author

N68-21623*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PAIRS OF EMITTER AND COLLECTOR SHEATHS FOR CESIUM THERMIONIC DIODES

James F. Morris Washington Apr. 1968 56 p refs

(NASA-TN-D-4419) CFSTI: HC$3.00/MF$0.65 CSCL 20I

Coupled theoretic sheaths given approximate thermionic diodes. The sheaths result from particle emissions of electrodes affected by sheath fields and of cesium plasmas ionized by thermal electrons. By matching their net current densities, the analysis pairs collisionless emitter and collector sheaths to simulate diodes. Midway between the electrodes in both space and temperatures lie the plasmas at 1700° to 2000°K with 10^{12} and 10^{13} electrons per cubic centimeter. The emitters and collectors differ by 400° to 800°K. For these conditions, the computed outputs for the converters range from 0.01 to 1 watt per square centimeter. Although such powers fall below desired performance levels, they provide low-current checks for thermionic-diode experiments. Sheath properties for the present systems and for electrodes in plasmas with raised electron temperatures agree with equilibrium results. But the theory applies only for equilibria, near-equilibria, and relatively low net transports. Overall sheath characteristics correlate with electrode and plasma conditions. One helpful parameter is a hybrid, the emission Debye length, $\lambda_{DE} \approx 6.9 (T_E/N_{eP})^{1/2}$. This variable correlates data for these sheaths better than the plasma Debye lenth. Effective sheath widths for the present study lie between 1.7 and 2.6 emission Debye lengths. The independent variables for the present graphic correlations of sheath properties involve only electrode and plasma parameters. Because one states these conditions at the outset, the graphs allow immediate estimates of sheath characteristics–without the complex iterative calculations. Author

N68-21691*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
BOUNDARY CORRECTIONS FOR A THREE-COIL CONDUCTIVITY/VELOCITY PLASMA PROBE
Edward W. Vendell Washington Apr. 1968 32 p refs
(NASA-TN-D-4538) CFSTI: HC $3.00/MF $0.65 CSCL 20I

A three-coil plasma probe that measures both the electrical conductivity and velocity of laboratory plasmas having low magnetic Reynolds numbers has been developed and tested. As a first approximation, it was assumed that the plasma boundary was far from and much larger than the probe. The present work was undertaken to extend the previous theory by deriving factors that correct for the presence of cylindrical boundaries. As a check on this numerical work, several computed values were compared with electrical conductivity measured in cylinders of acid. Since the agreement was satisfactory, the boundary correction factors were used to reduce data taken as the probe was swept through an argon plasma generated by a constricted-arc wind tunnel. These resultant profiles represent local conductivity and velocity values for a free plasma jet having a cylindrical boundary. It was found that the raw data underestimates conductivity and overestimates velocity. Author

N68-22887*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERIODIC, SMALL-AMPLITUDE SOLUTIONS TO THE SPATIALLY UNIFORM PLASMA CONTINUITY EQUATIONS
J. Reece Roth Washington May 1968 43 p refs
(NASA-TN-D-4472) CFSTI: HC $3.00/MF $0.65 CSCL 20I

The coupled set of first-order nonlinear differential equations $\dot{\chi} = C_0 + C_1\chi + C_2 y + C_3 \chi y + C_4\chi^2 + C_5 y^2$ and $\dot{y} = A_0 + A_1\chi + A_2 y + A_3 \chi y + A_4\chi^2 + A_5 y^2$ are solved by an approximate method which gives y(t) in closed form for the particular case in which the variables χ and y vary periodically in time, the coefficients C_i and A_i are real, and the peak-to-peak variation of χ is of small amplitude relative to the mean value of χ. The peak-to-peak amplitude of y, however, is not necessarily small compared with the mean value of y. These equations are a generalized form of Volterra's problem of two conflicting populations, in which χ is the population density of the prey, and y is the population density of the predator, or vice versa. Similar equations may also be derived from the spatially uniform neutral and charged-particle continuity equations in the field of plasma physics. These equations then describe relatively low-frequency oscillations in the number density of electrons and neutral atoms in a partially ionized plasma. Author

N68-24161*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TABLES OF Fe I LINE INTENSITIES. VOLUME 1: TEMPERATURES FROM 1000° TO 6500°K. VOLUME 2: TEMPERATURES BETWEEN 6500° AND 20,000°K
William J. Borucki Washington 1968 219 p refs
(NASA-SP-3041) CFSTI: HC $3.00/MF $0.65 CSCL 20I

Tables of intensities for the 2200 atomic lines listed by Corliss and Warner and Corliss and Bozman for Fe I are presented for temperatures between 1000° and 20,000°K. These tables should be useful in computing the absolute intensity and the spectral distribution for Fe I line radiation from optically thin media, determining the temperature of an observed plasma, and indicating the existence of a non-Boltzmann distribution of excited electronic states when such a condition exists. Author

N68-25630*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECTS OF ARRIVAL RATES OF ABSORBATE IONS AND ATOMS ON SURFACE COVERAGE, HENCE WORK FUNCTIONS, OF EMITTING ELECTRODES
James F. Morris Washington Jun. 1968 10 p refs
(NASA-TN-D-4369) CFSTI: HC $3.00/MF $0.65 CSCL 20I

This report gives equations for determining substrate surface coverages from arrival rates and desorption characteristics of adsorbate ions and atoms. With a correlating theory by Gyftopoulos and Steiner, these coverages yield estimates of work functions for emitting electrodes with partial monolayers of other metals on their surface. Author

N68-25821*# Space Sciences, Inc., Waltham, Mass.
PLASMA BOUNDARY INTERACTIONS—2
S. Aisenberg, P. Hu, V. Rohatgi, and S. Ziering Washington, D. C. NASA Jun. 1968 68 p refs
(Contract NASw-1014)
(NASA-CR-1072) CFSTI: HC $3.00/MF $0.65 CSCL 20I

A study has been made of additional factors describing plasma-boundary interactions. The theoretical analysis of the sheath has been extended to include a transverse plasma flow outside the sheath region. The sheath model has been made more general, and also reveals the importance of the accommodation coefficients at the boundary surface. The presence of ionization and collisions in the sheath has also been studied theoretically. The interpretation of the experimentally observed threshold in the tangential electrode drag as a function of transverse magnetic field and of arc current has suggested the possibility of a threshold in the tangential accommodation coefficient. The threshold tangential energy appears to be proportional to the sputtering threshold and can be related to the threshold for displacement of surface atoms. The relationship between plasma phase velocity and particle velocity was studied and it was shown that there is not necessarily a simple connection: The related problem of arc retrograde motion (where plasma phase and particle motion have opposite signs) was studied and a simple model was proposed. It appears that the plasma propagates in the retrograde direction because of an increased net ion generation rate due to the inhibited diffusion loss of ions and electrons in the region of higher magnetic field. The importance of direct measurement of ion and atom velocity by means such as the Doppler shift is discussed. Author

N68-25877*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
GENERAL OPERATING CHARACTERISTICS OF A BACK STREAMING DIRECT-CURRENT PLASMA GENERATOR
Roman Krawec Washington Jun. 1968 26 p refs
(NASA-TN-D-4604) CFSTI: HC $3.00/MF $0.65 CSCL 20I

Experimental studies were performed on a plasma generator consisting of a filament and a hollow, gas-fed anode which were immersed in an axial magnetic field. The hydrogen plasma formed between the filament and anode was allowed to diffuse past the filament, through a transition section, and into a low-pressure test section. The plasma within the test section was characterized by having two groups of electrons which differed in temperature and had a peak density greater than 2×10^{12} centimeter^{-3}. The no-plasma background pressure within the test chamber was an order of magnitude less than the peak electron density. Evidence was found indicating that thermal dissociation of the hydrogen molecule occurred within the hollow anode. Author

N68-25920*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THERMODYNAMIC STUDY OF PLASMAS USING THE PRINCIPLE OF MAXIMUM ENTROPY
Norbert Stankiewicz Washington Jun. 1968 26 p refs
(NASA-TN-D-4621) CFSTI: HC $3.00/MF $0.65 CSCL 20I

A maximum entropy (disorder) principle is used to determine the velocity distribution functions in a quiescent plasma (case 1), a current-carrying plasma (case 2), and a viscous plasma (case 3). The Saha equation (at the electron temperature) holds for case 1, and modified Saha equations hold for cases 2 and 3. The modification in case 2 is important only in situations where the directed energy of the electrons is a substantial fraction of the total energy. The

results of case 3 are presented in a general form and need simplification before they can be applied to a specific situation. Author

N68-28154*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COAXIAL PLASMA GUN RESEARCH AT LEWIS RESEARCH CENTER
Charles J. Michels Washington Jul. 1968 15 p refs
(NASA-TM-X-1600) CFSTI: HC$3.00/MF$0.65 CSCL 20I

Research on coaxial plasma guns in an effort to determine their potential for space propulsion applications was undertaken at the Lewis Research Center. The experimental parametric examination of various gun geometries, the theoretical analysis of capacitor-bank–variable-mass distribution gun systems, and the plasma diagnostics of various geometries are summarized. The results of this program indicated that the efficiency (≈40 percent) was too low to be competitive with alternative systems. Propellant, switching, and heat-rejection systems proved to be complicated. Author

N68-29888*# Humphreys Corp., Concord, N. H.
INDUCTION PLASMA HEATING: SYSTEM PERFORMANCE, HYDROGEN OPERATION AND GAS CORE REACTOR SIMULATOR DEVELOPMENT
Merle L. Thorpe Washington NASA Aug. 1968 47 p refs
(NASA-CR-1143) CFSTI: HC$3.00/MF$0.65 CSCL 20I

The induction plasma heating system has been studied and optimized. A reliable 80 kW 3 in. diameter sheath system has been developed which permits efficiently heating argon core gas to arc temperatures surrounded by a high velocity sheath of hydrogen. This unit will permit studies of mixing, fuel addition and other related phenomena associated with such a heat addition system. Other studies of hydrogen heating and particle injection into the arc are described. Author

N68-30031*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
DYNAMICS OF A ONE-DIMENSIONAL PLASMA SHEATH
Frank Hohl and Leo D. Staton Washington Jul. 1968 56 p refs
(NASA-TN-D-4651) CFSTI: HC$3.00/MF$0.65 CSCL 20I

Analytical and numerical methods are used to investigate a bounded one-dimensional plasma with a fixed neutralizing ion background. A variational method is used to show that a large class of stationary solutions of the nonlinear Vlasov equations represent minimum-energy states. The consequence of the minimum-energy property is that the stationary states, which represent minimum-energy configurations, can never be completely reached. However, numerical experiments which simulate the system reveal the interesting property that the plasma approaches its stationary state closely whenever the initial energy is not too different from the energy of this stationary state. Author

N68-30093*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYSIS OF INTEGRATED CHARGED PARTICLE ENERGY SPECTRA FROM GRIDDED ELECTROSTATIC ANALYZERS
F. Reece Roth and Marion Clark (Cornell Univ., Ithaca) Washington Aug. 1968 73 p refs
(NASA-TN-D-4718) CFSTI: HC$3.00/MF$0.65 CSCL 20I

This report relates the shape of the retarding potential curve produced by gridded electrostatic analyzers to the floating potential, the kinetic temperature, and the half-angle subtended in velocity space by the particles. Special emphasis is placed on the case in which the particles are Maxwellianized, but restricted within an escape cone in velocity space of half-angle. The cases of pulsed and steady state supply of particles are both considered. A computer program is included which produces an iterated best fit of experimental integrated energy spectra to these analytical expressions, and provides the effective values of the kinetic temperature, floating potential, and escape cone angle. A series of experimental runs is analyzed with the computer program as an illustrative example, and the possible sources of error are discussed. Author

N68-30593*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SOME INTERACTIONS OF POLYCRYSTALLINE TUNGSTEN ELECTRODES WITH CESIUM PLASMAS
James F. Morris Washington Aug. 1968 17 p refs
(NASA-TN-D-4745) CFSTI: HC$3.00/MF$0.65 CSCL 20I

At thermionic diode temperatures, work functions of tungsten electrode surfaces depend strongly on positive ion sheaths between these electrodes and cesium plasmas. The present theoretic study demonstrates this effect for a plane field-modified emitter with a collisionless positive ion sheath in a thermally ionized plasma. The analysis covers temperatures from 1700° to 2600°K; plasma electron number densities of 10^{12}, 10^{13}, and 10^{14} cm^{-3}; and a bare work function of 4.59 V. Values for sheath voltages, work functions, and cesium arrival rates and coverages on tungsten result from equilibrium calculations. In addition to these variables, computations for elevated plasma electron temperatures yield net current densities. Throughout this work, the sheath drops lie below 1 V. And atom arrival rates approach total cesium arrival rates only at low temperatures and sheath voltages. Author

N68-30784*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SHAPE OF A MAGNETICALLY BALANCED ARC
Marvin E. Goldstein and Willis H. Braun Washington Aug. 1968 34 p refs
(NASA-TN-D-4736) CFSTI: HC$3.00/MF$0.65 CSCL 20I

An improved model is developed for predicting the shape of an electric arc balanced in transverse convective and magnetic fields. The improvement over the previous model is in the more accurate description of the external flow field. The techniques used are based on conformal mapping and are an extension of those methods developed for problems of free surface flows. Author

N68-31640*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EMITTER AND COLLECTOR SHEATHS FOR CESIUM THERMIONIC DIODES WITH POLYCRYSTALLINE TUNGSTEN ELECTRODES
James F. Morris Washington Aug. 1968 13 p refs
(NASA-TN-D-4744) CFSTI: HC$3.00/MF$0.65 CSCL 20I

Using electrode temperatures above and below those of thermally ionized plasmas, this analysis estimates sheath properties for polycrystalline tungsten emitters and collectors in cesium thermionic diodes. The fields of these positive ion sheaths modify particle emissions from the plane electrodes; the sheath voltages affect cesium arrival, hence contact ionization rates. Cesium coverage dicates the work function, which is 4.59 volts for a bare electrode. In this study the assigned temperatures run from 1600 to 2400 K for plasmas with 10^{12} and 10^{13} electrons per cubic centimeter. Tabulations give results for diodes putting out from 0 to 1 ampere per square centimeter. Graphic trends of electrode and sheath characteristics also appear. The analysis applies to equilibria and near-equilibria. Author

N68-32072*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANOMALOUS DIFFUSION IN A PLASMA FORMED FROM THE EXHAUST BEAM OF AN ELECTRON-BOMBARDMENT ION THRUSTER
Allan J. Cohen Washington Aug. 1968 30 p refs
(NASA-TN-D-4758) CFSTI: HC$3.00/MF$0.65 CSCL 20I

A 10-cm-diam. cylindrical anode with a grounded coaxial center rod was immersed in the low density ($n_e \approx 2 \times 10^7 cm^{-3}$) exhaust beam of an ion thruster. A longitudinal magnetic field was applied. A theoretical and experimental study was made of the electron diffusion process in the beam plasma passing through the electrically floating anode. Anomalous diffusion and low frequency noise wer found. The mechanism of anomalous diffusion was considered similar to that reported by Kadomtsev and Nedospasov. Bohm's diffusion equation was found applicable and a constant of 1/8 (twice Bohm's value) was deduced experimentally. Rotation in the plasma was found by means of a correlation technique. The measured frequency of rotation ranged from 100 to 150 kHz.

N68-33021*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COLLISIONLESS SHEATHS BETWEEN FIELD-MODIFIED EMITTERS AND THERMALLY IONIZED PLASMAS EXEMPLIFIED BY CESIUM

James F. Morris Washington Aug. 1968 62 p refs

(NASA-TN-D-4376) CFSTI: HC $3.00/MF $0.65 CSCL 20I

The model, an iterative calculation method, and results for plane collisionless sheaths are presented. These sheaths separate thermally ionized plasmas from emitters of electrons, ion, and atoms and change emission with their fields. Still the model gives identical absolute potential changes through the sheath for ions and electrons, contrary to usual practice. For cesium, the emitter and plasma ion and atom temperatures range from 1600° to 2400°K with plasma electron temperatures up to 300°K higher. Plasma electron number densities are 10^{12} to 10^{15} per cubic centimeter. At these conditions work functions from 1.5 to 5 volts produce absolute potential drops from 0 to 1.5 volts for electron and positive-ion sheaths. And some currents greater than 10^2 amperes per square centimeter result. Certain generalizations apply: Sheath fields affect emissions and sheath characteristics significantly. The overall sheath characteristics correlate better with an emission Debye length (6.9 time the square root of the emitter temperature (°K) divided by the plasma electron number density (cm^{-3})) than with the conventional Debye length. Where conditions comply with the assumptions of the model, effective sheath widths decrease from 2.6 to 2 emission Debye lengths as overall sheath drops grow from less than 0.1 to 1.5 volts. Author

N68-33372*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

THE PREHEATING OF PLASMA IN A MEGAJOULE THETA-PINCH EXPERIMENT

W. A. Cilliers, Joseph Norwood, Jr., and G. K. Oertel Washington Sep. 1968 22 p refs

(NASA-TN-D-4708) CFSTI: HC $3.00/MF $0.65 CSCL 20I

The preheating of plasma in a megajoule theta-pinch experiment was investigated and distinct modes of operation have been delineated. The criteria for satisfactory preionization are discussed. For typical experiments where a number of discharges from different capacitor banks are applied sequentially to a common load, these criteria are determined not only by the requirement for a reproducible and stable plasma, but also by the limitations on the voltage that can be applied to the coil without precipitating prefire of banks that should fire later in the sequence. A range of preheater energies and a bank voltage that are satisfactory for this particular experiment were determined. Streak photographic evidence of plasma conditions in the various modes is presented. Author

N68-35171*# Ohio State Univ., Columbus.

INPUT ADMITTANCE AND REFLECTION COEFFICIENT OF A CIRCULAR APERTURE IN A GROUND PLANE COVERED BY A HOMOGENEOUS DIELECTRIC OR PLASMA SLAB

R. E. van Doeren Washington NASA Sep. 1968 33 p refs (Grant NGR-36-008-048)

(NASA-CR-1177) CFSTI: HC $3.00/MF $0.65 CSCL 20I

The reflection coefficient and admittance of a circular aperture in a ground plane radiating into a dielectric slab medium lying directly on the ground plane is considered. The work relies heavily on previous efforts by Compton and Rudduck. Calculations are performed for lossless dielectric and lossy plasma slabs. The admittance for lossless slabs is compared with the experimental data of others. Author

N68-37237*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYSIS OF ELECTROMAGNETIC WAVES ON A DIELECTRIC ROD IMMERSED IN A PLASMA INCLUDING A DISCUSSION OF DIAGNOSTIC APPLICATIONS

David L. Wright and Norman C. Wenger Washington Oct. 1968 31 p refs

(NASA-TN-D-4866) CFSTI: HC $3.00/MF $0.65 CSCL 20I

The guided electromagnetic waves that propagate along a lossless dielectric rod immersed in isotropic and uniaxial plasmas are determined. For the uniaxial plasma, only the case where the optic axis is alined parallel to the dielectric rod is considered. Both plasmas are described by the linearized momentum transport equation for a cold, collisionless, electron fluid of uniform density. Numerical results for the propagation constants of the waves are presented as a function of the rod and plasma parameters for both the circularly symmetric and dipole modes. Important aspects of the results are discussed with particular emphasis on plasma diagnostic applications. Author

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PHYSICS, SOLID-STATE

Includes semiconductor theory; and superconductivity. For applications see: 16 Masers. For related information see also: 10 Electronics.

N68-17594*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DAMPING OF A TORSIONAL OSCILLATOR IN LIQUID HELIUM 4 AND 3 FROM 0.4° TO 2.5°K

Rayjor W. H. Webeler and David C. Hammer Washington Mar. 1968 refs

(NASA-TN-D-4381) CFSTI: HC $3.00/MF $0.65 CSCL 20L

The logarithmic decrements of a piezoelectric cylindrical quartz crystal driven in a torsional mode of vibration were determined as a function of temperature with the crystal immersed in liquid He^3 and He^4. These measurements were used to calculate the applicable "viscosity–density" product of these two liquids as a function of temperature. The results in the interval 2.14° to 2.20°K represent the most extensive and precise viscosity-density values for He^4 that are available to data. Inspection of this viscosity-normal density product ($\eta_n\rho_n$) data near the lambda point (T_λ) indicates that a discontinuity in ($\eta_n\rho_n$) data may exist. Results between 2.0° and 1.35°K in liquid He^4 are in agreement with three other investigations. Between 1.1° and 0.95°K, the data substantiate only the rotating viscometer results of Woods and Hollis Hallett. At temperatures below 0.6°K, the phonon density temperature dependence is $T^{4.0\pm0.1}$, confirming the temperature dependence of the Landau expression for the phonon density. With the torsional crystal technique there was evidence of suppression of the phonon viscous contribution. Viscosity values for liquid He^3 were determined between 0.4° and 2.5°K and are compared with the results of other investigators. Author

N68-18772*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

LIGHT-INDUCED MODULATION OF ABSORPTION (LIMA) IN CADMIUM SULFIDE

Karl W. Boer and Edmund J. Conway Washington Mar. 1968 11 p refs

(NASA-TN-D-4466) CFSTI: HC $3.00/MF $0.65 CSCL 20L

The bulk optical absorption from 0.5 micrometer to 2 micrometers of cadmium sulfide single crystals has been modulated by a chopped continuous wave laser. Data showing the intensity and chopping frequency dependences are discussed. A few of the implications of these data are also mentioned. Author

N68-19924*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EFFECTS OF 22 MEV PROTON AND 2.4 MEV ELECTRON RADIATION ON BORON AND ALUMINUM-DOPED SILICON SOLAR CELLS

Gilbert A. Haynes and Walter E. Ellis Washington Apr. 1968 67 p refs

(NASA-TN-D-4407) CFSTI: HC $3.00/MF $0.65 CSCL 10A

A comparative analysis is presented of the effects of proton and electron irradiation on the electrical properties of boron-doped and aluminum-doped, N on P, silicon solar cells having base resistivities of 1 ohm-cm and 10 ohm-cm. Electrical measurements were made before and after irradiation at various flux levels up to 2.1×10^{12} protons per square centimeter at 22 MeV, and 1.0×10^{16} electrons per square centimeter at 2.4 MeV. Measurements of short-circuit current and maximum power under illumination with a tungsten light source and a solar simulator indicate that 1 ohm-cm aluminum-doped cells are slightly more resistant to damage by 2.4 MeV electrons than 1 ohm-cm boron-doped cells; however, 10 ohm-cm boron-doped cells were found to be more resistant to electron damage than 10 ohm-cm aluminum-doped cells. Spectral response measurements made before and after irradiation indicated no significant difference due to the type of doping element employed. From these spectral response curves, conversion factors were computed for use in predicting the output of solar cells in space sunlight from direct measurements under tungsten light or the solar simulator. Author

N68-20295*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ELECTRON-BEAM, CRYSTALLIZATION OF SILICON, GERMANIUM, AND CADMIUM SULFIDE

John C. Evans, Jr. Washington Apr. 1968 24 p refs

(NASA-TN-D-4522) CFSTI: HC $3.00/MF $0.65 CSCL 20L

Amorphous semiconductor films were electron-beam irradiated, and the effects were observed in the electron microscope. This study shows that oriented polycrystalline films of silicon, germanium, and cadmium sulfide may be made by electron bombardment of their amorphous films deposited on glass and plastic substrates. This transition was shown to occur without deleterious effects upon the substrates. The film bombardment was conducted both in the electron microscope and in a separate vacuum crystallizer capable of electron-beam raster scanning. Electron micrographs and electron diffraction patterns were used to record the results of the film treatments. Both silicon and germanium films underwent amorphous-to-crystalline changes at substrate temperatures well below the melting points of the semiconductors. Nucleation and crystal growth by coalescence were observed. The compound semiconductor, cadmium sulfide, crystallized by passing through a quasi-liquid state without subliming in the vacuum environment. The thickness of the untreated films was such as to allow transmission electron microscopic studies. Author

N68-21219*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

RADIATION DAMAGE IN THICK COPPER AND GOLD SPECIMENS PRODUCED BY LOW-ENERGY PROTONS

Howard F. Savage and Robert D. Morris Washington Apr. 1968 12 p refs

(NASA-TN-D-4452) CFSTI: HC $3.00/MF $0.65 CSCL 20L

The production of defects at 90°K in thick gold and copper foils by 50 to 400 keV protons and subsequent annealing characteristics of these metals have been studied. The thickness of the specimens was several times the calculated range of the protons. The defects formed in gold were uniformly distributed along

the proton range, whereas the defects formed in copper were more than twice as dense toward the end of the range as at the beginning. At doses from 10^{15} protons/cm^2 to at least the maximum of the tests, the change in electrical resistivity of both the gold and copper at incident energies between 50 and 400 keV can be decribed by a relation of the form $\Delta\rho = A\phi^n$, where $\Delta\rho$ is the increase in resistivity and ϕ is the dose. The recovery of gold upon isochronal annealing was similar to that observed for high-energy irradiations of thin specimens. Author

N68-21708*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SPECTRAL EMISSIVITY OF HIGHLY DOPED SILICON

Curt H. Liebert and Ralph D. Thomas Washington Apr. 1968 26 p refs

(NASA-TN-D-4303) CFSTI: HC$3.00/MF$0.65 CSCL 20L

Measurements were made at temperatures of 300°, 882°, and 1074°K of the normal spectral emissivity of opaque, highly doped silicon. The silicon was doped with arsenic and boron to electron carrier concentrations of 2.2×10^{19}, 3.7×10^{19}, and 8.5×10^{19} electrons per cubic centimeter and hole carrier concentrations of 6.2×10^{19} and 1.4×10^{20} holes per cubic centimeter. The 300°K emissivity data were obtained at wavelengths from 2.5 to 35 microns. The high temperature emissivities were measured from 3.5 to 14.8 microns. Carrier concentrations and direct current resistivity of the silicon were also measured. The carrier concentrations were determined from Hall measurements made at 300°K. The direct current resistivity was measured at temperatures from 300° to 1200°K. These quantities were used in analytical calculations of the emissivities. Agreement of the Hagan–Rubens theory with experiment was found at wavelengths greater than 12 microns and at 300°K. Good agreement of the free carrier absorption theory with experiment was achieved at all wavelengths and temperatures investigated. The free carrier absorption theory predicts the emissivity in terms of the index of refraction and the absorption index. The values of these quantities are presented. A comparison of the values of the absorption index obtained with those obtained from the literature showed good qualitative agreement. Author

N68-22271*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AN EXPLANATION OF ANOMALOUS NON-HOOKEAN DEFORMATION OF IONIC SINGLE CRYSTALS

James P. Cusick and Donald R. Behrendt Washington May 1968 34 p refs

(NASA-TN-D-4513) CFSTI: HC$3.00/MF$0.65 CSCL 20L

Previously published non-Hookean load-deflection data are reviewed. The results of this review show that roughness of the sample loading surfaces contributes to the measured deflection. Simple calculations presented herein show the effect of surface roughness on load-deflection data. Experiments are described in which two simultaneous deflection measurements are made; one measures bulk sample deflections only, the other measures bulk and loading surface deflections. Non-Hookean effects are observed only when surface deflections are included in the measurement. Finally, microscopic surface examination reveals surface roughness of the size needed to produce the non-Hookean effect. The non-Hookean effects are a consequence of the experimental techniques and do not reflect the bulk properties of the sample. Author

N68-24273*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.

MANY-BODY THEORY OF A RAPIDLY VARYING INHOMOGENEOUS ELECTRON GAS

John William Gadzuk Washington May 1968 94 p refs

(NASA-TR-R-283) CFSTI: HC$3.00/MF$0.65 CSCL 20L

The case of an inhomogeneous electron gas within which the density variation is significant over a spatial range of the order of a Fermi wavelength is considered. The first considerations are directed towards the problem of a weak periodic potential in an interacting electron gas. The momentum-dependent self-energy is calculated for an electron propagating in the many-body medium of an electron gas plus a periodic lattice pseudo-potential. This is the equivalent of a quasi-particle energy spectrum and thus an orthogonalized plane wave energy band. It does not appear that the lattice drastically changes qualitative aspects of plane wave many-body theory. A dielectric formulation for a general inhomogeneous electron gas is presented. By introducing a new image technique, the dielectric function within the random phase approximation, which is valid in the surface region of an electron gas, is obtained. A Green's function formalism is developed for treating the static dielectric screening of a point impurity in an electron gas. The surface dielectric function is used with the impurity screening formalism to treat the problem of impurity screening in the surface region. Author

N68-24510*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

IONIC CONDUCTIVITY OF SOLID MIXTURES

William L. Fielder Washington May 1968 refs

(NASA-TN-D-4606) CFSTI: HC$3.00/MF$0.65 CSCL 20L

The conductivities of four solid mixtures were determined as a function of temperature: (1) the lithium fluoride–lithium chloride eutectic, (2) the lithium chloride–potassium chloride eutectic, (3) the lithium fluoride–sodium chloride eutectic, and (4) a 50-mole-percent mixture of sodium chloride and potassium chloride. Two conductivity regions were obtained for each of the four mixtures. The activation energies for the conductivity for the lower-temperature regions ranged from 14 to 27 kilocalories per mole (59 to 114 kJ/mole). These energies were similar to the cation migration energies for the single crystals of the alkali halides. The conductivity of the mixtures in the lower-temperature regions is best explained by the following mechanism: (1) formation of cation vacancies primarily by multivalent impurities, and (2) migration of the cations through these vacancies. The activation energies for the conductivity of the solid mixtures in the upper-temperature regions ranged from 5 to 9 kilocalories per mole (20 to 39 kJ/mole). These values are significantly smaller than those energy values that might be expected for a normal intrinsic process. The low activation energies may reflect an ion transport process through a liquid-like state (premelting) or along low-energy paths such as line or plane imperfections. Additional evidence is needed before an upper-temperature region mechanism can be suggested with certainty. Author

N68-24660*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

HIGH ENERGY PROTON DAMAGE IN SILICON SURFACE BARRIER DETECTORS

Jag J. Singh and Emanuel Rind Washington May 1968 33 p refs

(NASA-TN-D-4528) CFSTI: HC$3.00/MF$0.65 CSCL 20L

The performance of a number of silicon surface barrier detectors has been studied under bombardment with 5.0-MeV, 20.0-MeV, and 40.0-MeV protons. The detectors investigated fall under three categories: (1) normal 100 microns deep; (2) normal 500 microns deep; and (3) fully depleted (dE/dx) type, 500 microns deep. Measurements made include rate of deterioration of charge collection efficiency, variation of resolving power, variation of leakage current, variation of noise level, and changes in detector capacitance as a function of the incident proton dose. From these several data, formulas giving relationships between the proton dose and the degree of detector resolving power deterioration have been developed for the normal and fully depleted type of detectors. Measurements clearly establish that: (1) the fully depleted detectors are more radiation damage resistant than the normal detectors; (2) the increased collecting field across the sensitive region reduces the damage sensitivity; and (3) the damage threshold of detectors made from lower resistivity materials is higher than that of those

made from higher resistivity materials. In the case of dE/dx detectors, there was no convincing evidence of any difference in degradation rates when viewed from the positive or negative sides of the detectors. Author

N68-25972*# Kansas Univ., Lawrence.
INVESTIGATION OF ELECTROCALORIC EFFECTS IN FERROELECTRIC SUBSTANCES Final Report, 1 Mar. 1964–1 Jul. 1967
Gordon G. Wiseman Washington NASA Jun. 1968 78 p refs
(Grant NsG-575)
(NASA-CR-1080) CFSTI: HC $3.00/MF $0.65 CSCL 20L

The electrocaloric effect in ferroelectric and pyroelectric substances was investigated in order to obtain a better understanding of the spontaneous electrical polarization in these substances. Quantitative measurements of the electrocaloric effect are feasible over a wide range of temperature. The accuracy and validity of such measurements were established by observing the effect in a substance while it was in its paraelectric phase where the results were predictable from the Curie-Weiss law. Measurements of the electrocaloric effect in the ferroelectric region further confirm the idea that the Langevin-type model which is based on long range interactions between dipoles characterized by an inner field parameter ν is not sound. A useful characteristic of a material which is to be used as a radiation detector delivering its signal into a low-impedance detector is considered to be the pyroelectric coefficient. Under certain conditions the sensitivity of a pyroelectric radiation detector can be changed by a change in the applied field whereas in others it can be made independent of an applied field. A.L.

N68-26603*# Research Triangle Inst., Durham, N. C.
A STUDY OF CHARGE STORAGE IN SILICON OXIDE RESULTING FROM NON-PENETRATING ELECTRON IRRADIATION
M. Simons, L. K. Monteith, and J. R. Hauser Washington NASA Jun. 1968 78 p refs
(Contract NAS1-6900)
(NASA-CR-1088) CFSTI: HC $3.00/MF $0.65 CSCL 20L

Charge storage in silicon dioxide resulting from low energy electron irradiation has been observed. The positive charge build-up has been studied in MOS type structures for various oxide thicknesses as a function of beam energy, electron fluence, sample bias, electrode thickness, and a number of oxide-related parameters. The effective radiation-induced oxide charge appears to be a function of beam energy dissipated within the oxide near the oxide–silicon interface; this charge increases with electron fluence up to a saturation level which was observed in some steam-grown oxides; the experimentally observed dependence of induced charge on applied bias is compared with that predicted by several models for charge accumulation. Optical and thermal annealing of the trapped charge has been studied in an effort to derive information on the nature of the oxide trapping levels. Reduction of trapped charge by irradiation at small negative biases has also been explored. Finally the development of a two-carrier model for space charge build-up in an MOS structure is discussed and the experimental results obtained for silicon dioxide are related to device performance in the radiation environment. Author

N68-26627*# Research Triangle Inst., Durham, N. C.
SEMICONDUCTOR PIEZOJUNCTION TRANSDUCERS
J. J. Wortman Washington NASA Jun. 1968 94 p refs
(Contract NASr-222)
(NASA-CR-1089) CFSTI: HC $3.00/MF $0.65 CSCL 20L

Techniques for utilizing the piezojunction effect as the sensory element in transducers are discussed. A new technique for applying the phenomenon (silicon needle) in a broad class of mechanical transducers has been developed and demonstrated in several transducers. Particular emphasis was placed on accelerometers where it was shown that devices could be fabricated with resonant frequencies greater than 3 KC, capable of measuring ac and dc accelerations in the range from ±1 g to ±100 g. Several techniques were developed for providing a digital output for the piezojunction sensors. Author

N68-28239*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LOW-TEMPERATURE RESISTANCE IN MINIMUM AND MAGNETORESISTANCE FOR DILUTE ALLOYS OF IRON IN COPPER
John S. Loomis and Wayne R. Hudson Washington Jul. 1968 12 p refs
(NASA-TN-D-4626) CFSTI: HC $3.00/MF $0.65 CSCL 20L

A temperature dependence of the Fe–Cu resistivity was compared with the predictions of Kondo and Nagaoka. The Nagaoka theory fits the experimental results better than the Kondo theory. The transverse magnetoresistance was measured as a function of temperature and magnetic field. For concentrations less than 0.03 at. % Fe in Cu, the magnetoresistance was positive and was approximately linear for higher magnetic fields. For Fe concentrations greater than 0.03 at. %, the magnetoresistance became increasingly negative with increasing concentrations. The magnetoresistance of the 0.073-at. %-Fe sample fit a magnetic field dependency of H 1.33. Author

N68-33228*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
ELECTRON SPIN RESONANCE OF LITHIUM-DIFFUSED SILICON
F. E. Geiger Washington Aug. 1968 28 p refs
(NASA-TR-R-290) CFSTI: HC $3.00/MF $0.65 CSCL 20L

Electron paramagnetic resonance was studied in floating-zone, lithium-diffused silicon. The resonances observed were identified as the result of Li-O complexes. The g-factor for the Li-O complex with the magnetic field H_0 in the ⟨100⟩ direction was found to be in good agreement with the calculated value obtained from the principal g-factors determined by Feher for crucible-grown silicon. Instrument sensitivity allowed the recording of Li-O and phosphorus donor hyperfine structure, thus permitting the Li-O concentration to be determined and the oxygen concentration in floating-zone silicon to be estimated. Irradiation of floating-zone, lithium-diffused silicon emptied the phosphorus donor levels and about 54 percent of the Li-O levels into deep traps; however, no new centers were found, although an unidentified structure was observed at approximately g=2.006. The lithium-diffused sample of 0.16 ohm-cm resistivity gave a narrow (0.9 oersted), stress-sensitive resonance line. The resonance split into a doublet in the ⟨100⟩ direction. The resonance was attributed to lithium donor electrons in a ground state and donor wave functions arising from single conduction electron valleys. Author

N68-35178*# National Bureau of Standards, Boulder, Colo. Inst. for Basic Standards.
SUPERCONDUCTION THIN FILMS
R. A. Kamper, L. O. Mullen, and D. B. Sullivan Washington NASA Sep. 1968 38 p refs
(NASA Order C-7756-B)
(NASA-CR-1189; NBS-9708) CFSTI: HC $3.00/MF $0.65 CSCL

Attention is concentrated mainly on the properties and applications of the Josephson effect at radio frequencies. The characteristics of the emitted radiation under various conditions were explored; a simple theory was constructed of the linewidth (which was verified); new principles were conceived for an absolute milli-degree thermometer and a picovoltmeter; a prototype of the picovoltmeter was built and tested; and a reliable method for fabricating good tunnel junctions between thin films of niobium and lead was developed. Author

N68-35356*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ULTRASONIC ATTENUATION IN SUPERCONDUCTING TANTALUM

Zoltan W. Sarafi Washington Sep. 1968 23 p refs
(NASA-TN-D-2806) CFSTI: HC $3.00/MF $0.65 CSCL 20L

Ultrasonic attenuation was measured in single crystals of tantalum at frequencies from 30 to 330 MHz. The crystals were oriented in the (100) and (110) directions. The attenuations of longitudinal and transverse waves were measured as a function of temperature and magnetic field. Curves are presented showing the transition between the normal and superconducting states. The zero-temperature energy gaps obtained were 3.3 kT_c for both directions. The samples had q/ values intermediate between those used by other investigators, and a comparison of results indicated that the energy gap in tantalum is lower for samples with larger electronic mean-free paths. Author

N68-37051*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

PROTON-PRODUCED DEFECTS IN n-TYPE SILICON

Roger A. Breckenridge Washington Oct. 1968 27 p refs
(NASA-TN-D-4830) CFSTI: HC $3.00/MF $0.65 CSCL 20L

Defect energy levels and concentrations were determined for n-type silicon single crystals with initial resistivities between 10 and 200 ohm-cm after 22.4 -MeV proton irradiations. Two defect energy levels were located: one at 0.17 eV below the bottom of the conduction band and one at 0.41 eV below the bottom of the conduction band. The introduction rate of the oxygen-vacancy complex was independent of the oxygen content of the silicon for the samples investigated. Heat treatment of Czochralski-grown silicon at 1000°C for 65 hours had no effect on the introduction rate of the oxygen-vacancy complex. Author

N68-37055*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EFFECTS OF ZINC CONCENTRATION ON OUTPUT OF ZINC DOPED GERMANIUM DETECTORS

Wilfred D. Hesketh Washington Oct. 1968 36 p refs
(NASA-TN-D-4834) CFSTI: HC $3.00/MF $0.65 CSCL 20L

The effects of dopant concentration on the operation of far infrared detectors were investigated theoretically and experimentally. The theoretical investigation shows that an optimum dopant concentration does exist in extrinsic quantum detectors. This optimum point will vary with changes in the host or dopant material. The optimum will also vary with changes in the integrating chamber used. In the experimental investigation, an integrating chamber was constructed and evaluated for its characteristics. These characteristics, radiation loss coefficient due to reflections from the input port, and radiation loss due to absorption by the integrating chamber walls were then used in predicting the optimum dopant concentration of zinc doped germanium. Ten pairs of detectors were produced of various dopant concentration with equal dopant concentration in the two detectors of each pair. The output of the detectors was measured, the measurement being normalized to the maximum value and plotted. These curves were then compared with similarly normalized theoretical curves. The optimum dopant concentration occurred as predicted but with a greater slope on each side of the optimum point than was predicted. Author

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PROPELLANTS

Includes fuels; igniters; and oxidizers. For basic research see: 06 Chemistry; and 33 Thermodynamics and Combustion. For related information see also: 28 Propulsion Systems.

N68-11645*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF GRAVITY ON SELF-PRESSURIZATION OF SPHERICAL LIQUID-HYDROGEN TANKAGE
John C. Aydelott Washington Dec. 1967 21 p refs
(NASA-TN-D-4286) CFSTI: HC $3.00/MF $0.65 CSCL 13D

The information obtained from several experimental programs was examined in order to understand better the thermodynamic history of spherical, 9-inch- (23-cm-) diameter liquid-hydrogen tankage at both normal and reduced gravities. The rate of pressure rise in the hydrogen container was lower under reduced-gravity conditions than under normal-gravity conditions because of the increase in the liquid-wetted wall area and the increased boiling. The location of the sources of heat relative to the hydrogen liquid and vapor was the most important factor in determining the rate of pressure rise. Author

N68-17093*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FEASIBILITY OF SUPPORTING LIQUID FUEL ON A SOLID WALL IN A RADIATING LIQUID-CORE NUCLEAR ROCKET CONCEPT
Henry A. Putre and Albert F. Kascak Washington Feb. 1968 29 p refs
(NASA-TN-D-4413) CFSTI: HC $3.00/MF $0.65 CSCL 21F

A reference liquid fuel nuclear rocket concept, previously analyzed, consists of a liquid carbide fuel mixture supported on the inside wall of a rotating tube. This report extends the original liquid fuel heat-transfer analysis for the reference engine by developing an expression for combined molecular and propellant induced turbulent heat transfer in the liquid fuel, and results in a more rigorous determination of support-wall temperature. In addition, two means of reducing support wall temperature without severly affecting rocket performance are investigated. For the reference fuel element configuration, with uniform heat source distribution in the liquid fuel, the support wall temperature calculated from the more complete turbulent analysis was 9830°R (5460°K). When the fuel was zoned into a region in the liquid near the propellant interface, the support wall temperature was about 1200°R (670°K) lower than for the unzoned case. A simplified mass-transfer analysis indicated that wall temperature reduction by fuel zoning does not appear feasible. The insulating effect of a stable opaque vapor layer built up at the solid liquid interface was also evaluated. Wall temperature was found to be reduced to 8500°R (4720°K) at 1430 seconds specific impulse by the vapor layer. Current wall materials, such as graphite used at 7200°R (4000°K) in conjunction with an opaque vapor layer, may permit operation at a reduced specific impulse of about 1250 seconds. Author

N68-21267*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPUTER CODE FOR CALCULATING TEMPERATURE PROFILES IN A PROPELLANT TANK
Ronald L. Danilowicz Washington Apr. 1968 35 p refs
(NASA-TM-X-1556) CFSTI: HC $3.00/MF $0.65 CSCL 20M

A FORTRAN IV computer code for determining temperature histories in a propellant tank due to wall and internal heating was written. The analysis, on which the code is based, is presented. The assumptions and approximations made are also discussed. Also included are instructions for use of the code, a sample problem, a flow chart and a complete listing of the code. Author

N68-21893*# Atlantic Research Corp., Alexandria, Va.
STUDY OF PROPELLANT VALVE LEAKAGE IN A VACUUM Final Summary Report
Ralph D. Gift, John A. Simmons, Jack M. Spurlock, Joseph P. Copeland, and Jaydee M. Miller Washington NASA Apr. 1968 12 p ref
(Contract NAS9-4494)
(NASA-CR-1047) CFSTI: HC $3.00/MF $0.65 CSCL 21H

Condensed summary report is presented of an investigation of the adverse effects of propellant leakage through propellant valves and into rocket injector manifolds and combustion chambers exposed to a vacuum environment. In space, during a nonfiring condition, these various regions of the engine are exposed to a vacuum environment. Consequently, should any propellant leak past the control valve, it can freeze and accumulate in the injector flow passages and combustion chamber. Investigation was conducted to study the likelihood that such accumulation may cause blockage of the propellant flow system or result in a catastrophic hard start. The investigation consisted of concurrent theoretical and experimental studies, with emphasis of consideration being given to the factors that could affect the performance of the Apollo Service Propulsion System and the Gemini Orbit Attitude Maneuvering System engines. Author

N68-28155*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE BOILOFF PROBLEM WITH METHANE FUEL IN SUPERSONIC AIRCRAFT
Richard J. Weber Washington Jul. 1968 15 p refs
(NASA-TM-X-1604) CFSTI: HC $3.00/MF $0.65 CSCL 21D

The benefits of employing methane fuel in supersonic aircraft are lessened by the tendency of the cryogenic fuel to boil away in flight. Boiloff due to ambient pressure reduction during climb appears to be the most difficult to avoid. Subcooling the fuel and using a soluble pressurant such as air or nitrogen is evaluated. Another solution is zero-ullage storage. Alternatively, it is suggested that the boiloff penalties with nonsubcooled fuel may be acceptable. In the study airplane gross weight is allowed to vary as required to yield the desired range and payload. Author

N68-30077*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ON THE SOLUBILITIES AND RATES OF SOLUTION OF GASES IN LIQUID METHANE
Robert R. Hibbard and Albert Evans, Jr. Aug. 1968 25 p refs
(NASA-TN-D-4701; E-4324) CFSTI: HC $3.00/MF $0.65 CSCL 21D

Curves are given which permit the easy calculation of the solubilities of oxygen, argon, carbon monoxide, nitrogen, neon, hydrogen, and helium in liquid methane at temperatures between 90 and 112 K. The solubilities of these gases decrease in the order in which they are listed above. It was also found that the rates of solution of gases in liquefied natural gas are very high. It appears that only the least soluble gases, neon, hydrogen and helium can be used as fuel system pressurants if liquefied natural gas is to be used in aircraft. Author

N68-30313*# National Aeronautics and Space Administration, Washington, D. C.
HIGH ENERGY PROPELLANTS: A CONTINUING BIBLIOGRAPHY WITH INDEXES
Jun. 1968 57 p refs
(NASA-SP-7002(04)) CFSTI: HC $3.00/MF $0.65 CSCL 21I

References on high energy propellants announced in the NASA abstract journals during 1967 are presented in this continuing bibliography that contains subjects and author indexes. The 103 references deal with research and development studies on solid, liquid, and hybrid propellants and oxidizers as well as propellant handling and storage, combustion characteristics, toxicity, hazards, and safety measures. M.W.R.

N68-32793*# TRW Systems, Cleveland, Ohio.
ANALYTICAL PREDICTIONS OF DELIVERED SPECIFIC IMPULSE
Victor Quan Washington NASA Aug. 1968 137 p refs
(Contract NAS9-4358)
(NASA-CR-1123; TRW-02874-6008-R000) CFSTI: HC $3.00/MF$0.65 CSCL 21I

Summary data are presented on the four computer programs developed to calculate inviscid, one-dimensional and axisymmetric nonequilibrium nozzle flow fields accounting for the nonequilibrium effects of finite rate chemical reactions between gaseous combustion products and velocity and thermal lags between gaseous and condensed combustion products. Written in Fortran 4, these are the (1) one-dimensional reacting gas program, (2) one-dimensional two-phase reacting gas program, (3) axisymmetric reacting gas program, and (4) axisymmetric two-phase perfect gas program. Program limitations are delineated. Tabulated data are included on the results of studies undertaken to determine the chemical species and chemical reactions and reaction rates for typical propellant systems. The implicit integration method used in the programs is described, along with the transonic analyses used to construct the initial lines for the characteristics calculations in the axisymmetric programs. Graphs depicting the results of the four programs are included. M.G.J.

N68-35072*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE AND STABILITY CHARACTERISTICS OF NITROGEN TETROXIDE-HYDRAZINE COMBUSTORS
Martin Hersch Washington Sep. 1968 23 p refs
(NASA-TN-D-4776) CFSTI: HC $3.00/MF $0.65 CSCL 21B

Studies were conducted to determine the effects of various design and operating parameters on storable propellant rocket combustion. An injector incorporating like-on-like doublets forming parallel sheets achieved 95 percent of theoretical performance and gave best stability. Triplet injectors with unlike impingement had poorest stability characteristics. Increasing combustor length improved performance for parallel sheet but not for triplet injection. Effects of contraction ratio, propellant flow rate, and chamber pressure on performance were small. It was concluded that unlike impingement of hypergolic propellants may be initiating cause of high-frequency instability. Author

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PROPULSION SYSTEMS

Includes air breathing, electric, liquid, solid, and magnetohydrodynamic propulsion. For nuclear propulsion see: 22 Nuclear Engineering. For basic research see: 23 Physics, General; and 33 Thermodynamics and Combustion. For applications see: 31 Space Vehicles. For related information see also: 27 Propellants.

N68-10496*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

THERMAL INVESTIGATION OF AN ION ENGINE MICRO-THRUSTOR

N. J. Stevens and D. C. Briehl Washington Nov. 1967 15 p refs (NASA-TM-X-1473) CFSTI: HC $3.00/MF $0.65 CSCL 21C

A cesium contact-ion microthrustor that was designed at the Lewis Research Center was studied to determine the heat transfer conditions necessary to minimize the heater power. The microthrustor was simulated on a resistance analog network which was balanced to an experimentally obtained set of temperatures and power inputs from a full-size thermal model test. No cesium was used in the thermal model. The major thermal losses were identified as conduction through the tank mounts and radiation from the hot feed tube insulation, accelerator, and cesium tank. The thermal model with these losses minimized was predicted to operate at 13.1 watts, and actually it operated at 12.9 watts. Application of modifications to the actual thrustor reduced the power requirements by the expected 13 percent. Author

N68-10502*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EFFECTS OF AXIAL GRADIENTS OF VELOCITY AND MAGNETIC FIELD, ELECTRODE STAGGER, AND ION SLIP ON PARAMETERS IN MHD ACCELERATORS

Frank Hohl Washington NASA Nov. 1967 40 p refs (NASA-TN-D-4239) CFSTI: HC $3.00/MF $0.65 CSCL 20I

The distributions of current and potential have been determined for two linear Faraday plasma accelerators. The equations describing the electrical parameters of accelerators were reduced to two dimensions and numerical analysis was used to solve the equations. The internal resistance of the accelerator, the Hall potential gradient, and various other parameters have been calculated as functions of: velocity and magnetic field gradients along the channel axis, ion slip, various amounts of stagger of electrodes, the ratio of electrode width to insulator width, and the Hall parameter. The results are compared with previous theoretical work and with experimentally obtained data. Author

N68-10562*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

PERFORMANCE TESTS OF A 1/2-MILLIPOUND (2.2 mN) AMMONIA RESISTOJET THRUSTOR SYSTEM

Harold Ferguson and James S. Sovey Washington Nov. 1967 19 p refs

(NASA-TN-D-4249) CFSTI: HC $3.00/MF $0.65 CSCL 21H

Performance data were obtained and evaluated for a nominal 1/2-millipound-(2.2 mN) thrust resistojet system, with ammonia as the propellant. The system is defined to include the thrustors, the propellant storage and feed components, and the power and signal conditioning module. For a nominal system input power of 8 watts, the valves and power conditioning required 3 watts. The power delivered to the thrustor was 5 watts, of which approximately 1 watt represented augmented thrust power. For these conditions, a specific impulse of 140 seconds was obtained. The system was capable of maintaining specified thrust tolerances for either liquid or vapor propellant extraction and thus should be able to operate in a zero-gravity environment. Author

N68-11829*# Israel Program for Scientific Translations, Ltd., Jerusalem.

RUSSIAN SOLID-FUEL ROCKETS [RAKETY NA TVERDOM TOPLIVE V ROSSII]

V. W. Sokol'skii 1967 242 p refs Transl. into ENGLISH from Izd. Akad. Nauk SSSR (Moscow), 1963 Prepared for NASA and NSF

(NASA-TT-F-415; TT-66-51152) CFSTI: $3.00 CSCL 19G

A history of solid fuel rocketry in Russia is presented. Consideration is given to pyrotechnic rockets before the beginning of the 19th century, the earliest military application of rockets, rocket armament of the Russian army, other types of rockets in the second half of the 19th century, attempts to power aircraft by solid propellant rockets, and solid propellant rockets in Russia at the turn of the 20th century. C.T.C.

N68-15644*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

COMBUSTION IN STABILITY IN STEEL AND ABLATIVE ROCKET CHAMBERS

Ralph R. Goelz Washington Feb. 1968 11 p refs

(NASA-TM-X-1511) CFSTI: HC $3.00/MF $0.65 CSCL 21B

An investigation was conducted to compare the effects of ablative chambers and steel chambers on combustion instability in a hydrogen-oxygen rocket engine. Both uncharred and charred ablative materials were evaluated. Two concentric tube injectors were used for the testing at a chamber pressure of 300 psia (2070 kN/m^2) and a nominal thrust of 20,000 pounds (89 kN). Hydrogen-injection temperature ramping was the basic stability rating technique. An instability amplitude comparison analysis was completed to detect amplitude variations for the two materials. Both the hydrogen-injection temperature ramping and the amplitude analysis lead to the same conclusion: There is no significant difference in stability limit or instability amplitude between the steel, charred ablative, and uncharred ablative chambers. Author

N68-16413*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COLD-AIR PERFORMANCE EVALUATION OF SCALE MODEL OXIDIZER PUMP-DRIVE TURBINE FOR THE M-1 HYDROGEN-OXYGEN ROCKET ENGINE. 3: PERFORMANCE OF FIRST STATE WITH INLET-FEEDPIPE-MANIFOLD ASSEMBLY

Roy G. Stabe and John F. Kline Washington Feb. 1968 21 p refs

(NASA-TN-D-4392) CFSTI: HC $3.00/MF $0.65 CSCL 21H

The aerodynamic performance of the first stage of a 0.45-scale model of the oxygen pump-drive turbine for the M-1 rocket engine was determined experimentally. The first stage, including the inlet-feedpipe-manifold assembly, was tested over a range of speeds and pressure ratios. The results indicated that, at design equivalent speed and blade-jet speed ratio, the first-stage static and total efficiencies were very close to design values. The static and total efficiencies were 0.37 and 0.57 compared with the design values of 0.375 and 0.563, respectively. The equivalent weight flow at the design point was the same as that reported for the reference two-stage turbine investigation. The weight flow was reduced by a higher-than-design inlet-manifold total-pressure loss, a large

circumferential variation in manifold flow conditions, and a 3.7-percent deficit in nozzle throat area. The less-than-design throat areas changed the static-pressure distribution from design and reduced the nozzle-exit velocity. Results of a velocity diagram and a loss analysis of the first-state performance indicated that the rotor efficiency was 0.81 compared with the design value of 0.80. The nozzle performed better than design; the nozzle efficiency was 0.94 compared with the design value of 0.91. Author

N68-16632*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COLD-AIR INVESTIGATION OF A TURBINE FOR HIGH-TEMPERATURE ENGINE APPLICATION. 2: DETAILED ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF STATOR PERFORMANCE

Herman W. Prust, Jr., Harold J. Schum, and Frank P. Behning Washington Feb. 1968 45 p refs

(NASA-TN-D-4418) CFSTI: HC$3.00/MF$0.65 CSCL 21E

The effects on turbine stator performance of the blade features of low solidity and large profile and trailing-edge thicknesses were studied. At design mean-section critical velocity ratio of 0.790, the experimental results for the subject stator based on annular-sector data show an annular-sector, after-mix, kinetic-energy loss coefficient of approximately 0.05. The experimental performance of this stator was compared with the estimated performance of two stators with thinner profiles and higher solidities than the subject blading. This comparison indicated that the performance of the subject blading was not significantly affected by increased profile thickness, and that the mean-radius solidity of the subject blading of 1.39 was not too low for good performance. Good agreement was obtained between experimental and analytical mean-section performance for the subject stator and one of the reference stator bladings. These analytical results indicate that the large trailing-edge blockage of the subject stator (about 10 percent) caused a 1% loss of the kinetic energy available to the stator. Rather poor agreement was obtained for the subject stator between experimental annular-sector loss and annular-sector loss predicted from mean-section data. The after-mix kinetic energy loss coefficient obtained from radial integration was 0.010 larger than the predicted value at design critical velocity ratio. Author

N68-17028*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

INVESTIGATION OF A LARGE-SCALE MIXED COMPRESSION AXISYMMETRIC INLET SYSTEM CAPABLE OF HIGH PERFORMANCE AT MACH NUMBERS 0.6 TO 3.0

Norman E. Sorensen and Donald B. Smeltzer Washington Feb. 1968 180 p refs

(NASA-TM-X-1507) CFSTI: HC$3.00/MF$0.65 CSCL 21H

A model of a mixed-compression inlet with a 20 inch diameter capture area was designed and tested in combination with three subsonic diffuser designs. The major objective was to investigate relatively short axisymmetric inlet systems capable of high performance over the complete Mach number range. The model was tested in a wind tunnel at Mach numbers from 0.6 to 3.2 and angles of attack from 0° to 8°. The Reynolds number was about 2×10^6 per foot at Mach number 3.0. The supersonic diffuser of the inlet was designed with the aid of a computer program employing the method of characteristics. Preliminary tests showed that the supersonic portion of the inlet performed as predicted, but the flow separated in the subsonic diffuser limiting the performance at the engine face. The subsonic diffuser was then modified and the total pressure recovery was raised to 90% with about 11% boundary layer bleed mass flow from 86% recovery with 13-percent bleed. Off-design total-pressure recoveries were also improved about 4% over the Mach number range 1.55 to 3.0. The 1.50 capture diameter inlet, with vortex generators, showed an additional 1-percent improvement in recovery, but of more significance was the reduction in total pressure distortion at the engine face. The distortion was reduced to 6 to 7% from about 10% and the maximum recovery was improved to about 91% with about 11% boundary layer bleed mass flow. Without the generators the distortion of the 1.50-diameter inlet was about doubled (14%). The test results in the Mach number range 0.6 to 1.2 included details of experimentally measured additive drag. It was found that there was an optimum trade of additive drag for pressure recovery. Author

N68-18216*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COOLED BAFFLE DEVELOPMENT FOR M-1 ENGINE USING A SUBSCALE ROCKET ENGINE

E. William Conrad, John P. Wanhainen, and Jerome K. Curley Washington Oct. 1966 49 p refs (Declassified)

(NASA-TM-X-1267) CFSTI: HC$3.00/MF$0.65 CSCL 21H

A subscale rocket of 15,000 pounds thrust was used to provide a realistic environment for development of a suitable cooled baffle configuration for use in the M-1 engine development program. Chamber pressure, contraction ratio, mixture ratio, and injector elements were identical with the full-scale M-1 engine. Inasmuch as the size of an individual baffle compartment of the full-scale engine was approximated by the subscale engine, the heat transfer environment of the full-scale engine was also closely simulated. As a result of tests using a series of 25 baffles (segments of full scale) employing several cooling techniques, a configuration was developed that satisfied the design requirements and exhibited adequate durability. All baffle configurations employing transpiration cooling exhibited an unexpected multivalued flow characteristic curve, rendering these configurations unsuitable for use in the M-1 engine program. Author

N68-18221*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CHANGE IN INDUCER NET POSITIVE SUCTION HEAD REQUIREMENT WITH FLOW COEFFICIENT IN LOW TEMPERATURE HYDROGEN (27.9° TO 36.6°R)

Phillip R. Meng Washington Mar. 1968 28 p refs

(NASA-TN-D-4423) CFSTI: HC$3.00/MF$0.65 CSCL 21H

An 84° flat plate helical inducer was used to evaluate the thermodynamic effect of cavitation in low temperature liquid hydrogen over a range of flow coefficients. The range of liquid hydrogen temperatures studied was from 27.9° to 36.6°R. The tests were conducted at a rotative speed of 20 000 rpm over a range of flow coefficients from 0.060 to 0.076 (1200 to 1500 gal/min). For a given head coefficient ratio, the required net positive suction head increased as the fluid inlet temperature was lowered. This decrease in inducer performance was attributed to a decrease in the thermodynamic effect of cavitation at the lower fluid temperatures. For a given temperature the thermodynamic effect of cavitation increased with decreasing flow coefficient. This effect is attributed to changes in blade pressure distribution with flow coefficient. The measured values of required net positive suction head are in reasonable agreement with those obtained using a semiempirical prediction method. Author

N68-18249*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL INVESTIGATION OF ACOUSTIC LINERS TO SUPPRESS SCREECH IN STORABLE PROPELLANT ROCKET MOTORS

David W. Vincent, Bert Phillips, and John P. Wanhainen Washington Mar. 1968 47 p refs

(NASA-TN-D-4442) CFSTI: HC$3.00/MF$0.65 CSCL 21H

Several acoustic liners (Helmholtz type) were experimentally and theoretically evaluated to determine their effectiveness to suppress screech in a rocket motor. The liners were experimentally rated in a storable propellant (N_2O_4-50 percent hydrazine, 50 percent UDMH) rocket at a nominal chamber pressure of 100 psia (689 kN/m^2) and 6700 pounds of thrust (29.8 kN). Liner design

variables investigated included aperture size, liner percent open area, liner length, and aperture shape. Tests were conducted in both a marginally stable and a spontaneously unstable combustor. Bomb pulses were used to rate stability in terms of the grains (grams) of explosive necessary to induce instability. Bomb pulses as high as 170 psi (1172 kN/m^2) peak-to-peak were damped by liners when the liner resonant frequency was near the screech frequency. Calculated theoretical absorption coefficients assuming both flow and no flow past the apertures agreed with the experimental results. Full-length liners were not required for stabilization. Aperture size and shape had secondary effects. Longitudinal slots, which would be adaptable to regeneratively cooled configurations, were found to be as effective as circular apertures in suppressing screech. Author

N68-19581*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OUT-OF-THE-ECLIPTIC-PLANE PROBE MISSION EMPLOYING ELECTRIC PROPULSION

Frank J. Hrach Washington Apr. 1968 35 p refs

(NASA-TN-D-4455) CFSTI: HC$3.00/MF$0.65 CSCL 21C

Measurements out of the ecliptic plane are necessary in the study of the Sun and heliocentric space. The present analysis investigates the use of a combined propulsion system to accomplish the out-of-the-ecliptic-plane probe mission. In the combined propulsion system studied herein, energy beyond Earth-escape energy is given to the vehicle by a booster, after which a low-thrust electric propulsion system begins operation. The chemical boosters considered are the Atlas–Agena and the Atlas–Centaur. Three values of electric propulsion system specific powerplant mass are examined, 50, 100, and 150 pounds per kilowatt jet. Results are presented for missions to final heliographic inclinations from 25° to 45°. The basic mission profile considered is one in which the distance from the Sun to the vehicle is held constant at a value of 1 astronomical unit, and in which the propulsion is terminated before the argument of latitude of the trajectory reaches 90°. The effects of variations from the basic profile are investigated. Author

N68-19708*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL EVALUATION OF SEVERAL ADVANCED ABLATIVE MATERIALS AS NOZZLE SECTIONS OF A STORABLE-PROPELLANT ROCKET ENGINE

A. J. Pavli Washington Apr. 1968 23 p refs

(NASA-TM-X-1559) CFSTI: HC$3.00/MF$0.65 CSCL 21H

Eighteen ablative materials were evaluated for their relative erosion resistance in test firings of 22 nozzles in a storable-propellant engine of a 1.2-inch (3.05-cm) diameter throat at a chamber pressure of 100 psia (689.5 kN/m^2). The materials investigated were the phenolic, polyimide, phenolic plus polyamide, epoxy novalac, and phenyl-silane resins, reinforced with silica, quartz, and carbon-silica fibers. Quartz reinforcement was superior to silica with the three resins tested. The lower erosion rate is attributed to the higher melting temperature of quartz. Carbon-silica reinforcement exhibited the highest erosion rate. Its relatively poor performance is attributed to the rapid oxidation of the carbon. Ablatives made of phenolic resin had lower erosion rates than all other resins tested. Erosion at mixture ratios of 1.6 was greater than at mixture ratios of 2.0. Nozzle convergent entrance angle, throat radius of curvature, and source or resin supplier had no apparent effect on erosion resistance. A slight effect of fabrication technique on erosion was detected. Author

N68-20064*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL INVESTIGATION OF REACTION CONTROL, STORABLE BIPROPELLANT THRUSTORS

R. James Rollbuhler Washington Apr. 1968 35 p refs

(NASA-TN-D-4416) CFSTI: HC$3.00/MF$0.65 CSCL 21H

In order to evaluate the performance of low-thrust, chemical bipropellant rocket thrustors for possible applications in spacecraft reaction control systems, an experimental investigation was conducted with readily available thrustors. The thrustors were designed for a thrust of less than 5 pounds force (22.2 N), combustion-chamber pressures of 100 pounds per square inch absolute (68.9 M/cm^2) or less, and for use with nitrogen tetroxide—hydrazine-type propellants. A high instrumented altitude test facility was used to test each of the thrustors over a range of test durations and oxidizer to fuel ratios. The maximum specific impulse obtained was 262 pounds force per pound mass per second (2570(N)(sec)/kg), and the maximum characteristic velocity was 5200 feet per second (1588 m/sec). Total impulses were measured for run times as short as 10 milliseconds. The average value of the specific impulse, at minimum run times, was about 25 percent of the maximum specific impulse for the same thrustor. Also reported are response times and combustor-wall temperatures. Author

N68-20186*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

SCALE 1/14.2 INVESTIGATION OF SUBMERGED NOZZLE FOR SL-3 260-INCH SOLID ROCKET

Reino J. Salmi and James J. Pelouch, Jr. Washington Apr. 1968 12 p refs Presented at the 2d AIAA-ICRPG Solid Propellant Conf., Anaheim, Calif., Jun. 1967

(NASA-TM-X-1546) CFSTI: HC$3.00/MF$0.65 CSCL 21H

The original submerged nozzle configuration for the SL-3 260-inch solid propellant rocket was modified to provide additional insulation and protection against the erosive effects of hot exhaust gases in the annular channel between the submerged nozzle lip and the rocket aft-end casing. Tests of the modified nozzle design indicated that the circumferential flow velocities in the annular channel were lower for the modified nozzle than for the original configuration for the case of an unburned or 100-percent grain. For the case of the 34-percent regressed grain, which reduced the flow velocities in the annular channel, flow Mach numbers approximately equal to those of the original nozzle were obtained with the modified nozzle. Author

N68-20187*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DIVERGENT-FLOW CONTACT-IONIZATION ELECTROSTATIC THRUSTOR FOR SATELLITE ATTITUDE CONTROL AND STATION KEEPING

Walter C. Lathem and John F. Staggs Washington Apr. 1968 25 p refs

(NASA-TN-D-4420) CFSTI: HC$3.00/MF$0.65 CSCL 21C

A divergent-flow contact-ionization electrostatic thrustor is described herein. This thrustor performed well at thrust levels between 0.89 and 1.56 millinewtons, a range that is applicable to satellite attitude-control and station-keeping missions. Power efficiencies up to 45 percent (excluding vaporizer and neutralizer powers) were obtained for operation at specific impulses from 5000 to 8000 seconds. No damage due to primary ion impingement was detected in about 200 hours of running. Accelerator drain currents were typically less than 2 percent of the beam current. Computer studies indicated an accelerator electrode lifetime in excess of 20,000 hours. Experimental data verified the computer predictions for electrostatic beam deflection up to about 15°. This deflection produced a component of thrust normal to the center plane of up to 30 percent of the total thrust of an undeflected beam. Author

N68-21679*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STABILIZING EFFECTS OF SEVERAL INJECTOR FACE BAFFLE CONFIGURATIONS ON SCREECH IN A 20,000 POUND-THRUST HYDROGEN–OXYGEN ROCKET

Ned P. Hannum, Harry E. Bloomer, and Ralph R. Goelz Washington Apr. 1968 41 p refs

(NASA-TN-D-4515) CFSTI: HC$3.00/MF$0.65 CSCL 21H

Experimental tests were conducted to assess the worth of injector face baffles as screech suppression devices. Seventeen injector face baffle configurations were evaluated with 94 hot firings. The number of injector face baffle compartments was varied from 3 to 100 with lengths from 1/2 to 2 inches (1.3 to 5.1 cm). Stability data were obtained at a chamber pressure of 300 pounds per square inch absolute and over a range of oxidant-fuel ratios of from 4 to 6. Hydrogen injection temperature was used to rate the stability of the various baffles. The baffle with the lowest self-triggering temperature was considered to be the most stable. The results indicate that injector face baffles 2 inches long produced acoustic stability to the minimum hydrogen injection temperature limit of the test facility with maximum compartment dimensions as large as 9.1 inches. Acoustic stability down to a hydrogen injection temperature of 55°R (31°K) could also be achieved with injector face baffles 1 inch in length when the maximum compartment dimension was less than 4 inches (10.2 cm). One of the configurations was, however, only marginally stable at the reduced temperature. Author

N68-22096*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OPTIMAL FINITE-THRUST TRANSFER BETWEEN PLANET APPROACH AND DEPARTURE ASYMPTOTES WITH SPECIFIED INTERMEDIATE ORBIT

Edward A. Willis, Jr. Washington Apr. 1968 59 p refs

(NASA-TN-D-4534) CFSTI: HC$3.00/MF$0.65 CSCL 22C

Optimal control and finite thrust aspects of the approach maneuver–planetocentric orbit–departure maneuver sequence at the destination planet of a round trip are studied. Solutions are developed for single maneuvers, and conditions for joining these into an optimal total trajectory are derived. Numerical results are presented for an elliptic parking orbit and typical asymptotic velocities and directions. It is shown that gravity losses and steering losses are not directly additive, low vehicle thrust to weight ratios are desirable, and trajectories with single-burn escape and capture maneuvers are usually advantageous. Author

N68-22272*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL EVALUATION OF 7.82-INCH (19.8-CM) DIAMETER THROAT INSERTS IN A STORABLE-PROPELLANT ROCKET ENGINE

Jerry M. Winter and Donald A. Peterson Washington Apr. 1968 47 p refs

(NASA-TM-X-1463) CFSTI: HC$3.00/MF$0.65 CSCL 21H

A total of 14 nozzle throat inserts of 7.82-inch diameter were evaluated for use with reinforced plastic thrust chambers. The propellants used were nitrogen tetroxide and a blend of 50 percent hydrazine with 50 percent unsymmetrical dimethyl-hydrazine. Primary failure mechanisms were determined for specific materials and design concepts. Detailed failure mechanisms were explored as a means of recommending material and design modifications to improve reliability and performance. Silicon carbide provided erosion protection for 100 seconds of continuous firing. However, both one-piece and segmented silicon carbide inserts failed structurally. Tungsten infiltrated with copper or silver had relatively high resistance to oxidation for approximately 250 seconds of run time. The copper-infiltrated insert was structurally sound after a firing duration of 340 seconds. Careful attention to substrate design and coating techniques appreciably increased the erosion resistance of coated inserts. A preferentially oriented pyrolytic graphite design was partly successful, but, to realize the full potential of this design, additional development work would be required. Only limited correlation between small- and large-size testing was obtained. However, the time to failure for large-scale monolithic inserts was extended over small-scale inserts. Author

N68-22725*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYSIS OF FAN-TURBINE EFFICIENCY CHARACTERISTICS IN TERMS OF SIZE AND STAGE NUMBER

Warner L. Stewart and Arthur J. Glassman Washington May 1968 19 p refs

(NASA-TM-X-1581) CFSTI: HC$3.00/MF$0.65 CSCL 21E

This report presents a study of fan-drive turbine geometry and efficiency interrelations both in generalized form in terms of specific speed and specific diameter and for a selected set of representative turbofan engine conditions. Results are presented in terms of turbine efficiency and diameter variations as a function of number of stages for a range of fan speeds. Also shown are the variations in engine specific thrust and specific fuel consumption as functions of fan-turbine efficiency for the selected engine conditions. Author

N68-23354*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

INVESTIGATION OF A NEARLY ISENTROPIC MIXED COMPRESSION AXISYMMETRIC INLET SYSTEM AT MACH NUMBERS 0.6 TO 3.2

Donald B. Smeltzer and Norman E. Sorensen Washington May 1968 152 p refs

(NASA-TN-D-4557) CFSTI: HC$3.00/MF$0.65 CSCL 21H

A 20-inch capture diameter model of a mixed-compression axisymmetric inlet system was designed and tested. The inlet system was 1.4 capture diameters long measured from the cowl lip to the engine face. The design Mach number was 3.0, and off-design performance was obtained by translation of the cowl. Vortex generators were employed just downstream of the throat to reduce the total-pressure recovery, and total-pressure distortion at the engine face. Tests were conducted over the Mach number range 0.6 to 3.2 at angles of attack from 0° to 8° and at a tunnel total pressure of 15 psia. The supersonic diffuser of the inlet was designed with the aid of a computer program which employs the method of characteristics. The subsonic diffuser was designed to have a linear variation of Mach number from the end of the throat to the engine face. Results indicated a level of performance at Mach number 3.0 of 90 to 93 percent total-pressure recovery at the engine face with a bleed mass-flow ratio of 7.5 to 12 percent and a total-pressure distortion level of about 10 percent. Author

N68-23477*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL INVESTIGATION OF MERCURY PROPELLANT FEED ISOLATORS FOR KAUFMAN THRUSTERS

Shigeo Nakanishi Washington May 1968 29 p refs

(NASA-TM-X-1579) CFSTI: HC$3.00/MF$0.65 CSCL 21C

Electrical breakdown voltages and leakage currents were experimentally determined for seven high-voltage isolator configurations designed for the mercury propellant feed system of a SERT II type Kaufman ion thruster. An isolator containing 40 insulated segments experienced no breakdown up to 5000 volts, but leakage current at 3000 volts was about 0.10 milliampere. A configuration utilizing a long propellent flow passage and large recombination surface areas operated at 3000 volts potential difference with a leakage current of less than 0.003 milliampere. Minimum breakdown voltage was 4400 volts. Author

N68-24614*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

STUDY OF UNDEREXPANDED EXHAUST JETS OF AN X-15 AIRPLANE MODEL AND ATTACHED RAMJET ENGINE SIMULATOR AT MACH 6.86

Earl H. Andrews, Jr. and R. Clayton Rogers Washington May 1968 refs

(NASA-TM-X-1571) CFSTI: HC$3.00/MF$0.65 CSCL 21H

An investigation was conducted using a 0.02-scale model of the X-15 airplane with a ramjet engine simulator attached to the underside of its afterbody. The investigation was initiated to approximate the effects of the ramjet exhaust plume upon the external pressures of a nozzle extension of an X-15 engine. The nozzle extension was tested with and without a simulated manifold designed to collect and to eject overboard auxiliary gases from the X-15 airplane. The presence of the ramjet and its pylon tended to cause the afterbody surface pressures on the X-15 airplane to remain constant and not be affected by underexpanded exhaust plumes of the X-15 and ramjet nozzles. The pressure-measuring station nearest the base of the X-15 afterbody did, however, experience an increase as the exit-to-ambient static-pressure ratio of the X-15 nozzle increased. Static-pressure measurements and schlieren photographs indicated that the ramjet nozzle exhaust plume initially impinged upon the nonblowing X-15 nozzle extension at very small ratios of ramjet nozzle-exit pressure to ambient static pressure of 8 and 12 for angles of attack of 0° and 3°, respectively. Upward forces on the X-15 nozzle extension caused by operation of the ramjet nozzle were approximated; the forces without the manifold ring were greater than those with the ring. Author

N68-25099*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MANAGEMENT OF CRYOGENIC PROPELLANTS IN A FULL SCALE ORBITING SPACE VEHICLE

Raymond F. Lacovic, Frederick C. Yeh, Steven V. Szabo, Jr., R. J. Brun, Andrew J. Stofan et al Washington May 1968 69 p refs

(NASA-TN-D-4571) CFSTI: HC $3.00/MF $0.65 CSCL 21H

The fourth and eighth Atlas–Centaur vehicles were launched to study cryogenic propellant management during coast. Kinetic energies imparted to the liquid hydrogen at first engine cutoff caused liquid motion within the hydrogen tank resulting in subsequent venting of liquid hydrogen rather than gaseous hydrogen. The vented liquid impinged on the vehicle causing it eventually to tumble out of control. Energy dissipators were installed on the hydrogen tank pressurization line and boost pump return flow lines. A balanced thrust hydrogen vent system was installed to reduce vehicle disturbances. A slosh baffle was installed in the hydrogen tank and a thrust schedule for propellant settling and retention was established. These modifications reduced the total kinetic energy at first engine cutoff from 200 foot-pounds (270 J) to less than 50 foot-pounds. Information obtained on heat inputs to the tank was used to establish the capability of the hydrogen vent system. Also, a thermal survey was made of the hydrogen tank ullage; this survey provided information on temperature stratification of the ullage gas. The flight demonstrated a practical method for control of a cryogenic propellant in a full-scale orbiting space vehicle. The method of propellant control established for the Centaur vehicle is applicable to any space vehicle having short-term storage of cryogenic propellants in space. Author

N68-26644*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SCREECH SUPPRESSION TECHNIQUES FOR ROCKET COMBUSTORS USING EARTH-STORABLE PROPELLANTS

David W. Vincent, Daniel E. Sokolowski, and Harry E. Bloomer Washington Jun. 1968 38 p refs

(NASA-TM-X-1595) CFSTI: HC $3.00/MF $0.65 CSCL 21H

A rocket investigation was conducted using N_2O_4/50 percent hydrazine 50 percent unsymmetrical dimethyl hydrazine propellants to determine the effects of injector faceplate baffles, concentrated injection distribution with divergent chamber geometry, nozzle entrance length, and injector-element radial coverage. Injector faceplate baffles and concentrated propellant injections were stabilizing. No stability effect was noted by increasing the nozzle entrance length. Creation of an element void at the circumference of an injector was destabilizing. Author

N68-26771*# McDonnell-Douglas Co., Long Beach, Calif. Aircraft Div.

A STUDY OF TURBOFAN-ENGINE COMPRESSOR-NOISE-SUPPRESSION TECHNIQUES

Alan H. Marsh, I. Elias, J. C. Hoehne, and R. L. Frasca Washington NASA Jun. 1968 182 p refs

(Contract NAS1-5256)

(NASA-CR-1056) CFSTI: HC $3.00/MF $0.65 CSCL 21E

Preliminary engineering designs of nacelle acoustical treatments applicable to operational jet transports have been studied. The treatments are intended to be used to suppress compressor noise, especially during the landing approach. Studies were limited to the P&WA JT3D turbofan engine series as installed on the Douglas DC-8 airplane; however, the principles developed are applicable to other installations as well. Concepts were investigated involving application of narrow-band resonators and wide-band acoustical absorbers to the walls of the fan-discharge and inlet ducts. The concept of choked engine inlets was also considered. Analytical aerodynamic studies and wind tunnel model tests evaluated inlets with lightbulb-shaped centerbodies to provide narrower duct dimensions, and increased surface area for the addition of acoustical treatment. Tests were run to determine the flow resistance and the normal-incidence acoustical impedance and absorption coefficient of various duct-lining treatment configurations. Author

N68-28112*# Bendix Corp., Southfield, Mich. Research Labs.

RESEARCH AND DEVELOPMENT OF A VORTEX VALVE FOR FLOW MODULATION OF A 16-PERCENT ALUMINIZED 5500°F PROPELLANT GAS

T. W. Keranen and A. Blatter Washington NASA Jun. 1968 137 p refs

(Contract NAS1-5199)

(NASA-CR-1091; Rept.-4227) CFSTI: HC $3.00/MF $0.65 CSCL 13K

The flow of hot (5500°F) gas from a solid propellant gas generator has been successfully throttled by a fluidic, no-moving-part, vortex valve. The vortex valve has been demonstrated in a system simulating a hot gas secondary injection thrust vector control (SITVC) system. The hot gas vortex valves were controlled by a pilot stage utilizing a flapper-nozzle and vortex amplifier valve arrangement which modulated the flow of a 2000°F pilot stage solid propellant gas generator. Materials found suitable for the 5500°F hot gas application consist of silver-infiltrated tungsten, carbon or silica phenolic and solid carbon. The development effort consisted of six hot gas firings which demonstrated satisfactory material selection, hot gas flow modulation, and steady-state and dynamic performance of a simulated SITVC system. Author

N68-29378*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYSIS OF SEVERAL METHANE-FUELED ENGINE CYCLES FOR MACH 3.0 FLIGHT

Brent A. Miller Washington Jul. 1968 36 p refs

(126-15-02-02-22)

(NASA-TN-D-4699) CFSTI: HC $3.00/MF $0.65 CSCL 21E

Several means of using methane's heat sink capacity for turbine cooling and for other purposes to improve engine specific impulse, specific thrust, and thrust per unit compressor frontal area were analyzed. Preheating of the methane with heat sources both internal and external to the engine was considered. In general, small gains in performance were obtained for the various cycles with respect to a reference turbojet cycle. No attempt was made to determine the weights of the various cycles considered. Author

N68-29953*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COLD FLOW INVESTIGATION OF A LOW ANGLE TURBOJET PLUG NOZZLE WITH FIXED THROAT AND TRANSLATING SHROUD AT MACH NUMBERS FROM 0 TO 2.0

Donald L. Bresnahan and Albert L. Johns Washington Aug. 1968 39 p refs
(NASA-TM-X-1619) CFSTI: HC$3.00/MF$0.65 CSCL 21E

The performance of a full length plug nozzle can be maintained at a high level by extending the outer shroud with increases in nozzle pressure ratio from 2.5 to the design pressure ratio of 26.3. During acceleration, maximum external flow effects occurred at Mach 1.5 with performance losses of approximately 2.8 percent. At subsonic cruise, this loss was about 4.8 percent. Plug truncations to one-half and one-third of its full length resulted in losses of 1 and 1.7 percent, respectively, at Mach 2.0. Base bleed of about 1.5 percent of the primary flow optimized the performance of the truncated plugs. Author

N68-30040*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
TURBOJET-ENGINE NOISE STUDIES TO EVALUATE EFFECTS OF INLET-GUIDE-VANE-ROTOR SPACING
John L. Crigler, W. Latham Copeland, and Garland J. Morris Washington Aug. 1968 32 p refs
(NASA-TN-D-4690) CFSTI: HC$3.00/MF$0.65 CSCL 21A

Experimental results are presented of a noise study which made use of a turbojet engine having an axial flow multiple stage compressor. The objective of this study was to investigate the effect of increased inlet guide vane–rotor spacing on the compressor interaction noise and engine performance, particularly at partial power conditions. The engine selected for this investigation was in the 2000-pound (8896-newton) thrust category and was readily modified by relocating the linlet guide vane assembly approximately six mean rotor blade chords ahead of the first stage rotor. The data are presented in the form of engine performance curves, noise radiation patterns, and frequency spectra. The data show that there is a substantial noise reduction due to the increased inlet guide vane–first stage rotor axial spacing. The reductions were as much as 14 dB for the condition of 80 percent rated rpm, the highest engine speed at which noise measurements were made. The noise reductions have been accomplished without any measurable loss in engine performance. Stationary components of the compressor which are exposed to pulsating flows are identified as sources of noise and are noted to have characteristic frequencies. Author

N68-30599*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE OF A WIND TUNNEL MODEL OF AN AERODYNAMICALLY POSITIONED VARIABLE FLAP EJECTOR AT MACH NUMBERS FROM 0 TO 2.0
Fred W. Steffen and John R. Jones Aug. 1968 35 p refs
(NASA-TM-X-1639) CFSTI: HC$3.00/MF$0.65 CSCL 21E

A wind tunnel model of a variable flap ejector nozzle with an aerodynamically positioned shroud was evaluated over a range of Mach numbers from 0 to 2.0 at appropriate nozzle pressure ratios and statically at pressure ratios up to 26.0. Various power settings were simulated. Nozzle efficiency, pumping characteristics, boattail floating position, and boattail pressure drag were determined. The nozzle had typically high efficiencies at supersonic cruise and reheat acceleration conditions but rather low efficiency at subsonic cruise and dry acceleration conditions. The aerodynamically positioned shroud was stable at all simulated power settings and free stream Mach numbers. Author

N68-30604*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
M-1 INJECTOR DEVELOPMENT—PHILOSOPHY AND IMPLEMENTATION
Walter F. Dankhoff, Irving A. Johnsen, E. William Conrad, and William A. Tomazic Washington Aug. 1968 68 p refs
(NASA-TN-D-4730) CFSTI: HC$3.00/MF$0.65 CSCL 21H

The M-1 injector design was a cooperative effort to achieve high performance with completely stable operation. The approach was based on the technology already established in the RL-10 and J-2 engine development programs, supplemented with the latest data obtained at NASA–Lewis. Small scale tests were conducted to verify design concepts prior to incorporation into the full scale hardware. Full scale injector testing demonstrated that the design goals were achieved. Author

N68-31476*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TURBOJET AND TURBOFAN CYCLE CONSIDERATIONS AND ENGINE CONFIGURATIONS FOR APPLICATION IN LIGHTWEIGHT AIRCRAFT
Richard J. Roelke and Warner L. Stewart Washington Aug. 1968 17 p ref
(NASA-TM-X-1624) CFSTI: HC$3.00/MF$0.65 CSCL 21E

Engine studies were made to define cycle characteristics of small turbojet and turbofan engines for a selected set of lightweight aircraft flight requirements. From these cycle studies, representative engine conditions were selected and used as a basis for the examination of associated engine configurations. Emphasis was placed on the types of turbomachinery involved and their associated diameters. Author

N68-32987*# General Motors Corp., Indianapolis, Inc. Allison Div.
EXPERIMENTAL INVESTIGATION OF ADVANCED CONCEPTS TO INCREASE TURBINE BLADE LOADING. 2: PERFORMANCE EVALUATION OF PLAIN ROTOR BLADE
H. G. Lueders Washington NASA Aug. 1968 46 p refs
(Contract NAS3-7902)
(NASA-CR-1172; EDR-4909, V. 2) CFSTI: HC $3.00/MF $0.65 CSCL 21E

The overall performance of a single stage turbine designed with a rotor blade suction surface diffusion factor of 0.3 and negative rotor hub reaction was investigated over a range of equivalent speeds and expansion ratios. Total pressure surveys were made at the stator and rotor exits and a hot-wire survey was taken at the rotor trailing edge. The performance of turbine with this rotor-blade forms a base line that will be compared with advanced turbine blade loading comcepts. Author

N68-35101*# Northern Research and Engineering Corp., Cambridge, Mass.
ANALYSIS OF GEOMETRY AND DESIGN POINT PERFORMANCE OF AXIAL FLOW TURBINES. 1: DEVELOPMENT OF THE ANALYSIS METHOD AND THE LOSS COEFFICIENT CORRELATION
A. F. Carter, M. Platt, and F. K. Lenherr Washington NASA Sep. 1968 113 p refs
(Contract NAS3-9418)
(NASA-CR-1181) CFSTI: HC $3.00/MF $0.65 CSCL 21E

The development of a stream-filament analysis procedure is presented and a correlation of total-pressure-loss coefficients which forms the basis for a computer program with which the geometry and design-point performance of axial turbines is investigated. Since one of the principal features of the analysis procedure is the solution of the radial equilibrium equation taking into account radial gradients of enthalpy and entropy, the computer program based on this analysis will provide the turbine designer with the freedom to consider arbitrarily selected distributions of tangential velocities and radial distributions of work output as analysis variables. In addition, with the incorporation of a total-pressure-loss coefficient correlation, the computer program which results from the analysis can be used for a systematic investigation of the performance of alternative turbine designs for specified design requirements. Author

N68-35115*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
A SIMPLIFIED EQUILIBRIUM HYDROCARBON-AIR COMBUSTION GAS MODEL FOR USE IN AIR-BREATHING ENGINE CYCLE COMPUTER PROGRAMS
Vincent R. Mascitti Washington Sep. 1968 48 p refs
(NASA-TN-D-4747) CFSTI: HC$3.00/MF$0.65 CSCL 21A

Details are given on a simplified hydrocarbon–air combustion gas model, including the effects of dissociation for convenient use in engine cycle computer programs. The generalized model reduces to the hydrogen–air system as well as to the dissociating–air system. The exclusion of chemical species containing atomic nitrogen allows a considerable simplification of the composition equations. The thermodynamic properties of stoichiometric combustion of the kerosene–air and hydrogen–air systems are computed with the simplified model and compared with those of more comprehensive gas models. In addition, the effect of the neglected chemical species on the performance of an idealized subsonic combustion ramjet is presented. The simplified gas model has been used to define the limiting conditions for solid carbon and ammonia formation for fuel-rich gas mixtures. A computer program listing of the calculation procedure for the simplified gas model is presented. Author

N68-35594*# North American Rockwell Corp., Los Angeles, Calif.
ANALYSIS OF PERFORMANCE CHARACTERISTICS IN GROUND EFFECT OF A LARGE SCALE V/STOL MULTI-FAN-IN-WING TRANSPORT MODEL
R. J. Oberto, D. J. Renselaer, and D. L. Alfano Washington NASA Oct. 1968 130 p ref
(Contract NAS2-4352)
(NASA-CR-1180) CFSTI: HC$3.00/MF$0.65 CSCL 01C

Performance data obtained from static tests in ground effect of a large multi-fan-in-wing V/STOL transport model are described. The data include plots of propulsion systems performance, force and moment characteristics, and induced thermal conditions. Major test variables were height above ground plane, lift/cruise (L/C) nozzle angle, fan louver angle, fan speed, L/C engine power, and operations with L/C nozzles and fans in combination, L/C nozzles alone, and fans alone. Author

N68-35764*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STATIC PERFORMANCE OF AN AUXILIARY INLET EJECTOR NOZZLE FOR SUPERSONIC-CRUISE AIRCRAFT
George D. Shrewsbury and John R. Jones Washington Oct. 1968 41 p refs
(NASA-TM-X-1653) CFSTI: HC$3.00/MF$0.65 CSCL 21H

A model of an auxiliary inlet ejector nozzle was tested in the Lewis Research Center's static test facility over a range of nozzle pressure ratios of approximately 1.5 to 17. The model diameter was 33 cm. Secondary flows of from 0 to 10 percent of the primary nozzle flow were investigated. Configurations simulating takeoff, transonic acceleration, supersonic acceleration, and supersonic cruise were tested. The takeoff configurations were evaluated with and without noise suppressor chutes. Author

N68-36507*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CENTAUR LAUNCH VEHICLE PROPELLANT UTILIZATION SYSTEM
Steven V. Szabo, Jr., James A. Berns, and Andrew J. Stofan Washington Oct. 1968 35 p refs
(NASA-TN-D-4848) CFSTI: HC$3.00/MF$0.65 CSCL 21H

The development history, configuration, and operation of the Centaur propellant utilization system is described. The system used capacitance mass sensors to sense boiling liquid oxygen and liquid hydrogen in the propellant tanks. The system electronics utilized signal levels in the nanoampere range for control. The system operation was verified on nine Atlas-Centaur flights; end propellant residuals were controlled to less than 20 kilograms of liquid hydrogen out of a total tanked propellant weight of 13 600 kilograms. Author

N68-36512*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY TESTS OF A SINGLE-AXIS AMMONIA-RESISTOJET ATTITUDE CONTROL SYSTEM
Harold Ferguson, James S. Sovey, and Henry R. Hunczak Washington Oct. 1968 16 p refs
(NASA-TM-X-1677) CFSTI: HC$3.00/MF$0.65 CSCL 21H

Performance data are presented for an ammonia-resistojet attitude control system designed for use with stable platform type satellites in the 225- to 450-kg class. The system includes the fast-heatup thrusters (2 mN thrust), propellant storage and feed components, control logic, and power and signal conditioning. The ability of the system to acquire and maintain a soft limit cycle control mode within an attitude accuracy of ±0.2° was demonstrated. In particular, thruster performance was obtained which indicated that increased preheat time and pulse width cause significant decreases in propellant mass flow rate and thrust and an increase in specific impulse. Author

N68-36515*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF THRUST PER ELEMENT ON COMBUSTION STABILITY CHARACTERISTICS OF HYDROGEN OXYGEN ROCKET ENGINES
Reino J. Salmi, John P. Wanhainen, and Ned P. Hannum Washington Oct. 1968 30 p refs
(NASA-TN-D-4851) CFSTI: HC$3.00/MF$0.65 CSCL 21H

The results obtained with a series of 10.78-inch (0.27-m) coaxial INJECTORS ON A -!!))-pound (88 964-N) thrust oxygen-hydrogen rocket engine operated at a chamber pressure of 300 psia (2.064 MN/m^2) were analyzed to determine the effects of injector thrust per element T/E on the combustion stability. The thrust per element ranged from about 20 to 2500 pounds (88.96 to 11 120 N). Based on the minimum hydrogen temperature for stable combustion, the combustion stability increased with increasing thrust per element. No combustion instability was observed at a thrust per element of 200 pounds (889.6 N) or above. Bombing of the 572 and 1000 pound (2542 and 4448 N) T/E injectors failed to induce combustion instability. The hydrogen transition temperatures of the unstable injectors showed agreement with two different correlating parameters. Author

N68-36617*# Northern Research and Engineering Corp., Cambridge, Mass.
ANALYSIS OF GEOMETRY AND DESIGN POINT PERFORMANCE OF AXIAL FLOW TURBINES. PART 2: COMPUTER PROGRAM
M. Platt and A. F. Carter Washington NASA Oct. 1968 319 p refs
(Contract NAS3-9418)
(NASA-CR-1187) CFSTI: HC$3.00/MF$0.65 CSCL 21E

The computer program which has been developed to solve the equations governing flow in an axial turbine is examined. A complete description of the program, an indication of its usage, and sample results obtained from the program are included. The computer program follows directly from the analysis and the loss coefficient correlation which were developed previously. The program can be used to analytically investigate the effects of changes in the design variables. The variables include: number of stages, annulus geometry, work distribution, stage work split, radial distribution of stator exit whirl velocity or flow angle, radial variations of the meridional components of streamline slope and curvature, and blade element loss characteristics when values other than the internally computed total pressure loss coefficients are considered necessary for the analysis. The coefficients of the total pressure loss coefficient correlations are also input items and, therefore, can be used as analysis variables. Author

N68-37264*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF VARIABLE STATOR AREA ON PERFORMANCE OF A SINGLE STAGE TURBINE SUITABLE FOR AIR COOLING. 4: STATOR OVERALL PERFORMANCE WITH 70 PERCENT DESIGN AREA

Frank P. Behning, Bernard Bider, and Edward M. Szanca Washington Oct. 1968 18 p refs

(NASA-TM-X-1675) CFSTI: HC$3.00/MF$0.65 CSCL 21E

A program is being conducted to study a single stage turbine at stator area settings of 70, 100, and 130 percent of design. This report presents the overall stator performance at the closed setting and compares the results with those obtained from design tests. Results are presented in terms of mass flow, outlet flow angle, and blade surface static pressure and velocity distributions, as well as inner- and outer-wall static pressures as obtained over a range of stator pressure ratios. Author

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SPACE RADIATION

Includes cosmic radiation; solar flares; solar radiation; and Van Allen radiation belts. For related information see also: 13 Geophysics; and 24 Physics, Atomic, Molecular, and Nuclear.

N68-16008*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MCFLARE, A MONTE CARLO CODE TO SIMULATE SOLAR FLARE EVENTS AND ESTIMATE PROBABLE DOSES ENCOUNTERED ON INTERPLANETARY MISSIONS

Gerald P. Lahti, Irving M. Karp, and Burt M. Rosenbaum Washington Feb. 1968 55 p refs

(NASA-TN-D-4311) CFSTI: HC $3.00/MF $0.65 CSCL 03B

A computer program MCFLARE that uses Monte Carlo methods to simulate solar flare occurrences during an interplanetary space voyage is described. The total biological dose inside a shielded crew compartment due to the flares encountered during the voyage is determined. The computer program evaluates the doses obtained on a large number of trips having identical trajectories. From these results, a dose D_p having a probability p of not being exceeded during the voyage can be determined as a function of p for any shield material configuration. The user of the code selects any number of solar flares considered to be representative of the ones that will occur during future solar active periods. The flares are assumed to occur randomly during these periods. The dose at a distance of 1 astronomical unit (1.496×10^8 km) from the Sun from each of these flares behind any shield configuration investigated is input to the MCFLARE code. The code accounts for the dependence of the dose received from a flare on the distance from the Sun according to a $(1/r)^{\alpha}$ variation, where r is the distance from the Sun and the exponent α can be assigned any integral value including zero. To illustrate the use of the code, a trip to Mars and return is calculated, and estimated doses behind several thicknesses of aluminum shield and water shield are presented. A FORTRAN IV listing, data input instructions, and sample output are given. Author

N68-16837*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

AN ANALYSIS OF ENERGETIC SPACE RADIATION AND DOSE RATES

M. O. Burrell, J. J. Wright, and J. W. Watts Washington Feb. 1968 63 p refs

(NASA-TN-D-4404) CFSTI: HC $3.00/MF $0.65 CSCL 03B

Presented is a compendium of the environmental data on trapped and untrapped radiation. It considers the calculated tissue dose rates received from these radiations and the induced secondary radiation behind various shield thicknesses. Energetic radiation, as used here, refers to particles with energies greater than about 0.5 MeV. The results should be of practical value for preliminary analysis of the radiation hazard to man during space flight. Author

N68-19188*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CALCULATIONS OF SOLAR PLASMA INTERACTION WITH MAGNETIC FIELD OF CURRENT LOOP AND TWO PARALLEL INFINITE LINES OF CURRENT

Daniel J. McKinzie, Jr. and Anthony L. Julius, Jr. Washington Mar. 1968 28 p refs

(NASA-TN-D-4304) CFSTI: HC $3.00/MF $0.65 CSCL 03B

An investigation was made of the forces resulting from the interaction of the unconfined magnetic field emanating from a space vehicle with the undisturbed solar wind. The integrated theoretical drag per unit area and the acceleration of a circular current loop exposed to the solar wind at zero degree angle of incidence were determined. Also, the integrated theoretical drag and lift per unit area, the restoring moment per unit area per unit length of span were determined for the case of two parallel infinite lines of current at a 45° angle of incidence. For the case of the current loop, the drag per unit area varied over a range of proton number densities from 10^6 to 10^8 particles per cubic meter and a magnetic field parameter from 10^{-4} to 10^{-2} tesla. An examination of the particle fluxes from a major solar flare showed it to have a negligible effect on the drag when compared with that from the solar wind. Accelerations were calculated for a hypothetical superconducting coil (hollow torus) that had a permanent unconfined magnetic field. For the case of the two parallel infinite lines of current at a 45° angle of incidence, the lift to drag ratio was approximately 1 to 6.8. Author

N68-21731*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

CALCULATIONS OF NON-DIFFUSE INFRARED RADIATION FROM THE LUNAR SURFACE INCIDENT ONTO A UNIT ELEMENT ABOVE THE SURFACE

James K. Harrison Washington Apr. 1968 38 p refs

(NASA-TM-X-1567) CFSTI: HC $3.00/MF $0.65 CSCL 03B

This report presents the results of calculations of the thermal radiation from the lunar surface incident onto a flat surface of unit area located a small distance above the moon. The orientation and height of the flat surface vary. The thermal radiation from the moon's surface is assumed to be non-diffuse. The calculations show that the thermal energy flux incident onto the flat surface can differ significantly for a lunar surface that emits radiation in a non-diffuse manner when compared to a lunar surface that emits in a diffuse manner. Author

N68-22849*# Boeing Co., Seattle, Wash.

STUDY OF RADIATION HAZARDS TO MAN ON EXTENDED MISSIONS

S. B. Curtis and M. C. Wilkinson Washington NASA May 1968 89 p refs

(Contract NASw-1362)

(NASA-CR-1037) CFSTI: HC $3.00/MF $0.65 CSCL 06R

This study attempts to identify the particle types and energies which are important in the evaluation of the radiation hazard on long manned missions outside the magnetosphere. Important areas where information is presently lacking are identified. Spectra of the various components of the galactic cosmic radiation have been compiled from experimental data gathered during the period of minimum solar activity. These spectra, as well as typical solar particle spectra, have been used to determine depth-dose curves and differential particle and dose spectra behind typical shielding thicknesses. From this analysis, the important energies for various thicknesses and various spectra have been determined. In general, low energy particles (below 100 MeV) appear to be the most important at the dose point in solar particle events. From the biological standpoint, very low energy particles are important only for very steep spectra. The high energy heavy component of the galactic cosmic rays is of considerable importance for thin shielding and it appears that low energy heavy particles may continue to be important at thicker shielding, although secondary production data are not available for a thorough analysis. Author

N68-25181*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

EXTERNAL AERODYNAMICS OF THE MAGNETOSPHERE

John R. Spreiter, Alberta Y. Alksne, and Audrey L. Summers Washington June 1968 73 p refs Presented at the Summer Inst. for Phys. of the Magnetosphere, Chestnut Hill, Mass., 19–28 Jun. 1967

(NASA-TN-D-4482) CFSTI: HC$3.00/MF$0.65 CSCL 04A

A unified basis for the entire discussion is provided by the equations of magnetohydrodynamics, augmented by relations from kinetic theory for certain small scale details of the flow. While the full complexity of magnetohydrodynamics is required for the formulation of the model and the establishment of the proper conditions to apply at the magnetosphere boundary, it is shown that the magnetic field actually experienced in space is usually sufficiently small that an adequate approximation to the solution can be obtained by first solving the simpler equations of gasdynamics for the flow and then using the results to calculate equations of gasdynamics for the flow and then using the results to calculate the deformation of the magnetic field. Numerous specific results are presented, including those for conditions in the solar wind, the shape of the magnetosphere boundary, and the flow and magnetic fields around the magnetosphere. The calculated results are compared with data obtained by numerous spacecraft, including Explorer 12, IMP-1, Pioneers VI and VII, and the Vela satellites. Author

N68-25818*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ELECTRICAL CHARACTERISTICS OF A DC COMPACT ARC IN ARGON FROM 1 TO 10 ATMOSPHERES AND FROM 600 TO 1200 AMPERES

Arthur J. Decker and Gary C. Goldman Washington, D. C. Jun. 1968 9 p refs

(NASA-TM-X-1596) CFSTI: HC$3.00/MF$0.65 CSCL 20I

Voltages across an arc have been measured in argon in the pressure range of 1 to 10 atmospheres (10^5 to 10^6 N/m^2), the current range of 600 to 1200 amperes, and with electrode separation varied from 1 to 2 inches (0.0254 to 0.0508 m). These measurements are summarized in the form of the empirical formula $V=12.4(LP)^{2/3}-1.18\ P^{2/3}+0.0116\ I+11.7$ expressing arc voltage V as a function of arc current I in amperes, electrode separation L in inches, and pressure P in atmospheres, or $V=6.67\times10^{-2}(LP)^{2/3}-5.48\times10^{-4}\ P^{2/3}+0.0116\ I+11.7$ where V is in volts, L is in meters, P is in newtons per square meter, and I is in amperes. Author

N68-25880*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

POLAR CAP ABSORPTIONS AND ASSOCIATED SOLAR TERRESTRIAL EVENTS THROUGHOUT THE 19TH SOLAR CYCLE

Yukio Hakura (NAS) Washington Jun. 1968 28 p refs

(NASA-TN-D-4473) CFSTI: HC$3.00/MF$0.65 CSCL 04A

Solar cycle variations in the emission of high-energy particles from the sun are examined, by using daily Polar Cap Absorption (PCA) indices, selected solar-terrestrial events, and satellite observations of low-energy solar protons. A close relationship between PCA's and type IV solar radio outbursts existed throughout the last solar cycle. The solar corpuscular activity showed three peaks in 1957, 1960, and 1963. The first peak is characterized by a random occurrence of type IV outbursts, PCA's and geomagnetic SSC's (geomagnetic storms with sudden commencement). Active centers were restricted in two parts of narrow heliographic longitudes during the second, the most prominent peak, giving a slight 27-day recurrence to the corpuscular activity. Finally, a pronounced peak of 27-day recurrence appeared during the third period. A recurrent series of solar Mev protons lasted 15 solar rotations, while those of geomagnetic Kp index and galactic cosmic ray intensity lasted 25 rotations. Author

N68-26128*# National Aeronautics and Space Administration, Washington, D. C.

PROTECTION AGAINST SPACE RADIATION

Arthur Reetz, Jr., ed. and Keran O'Brien, ed. 1968 627 p refs Proc. of the Spec. Sessions on Protect. against Space Radiation at the 13th Ann. Meeting of the Am. Nucl. Soc., San Diego, Calif., 11–15 Jun. 1967

(NASA-SP-169) CFSTI: HC$3.00/MF$0.65 CSCL 18F

Conference papers are presented on the basic interaction and transport of space radiation in materials, methods for space radiation shield penetration calculations, spacecraft shield design, and advanced shielding concepts for spacecraft. For individual titles see N68-26129–N68-26153.

N68-33370*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

EXPERIMENTAL TESTS OF THE SUPERNOVAE ORIGIN OF COSMIC RAYS

C. E. Fichtel and H. B. Ogelman Washington Sep. 1968 21 p refs

(NASA-TN-D-4732) CFSTI: HC$3.00/MF$0.65 CSCL 03B

The general problem of supernovae explosions as a possible origin of cosmic rays is reviewed. The shock wave theory of Colgate et al., the only detailed model of supernovae explosions to date, predicts a short, intense high energy gamma-ray pulse associated with the explosion and cosmic ray acceleration. Two experimental tests capable of detecting the predicted initial explosion are suggested. One is a spark-chamber gamma-ray telescope which, when flown above the earth's atmosphere, could detect pulses of protons above 30 mev. The other experiment, which is ground-based, could detect the fluorescence produced in the atmosphere by the electromagnetic pulse radiated by the supernova during its explosion. Author

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SPACE SCIENCES

Includes astronomy and astrophysics; cosmology; lunar and planetary flight and exploration; and theoretical analysis of orbits and trajectories. For related information see also: 11 Facilities, Research and Support; and 31 Space Vehicles.

N68-10164* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

TABULATED COMMUNICATION CHARACTERISTICS OF A STEADY-STATE MODEL OF INTERPLANETARY SPACE

Ronald J. Hruby, Austin H. Somes, John Dimeff, and Howard Tashjian Washington NASA 1967 526 p refs

(NASA-SP-3042) CFSTI: $3.00 CSCL 03B

The changes in an electromagnetic wave as it passes through interplanetary and coronal space depend on the intervening plasma and magnetic fields. These changes are presented as a function of the transmission range and the view angle relative to the earth–sun line in the ecliptic plane. This information can be used to determine the total change in an electromagnetic wave between any two points in the earth–sun volume excluding the magnetosphere. Models for the electron density, the magnetic fields, and the solar wind were derived from the best available estimates and experimental data. Tabulated data are derived from a steady-state model of the coronal space corresponding to a simplified quiet sun. The spiral pattern of the magnetic field model is considered to have no disordering effects, and the model of the electron density is a function of solar radial distance only. The interplanetary space is considered to be a neutral plasma with equal densities of electrons and protons. Communication between any two points within the earth's orbit and in the ecliptic plane can be analyzed from the tabulated data. Author

N68-11145*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

THREE BALLISTIC CAMERA DATA REDUCTION METHODS APPLICABLE TO REENTRY EXPERIMENTS

John E. Hogge Washington Nov. 1967 42 p refs

(NASA-TN-D-4260) CFSTI: HC $3.00/MF $0.65 CSCL 22C

Ballistic cameras were used to photograph a reentry test object against a star background in order to determine accurately the position, velocity, and deceleration of the object as it penetrates the earth's atmosphere. Three data reduction methods which are applicable to the determination of the reentry trajectories from the photographic records are discussed. One reduction method applies when the reentry image on each photographic plate can be approximated with a straight line. Another method applies when the reentry image is curved on each photographic plate. A third technique applies when the shutter of each of several cameras at different stations is synchronized in time. Author

N68-11369*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

INVESTIGATIONS IN HANSEN'S PLANETARY THEORY

Peter Musen Washington Nov. 1967 24 p refs

(NASA-TN-D-4169) CFSTI: HC $3.00/MF $0.65 CSCL 03C

The geometrical characteristics of Hansen's planetary theory favor the expansion of perturbations in terms of the disturbed mean anomalies of the auxiliary planets. This eliminates the need to expand the disturbing force and speeds up the convergence of series representing Hansen's coordinates. An economy is achieved on the expansions of odd negative power of the mutual distances. There is no need to form the derivatives of the first and higher orders of the disturbing function relative to the pseudo-time. Hansen's theory is more intimately connected with perturbations in the rectangular coordinates than with perturbations of the elements. For this reason, direct use is made of the differential equations of motion in rectangular coordinates relative to an inertial frame of reference. Hansen had to introduce the perturbations of the third coordinate by combining the direct kinematical considerations with the method of variation of constants. Hansen's W-function is not used because of the way the operations with periodic series are performed on electronic machines. However, the $\overline{W}$-function is retained because it is intimately connected with determining perturbations in the mean anomaly and with forming the integrating operators. R.N.A.

N68-11456*# National Aeronautics and Space Administration, Washington, D. C.

INTERSTELLAR GRAINS

J. Mayo Greenberg, ed. and T. P. Roark, ed. 1967 275 p refs Presented at Rensselaer Polytech. Inst., Troy, N. Y., 24–26 Aug. 1965

(NASA-SP-140) GPO: $1.25 CSCL 03B

Conference papers on observational and theoretical interpretations of interstellar grains are presented. The principal issues are identified as being the following: uniformity of the ratio of total to selective extinction; dielectric grains versus graphite or graphite core plus dielectric mantle grains; variations of the reddening law and of the wavelength dependence of polarization and their respective relations with localized phenomena and the problems of galactic structure; formation of interstellar molecules, mainly OH and H_2; diffuse interstellar lines; and the physics and chemistry of grain nucleation and growth. Discussions following the papers are also included. N.E.N.

N68-11630*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex..

AN EVALUATION OF THE THERMALLY RADIANT ENVIRONS OF A MAN ON THE LUNAR SURFACE

David H. Perel and Alan J. Chapman Washington Nov. 1967 72 p refs

(NASA-TN-D-4243) CFSTI: HC $3.00/MF $0.65 CSCL 03B

Analytical methods were developed for determining the quantities of radiative thermal energy to provide a quantitative evaluation of the effects of the lunar thermal environment on a pressure-suited man. Evaluations were limited to lunar plains. A multicylinder man and a hemisphere-cylinder man were considered in the analysis. While emphasis was placed on the evaluation of

quantities of thermal radiation from the lighted side of the moon, the radiation on the dark portion was also considered and illustrated. The results of the investigation are presented in parametric form to allow the solution of specific problems over a wide range of variables. Author

N68-11754*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
A GENERAL ANALYTICAL METHOD FOR ARTIFICIAL-SATELLITE LIFETIME DETERMINATION
Frank Garcia, Jr. Dec. 1967 27 p refs
(NASA-TN-D-4281) CFSTI: HC $3.00/MF $0.65 CSCL 22A

An expression for obtaining the lifetimes of artificial satellites in circular orbits is developed. A complete derivation of the method is presented to allow the user to evaluate its assumptions according to specific needs. The accuracy of the developed method is verified using Earth and Mars as examples and comparing the results to the results obtained from numerically integrated and approximate analytical trajectories. Characteristic altitude histories are presented for the trajectory methods and the described analytical solution. Expressions for computing lifetimes of elliptical orbits are also included, with the necessary graphical presentations to provide rapid solution of these expressions. Author

N68-14089*# North American Aviation, Inc., Downey, Calif.
GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 3: THE TWO-BODY PROBLEM
G. E. Townsend and M. B. Tamburro Washington NASA Jan. 1968 87 p refs
(Contract NAS8-11495)
(NASA-CR-1002; SID-65-1200-3) CFSTI: HC $3.00/MF $0.65 CSCL 22C

The approximate analysis of the motion of near-earth satellites, and/or the generation of precise trajectories via derivatives of an Encke formulation or via an osculating conic formulation, is the fundamental objective of this monograph. This objective will be achieved by developing the classical solution and modifying its form to assure that a completely deterministic solution is available. The two-body problem was one of the earliest problems in dynamics to be solved. Thus, the material to be presented does not represent the current status of a rapidly changing field on analysis as do some of the presentations in other monographs. Rather, the material is intended to express the results of these previous analyses, to express the observations regarding indeterminacies in the most commonly used form of the solution, and to provide alternate formulations of the motion to avoid the computational problems. In addition, this presentation is intended to function as a reference volume providing detailed tabulations of equations relating the most basic parameters of the motion and the dynamics. Author

N68-14941*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
GEMINI SUMMARY CONFERENCE
Washington 1967 335 p refs Conf. held at NASA. Manned Spacecraft Center, 1–2 Feb. 1967
(NASA-SP-138) CFSTI: HC $3.00/MF $0.65 CSCL 22B

Gemini program highlights are presented, and flight results are discussed in terms of space orbital maneuvering, extravehicular activities, operational experiences, and onboard experiments. For individual titles, see N68-14942 through N68-14962.

N68-15193*# North American Aviation, Inc., Downey, Calif.
GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 4: THE CALCULUS OF VARIATIONS AND MODERN APPLICATIONS
M. Mangad and M. D. Schwartz Washington NASA Jan. 1968 117 p refs
(Contract NAS8-11495)
(NASA-CR-1003; SID-65-1200-4) CFSTI: HC $3.00/MF $0.65 CSCL 22C

The discussions presented progress from the fundamental lemma to the Euler–Lagrange equations, to the transversality condition, to the incorporation of constraint equations, to other necessary conditions for extrema, to the problems of Bolza, Mayer and Lagrange, and finally to the bounded and unbounded control problems. In addition to providing the basis for formulating this class of problems, the monograph is intended to serve as a necessary introduction to subsequent discussions of the optimization problem. Author

N68-15484*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SIMULTANEOUS CORRECTION OF VELOCITY AND MASS BIAS IN PHOTOGRAPHY OF METEORS
C. D. Miller Washington Feb. 1968 74 p refs
(NASA-TR-R-280) CFSTI: HC $3.00/MF $0.65 CSCL 03A

An analysis was made to investigate the magnitude of the weighting factor, specifically for application to photographic meteor data. As a result, a revised factor was obtained to operate upon actual counts of photographic meteors within various classes of velocity to provide a correct ratio of counts for all velocities reduced to any given lower mass limit. An expression was derived theoretically for maximum effective exposure on the photographic plate produced by a meteor in terms of the original mass of the particle, its velocity relative to earth's atmosphere, and the angle of its path to the zenith. The expression for maximum effective exposure was tested and revised by application to 100 test meteors that were believed to have provided approximately uniform effective exposure density. The revised expression for maximum effective exposure was combined with a widely accepted equation for the influx rate of meteors of mass greater than a stated value to obtain approximately the desired weighting factor. The analysis indicated a large change in value of the exponent of velocity relative to earth's atmosphere in the weighting factor, namely, from -2 downward at least to -3.85 and possibly as low as -4.22. Author

N68-15683*# Planning Research Corp., Washington, D. C.
INTRODUCTION TO THE DERIVATION OF MISSION REQUIREMENTS PROFILES FOR SYSTEM ELEMENTS
NASA 1967 91 p refs
(Contract NASw-1032)
(NASA-SP-6503) CFSTI: HC $3.00/MF $0.65 CSCL 22A

The present report describes a methodology for deriving the mission requirements profiles of the subsystem and lower level hardware elements from the system profile. This methodology consists of: (1) identification of the parameters that relate the functions and operations of the lower elements to each specific function and operation of the overall system; (2) arrangement of the parameters in the order of their importance to that function and operation of the system (so that they can each be treated in accordance with the appropriate priority and allocation of resources); (3) resolution, through the selection and application of the most appropriate analytical or empirical techniques, of the influences of each parameter from the system level to the level of the element under consideration; (4) compilation of the parameters and their influences derived in this manner into the mission requirements profile for the element in question. The appendices to this document are devoted to the presentation of supplementary data regarding parameters and analytical techniques necessary for the implementation of the methology. Author

N68-15725*# Boeing Co., Seattle, Wash.
LUNAR ORBITER 3: PHOTOGRAPHY
Washington NASA Feb. 1968 128 p
(Contract NAS1-3800)
(NASA-CR-984; D2-100753-2, V. 2) CFSTI: HC $3.00/MF $0.65 CSCL 22A

A description of Mission III planning, its conduct with respect to photography, and an analysis of the photographic results are presented. Data pertinent to analysis and interpretation of the photographs are included. The telephoto coverage provided resolution equivalent to 1 meter from a nominal altitude of 46 kilometers. In addition to normal near-vertical photography, photographs were obtained with convergent telephoto stereo coverage. Oblique-angle photography was employed to enhance interpretation of topographic features, to provide photographs of areas beyond the field of view of a vertical camera orientation, and to investigate photometric characteristics of the lunar surface. Operation of the cameras was satisfactory and high-quality photographs were obtained. By combining priority and final readouts, 82.8% of the planned primary-site, wide-angle coverage and 70.3% of the telephoto coverage was obtained. Author

N68-15741*# North American Aviation, Inc., Downey, Calif.
GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 6: THE N-BODY PROBLEM AND SPECIAL PERTURBATION TECHNIQUES
M. S. Allione, A. L. Blackford, J. C. Mendez, and M. M. Whittouck
Washington NASA Feb. 1968 122 p refs
(Contract NAS8-11495)
(NASA-CR-1005; SID-65-1200-6) CFSTI: HC $3.00/MF $0.65 CSCL 22C

The analytical formulations and the numerical integration methods available for the solution of the n-body problem are discussed. For large pertubative accelerations which are changing rapidly, the Cowell method of mathematical formulation is preferred. For phases of the flight where the force field is nearly conservative and/or nearly central with respect to the body, either Encke's method or the variation of parameters is recommended. Multistep predictor–corrector methods are considered to be significantly more efficient than other numerical integration techniques. The Gauss–Jackson method is suggested for general application, with the Adams–Moulton predictor–corrector method as a close alternate. The Lanczos and Nordsieck methods are classified as new and promising. The single-step Runge–Kutta method is considered desirable in some cases due to its stability. The Runge–Kutta method is also recommended as a starter for the multi-step methods. N.E.N.

N68-15748*# National Aeronautics and Space Administration, Washington, D. C.
SIGNIFICANT ACHIEVEMENTS IN SPACE SCIENCE 1966
1967 224 p refs
(NASA-SP-155) GPO: $1.50 CSCL 03A

Scientific and technological advances are reported for the areas of space astronomy and bioscience, ionospheres and radio physics, particles and fields, planetary atmospheres and planetology, and solar physics. Considered to be among the year's highlights are the soft landing of Surveyor I and the photographs obtained by Lunar Orbiters I and II. Special mention is made of Explorer XXXIII's extended flight, the upper atmospheric data obtained by Explorer XXXII, and the interplanetary measurements taken by Pioneer VII in heliocentric orbit. N.E.N.

N68-15793*# National Aeronautics and Space Administration, Manned Spacecraft Center, Houston, Tex.
A COMPUTER PROGRAM FOR CALCULATING MODEL PLANETARY ATMOSPHERES
David E. Pitts Washington Feb. 1968 63 p refs
(NASA-TN-D-4292) CFSTI: HC $3.00/MF $0.65 CSCL 03B

The computer program presented here enables calculations to be made of a model atmosphere of a planet to one planetary radius above the surface. The variables calculated are altitude, temperature, pressure, density, specific weight, molecular weight, pressure scale height, density scale height, number density, mean particle velocity, mean free path, collision frequency, speed of sound, coefficient of viscosity, kinematic viscosity, and columnar mass. The calculations are usually made for atmospheres consisting of nitrogen, carbon dioxide, oxygen, argon, neon, hydrogen, helium, water vapor, carbon monoxide, and sufur dioxide. However, if the printouts of mean free path, collision frequency, coefficient of viscosity, and kinematic viscosity are ignored, calculations may be made for gases of any desired molecular weight. Author

N68-15891*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
SUMMARY OF GEMINI EXTRAVEHICULAR ACTIVITY
Reginald M. Machell, ed. Washington 1967 336 p refs
(NASA-SP-149) CFSTI: HC $3.00/MF $0.65 CSCL 22A

The actual systems employed, the testing and qualifications of these systems, the preparation of the flight crews, and the operational and medical aspects were described from a developmental viewpoint. During the Gemini program, the basic feasibility of extravehicular activity was established. Other significant results were: (a) demonstration of retrieval of equipment from within the spacecraft adapter and from another satellite, (b) establishment of requirements for handholds, foot restraints, and body restraints, (c) evaluation of the dynamics of motion on a short tether, (d) preliminary evaluation of a hand held maneuvering device, (e) demonstration that the extravehicular workload could be maintained within the limits of the life support system and the capabilities of the pilot, and (f) demonstration that underwater zero-g simulation was valid in solving body restraint problems and in assessing workloads. The most significant limitations were the inability to perform extravehicular tasks without the proper body restraints, the mobility restrictions imposed by the design of the space suit, and the limited cooling capacity of life support systems using gaseous cooling. Recommendations are made for development of future extravehicular operations. Author

N68-16103*# North American Aviation, Inc., Downey, Calif.
GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 1: COORDINATE SYSTEMS AND TIME MEASURE
M. B. Tamburro, A. S. Abbott, and G. E. Townsend Washington NASA Feb. 1968 115 p refs
(Contract NAS8-11495)
(NASA-CR-1000; SID-65-1200-1) CFSTI: HC $3.00/MF $0.65 CSCL 22C

A complete description of a coordinate measuring system to determine particle position and velocity is given. Emphasis is placed on the coordinate frameworks utilized for trajectory problems and body oriented axis systems. Developed is a mathematical model that derives the equations of motion from the fundamental reference system of the moon orbit around the earth and finds solutions to yield the nutation and precession corrections to the basic reference frame. Finally, discussed are time standards employed in astronomical studies for the purpose of relating the rotating coordinate systems to measurements of celestial spheres. G.G.

N68-16750*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
PHOTOMETRY OF AN IRON ARTIFICIAL METEOR REENTERING AT 11 KILOMETERS PER SECOND

J. B. Robertson and Wendell G. Ayers Washington Feb. 1968 27 p refs
(NASA-TN-D-4312) CFSTI: HC $3.00/MF $0.65 CSCL 22A

A man-made meteor was successfully produced in March of 1966 by reentering into the atmosphere a 5.7-gram steel pellet at 10.85 km/sec with a six-stage, solid-fuel Trailblazer II vehicle, the last stage of which was an explosive accelerator. The meteor was photographed with a system of cameras and spectrographs. The luminous power of the meteor as a function of time was determined from the photographs with stars for calibration. The velocity and deceleration of the meteor were determined from photographs taken by cameras with chopping shutters. The luminous efficiency of the meteor was calculated from the luminous power and velocity data. The panchromatic luminous efficiency was $(4.0\pm0.8)\times10^{-3}$ and the blue sensitive luminous efficiency was $(2.1\pm0.4)\times10^{-3}$. A spectrogram of the meteor on blue sensitive film showed that the radiation produced by the meteor in the spectral region from 3800 Å to 5000 Å was predominately line radiation from neutral iron. A filter photograph indicated considerable radiation in the spectral region from 4900 Å to 6500 Å. A large portion of this radiation may have been produced by iron oxide. Author

N68-17215*# North American Aviation, Inc., Downey, Calif. Space and Information Systems Div.
GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 2: GUIDANCE EQUATIONS FOR ORBITAL OPERATIONS
G. E. Townsend, D. R. Grier, and A. L. Blackford Washington NASA Feb. 1968 121 p refs
(Contract NAS8-11495)
(NASA-CR-1010; SID-66-1678-3; V. 11) CFSTI: HC $3.00/MF $0.65 CSCL 22C

This monograph develops the mathematical formulations of the maneuver in orbit problem and presents solutions for analyzing space missions and the associated guidance process. This is accomplished by isolating those factors which affect the motion of a vehicle and by defining the optimum sequence of events required to produce the desired motion. The maneuvers are considered in two general classes. The first class, referred to as gross maneuvers, contains all of those corrective strategies in which the individual corrections are of such mangitude as to require that the nonlinear equations describing the maneuver be solved explicitly to obtain the required accuracy. The second class of maneuvers contains all of the corrective strategies which are sufficiently small to allow the nonlinear equations describing them to be expanded in a first order series in the neighborhood of a pre-selected nominal trajectory without adversely affecting the accuracy of the analysis. This class of maneuvers, referred to as differential corrections or midcourse corrections, is treated by progressing from a simplified guidance process to optimal control as measured by several loss functions. Examples of application are also given. K.W.

N68-19064*# National Aeronautics and Space Administration. *Ames Research Center, Moffett Field, Calif.*
LUNAR BEACONS: A PRELIMINARY LOOK AT THEIR POSITION ESTIMATION AND THEIR USE IN LUNAR ORBIT ESTIMATION
Thomas M. Carson Washington Mar. 1968 20 p refs
(NASA-TM-X-1529) CSCL 22A

In the estimation of a lunar orbit, various data sources could be used. This report considers the use of on-board range and range-rate measurements of lunar beacons as an addition to the normal use of range-rate measurements from earth-based stations. The analysis considers both the improvement of the orbit estimation and the estimation of the location of the lunar beacons. The orbit estimation and the estimation of the location of the Schmidt–Kalman filtering process was used for the estimation. Random errors in the measurements and bias errors in the station and beacon locations were considered. Results show that the addition of on-board measurements of lunar beacons to earth-based range-rate measurements contributes significantly in the estimation of the orbit and in the knowledge of the beacon locations. Author

N68-19186*# North American Aviation, Inc., Downey, Calif.
GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 12: RELATIVE MOTION, GUIDANCE EQUATIONS FOR TERMINAL RENDEZVOUS
D. F. Bender and A. L. Blackford Washington NASA Apr. 1968 97 p refs
(Contract NAS8-11495)
(NASA-CR-1011; SID-66-1678-4) CFSTI: HC $3.00/MF $0.65 CSCL 22C

This monograph is intended to present a discussion of the principles and techniques of accomplishing a rendezvous between two spacecraft. In the context here, rendezvous is considered as the interface between the midcourse corrections of an orbital transfer maneuver which establishes the two spacecraft on nearly identical orbits and the docking maneuver which results in the physical contact of the two spacecraft. First consideration in the discussion is given to the development of the equations of relative motion of the two vehicles. To facilitate the use in guidance scheme, these equations are developed in various coordinate systems, with several choices for the independent variables, and with several simplifying assumptions. Next, guidance schemes are developed based on these equations of motion. As each guidance scheme is presented, its existance is in some way justified and the relative advantages and disadvantages as compared to the other schemes discussed. With this discussion enough information is available so that the elements of a rendezvous guidance scheme can be constructed for a particular set of conditions in which a rendezvous maneuver is required. Author

N68-19192*# St. Louis Univ., Mo.
SUBSOLAR-MERIDIAN MEAN ANNUAL DISTRIBUTIONS FOR MARTIAN TROPOSPHERE BELOW 50 KILOMETERS
F. C. Bates Washington NASA Mar. 1968 51 p refs
(Grant NGR-26-006-016)
(NASA-CR-1043) CFSTI: HC $3.00/MF $0.65 CSCL 03B

Available observations of the Martian atmosphere were employed to estimate the composition of the homogeneous atmosphere and equivalent-mean-sea-level pressure. A mean-annual subsolar-meridian distribution of temperature, pressure and zonal-wind speed was then constructed for a depth of 50 km based on the foregoing estimates and: (1) a wave regime; (2) hydrostatic balance; (3) midlatitude scale height consistent with Mariner IV observation; (4) tropopause height varying from 30 km at the equator to 10 km at the pole; (5) mean jet-stream position at 45° latitude and 20 km; and (6) estimates from similarity to Earth and other rotating-fluid systems. These results were then extended to an estimate of wind and wind regimes, including secondary circulations such as extra-tropical cyclones and yellow-dust devils. Computations of heating rates in a ten-layer model were used to test soundings at several latitudes to determine required dynamic and/or advective compensation. Author

N68-19315*# North American Aviation, Inc., Downey, Calif.
GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 13: NUMERICAL OPTIMIZATION METHODS
J. E. McIntyre Washington NASA Mar. 1968 109 p refs
(Contract NAS8-11495)
(NASA-CR-1012; SID-66-1678-5) CFSTI: HC $3.00/MF $0.65 CSCL 22C

A monograph is presented on the second step in the optimization process, which generates numerical solutions. The three

fundamental numerical procedures—neighboring external, steepest-descent and quasilinearization—are presented, and their application to both classical and nonclassical problems are shown. Two numerical methods for locating the minimum value of a function are reviewed; an extrapolation of these methods into a function space leads to the three fundamental techniques for locating the minimum value of a functional. The step by step calculation procedure used in each of these techniques is given for the classical Mayer problem and nonclassical versions of the Mayer problem arising in modern trajectory and control applications. The relative merits of each technique are discussed, and it is shown that the iterative numerical procedures used for solving nonlinear optimization problems consist in approximating the problem by a succession of linear problems. B.S.D.

N68-19330*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

A FORTRAN PROGRAM FOR COMPUTATION OF MASS IN EARTH ORBIT REQUIRED FOR INTERPLANETARY MISSIONS

Samuel W. Pitts and Alfred C. Mascy Washington Apr. 1968 29 p ref

(NASA-TM-X-1541) CFSTI: HC $3.00/MF $0.65 CSCL 22A

A necessary parameter to be investigated in the analysis of space missions is the total assembled mass in Earth orbit, as it is a strong indicator in comparisons of the performance of various propulsion systems. The computer code described in this paper was designed to compute the mass in Earth orbit for round-trip stopover missions, flyby missions, and orbiter missions with a single-stage high-thrust system for each propulsive phase. The actual gravity losses suffered during each propulsive phase are computed by complete integration of the equations of motion, thereby permitting the propulsion system to be optimized. The program allows the input of planet ephemeris data so that it may be used for any planet. Author

N68-19590*# Wisconsin Univ., Madison.

ULTRAVIOLET DAYGLOW AND STELLAR BRIGHTNESS MEASUREMENT FROM THE X-15 AIRCRAFT

Lowell R. Doherty Washington NASA Mar. 1968 22 p refs

(Grant NsG-618)

(NASA-CR-1017) CFSTI: HC $3.00/MF $0.65 CSCL 03A

The design and operation of a two channel photometer used to obtain sky brightness data are described. These data were used in preparation for an airborne astronomical photography program using the X-15 aircraft. Four Nikon 35 mm camera bodies with motor driven film transport mechanisms were used for ultraviolet stellar photography. The optics consisted of a lens system in a barrel mount and a field flattener located immediately above the focal-plane shutter. A focal length of 108 mm was used. An interference filter was mounted in front of the lens as a limiting aperture, producing an f/5 system. A gyroscopic platform designed to provide a constant pointing direction within an rms fluctuation of one minute of arc supported the four cameras in a hatch behind the pilot's compartment. Four stars were identified on ultraviolet films taken on two flights, and daytime stellar brightness was calculated for these. E.J.S.

N68-19622*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

LINE-OF-SIGHT VELOCITY AS AN INDICATOR OF PERICYNTHION ALTITUDE OF SELENOCENTRIC ORBITS

James Lloyd Williams Washington Mar. 1968 18 p refs

(NASA-TM-X-1508) CFSTI: HC $3.00/MF $0.65 CSCL 22C

An investigation was made to determine the feasibility of using simplified equations to predict the pericynthion of a selenocentric orbit. It was assumed that the angular rate of the line of sight with respect to a prominent lunar surface feature was available for positions along a ballistic trajectory. The equations used were derived in terms of this variable by utilizing the linearized rendezvous equations and certain parameters of a circular selenocentric orbit. The procedure used in the evaluation of these equations was to calculate the pericynthion of selected reference Hohmann trajectories and to compare the values calculated by these equations with the known reference orbit values. The results of the computations indicate that the pericynthion altitude predicted by the approximate equations generally is not accurate, and that the predicted pericynthion altitude is very sensitive to the reference orbit altitude, to the times at which measurements of the rotation of the line of sight are made, and to the length of time between the measurements of the angular rate of line of sight. Author

N68-19676*# North American Aviation, Inc., Downey, Calif.

GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 2: OBSERVATION THEORY AND SENSORS

B. J. Miller and A. S. Abbott Washington NASA Mar. 1968 181 p refs

(Contract NAS8-11495)

(NASA-CR-1001; SID-65-1200-2, V. 2) CFSTI: HC $3.00/MF $0.65 CSCL 22C

Reported is a monograph which is designed to illustrate analytical methods used in the fields of guidance, flight mechanics, and trajectory optimization. Primary objectives are to present a comprehensive technical discussion of observation theory and sensors applicable to the navigation of boost and space vehicles. Discussed are the following: radiation theory and sensors; radiation sensing techniques; inertial theory and sensors; observation (state vector relationships); observation errors; state determination from evenly determined data; sensor requirements imposed upon a vehicle; and criteria for selecting observables to be measured. S.C.W.

N68-19985*# North American Aviation, Inc., Downey, Calif.

GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 14: ENTRY GUIDANCE EQUATIONS

M. B. Tamburro and E. F. Knotts Washington NASA Apr. 1968 149 p refs

(Contract NAS8-11495)

(NASA-CR-1013; SID-66-1678-6, V. 14) CFSTI: HC $3.00/MF $0.65 CSCL 22C

Theories proposed for entry guidance are summarized, and the ways in which they may be applied for a given vehicle mission combination are described. The basic entry performance interactions that must be considered when formulating a guidance system are examined, and a method of discerning between unacceptable and acceptable trajectories is introduced. Mathematical theories of entry guidance are derived in terms of paths for which closed-form solutions can be obtained, in terms of paths which are defined by a fast-time integration method, or in terms of controlling the vehicle in the neighborhood of a nominal trajectory known to exhibit desirable trajectory characteristics. The techniques used in the Gemini and Apollo entry guidance are reviewed. The point mass equations of motions are written in terms of vectors resolved in two noninertial coordinate systems, and approximate integrals of motion for various flight modes are formulated. Atmospheric models for entry performance and guidance studies are discussed. Supericircular and subcircular entry velocities are considered, and the factors involved in finalizing a guidance system are assessed. M.G.J.

N68-20084*# North American Aviation, Inc., Downey, Calif.

GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 7: THE PONTRYAGIN MAXIMUM PRINCIPLE

J. E. McIntyre Washington NASA Apr. 1968 129 p refs
(Contract NAS8-11495)
(NASA-CR-1006; SID-65-1200-7, V. 7) CFSTI: HC $3.00/MF $0.65 CSCL 22C

Pertinent concepts from the maxima–minima theory are reviewed, and some of the concepts used in the calculus of variations are examined. The similarity between the Pontryagin maximum principle and the calculus of variations is discussed, and it is pointed out that both lead to the same set of governing equations which the extremizing solution must satisfy. However, the maximum principle is considered to be a clearer and more concise statement of how the optimization is to be conducted, particularly when certain types of inequality constraints are present. The maximum principle is used to formulate and solve a variety of problems encountered in optimal trajectory and control analysis. The treatment includes both linear and nonlinear systems, and problems with control inequalities and state inequalities. Several comparisons and parallels are drawn with both the calculus of variations and the maxima–minima theory of the differential calculus. Special problems and applications warrenting additional investigation are cited, such as the singular arc problem and the optimization of stochastic systems. M.G.J.

N68-20192*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
RELATIVISTIC MODELS OF THE UNIVERSE WITH PRESSURE EQUAL TO ZERO AND TIME-DEPENDENT UNIFORMITY
Windsor L. Sherman and Sylvia A. Wallace Washington Apr. 1968 42 p refs
(NASA-TR-R-282) CFSTI: HC $3.00/MF $0.65 CSCL 03B

Previous work on the zero-density and approximate models of the universe is summarized. The zero-density model is improved so that it is a useful approximation of the exact model to greater values of the red shift, and regions of applicability of the approximate model are determined. Regions where closed-form solutions of the exact model exist, other than zero-density and zero-cosmical-constant models, are defined and the solutions are given. The results of calculations are presented that indicate, for the data considered, all the models, simplified and exact, appear to fit the data equally well even though there is wide variation in the density and acceleration parameters. In addition, the results of the calculations indicate that density and acceleration parameters should be determined as a pair from observational data. It is concluded that data consistent with that for galaxies at red shifts greater than one-half are required before a model universe can be selected and a simplified model defined. Author

N68-20353*# Johns Hopkins Univ., Baltimore, Md.
INFRARED OBSERVATIONS OF THE OUTER SOLAR CORONA
Robert M. MacQueen Washington NASA Apr. 1968 54 p refs
(Grant NGR-21-001-044)
(NASA-CR-969) CFSTI: HC $3.00/MF $0.65 CSCL 03B

The 2.2μ wavelength infrared outer solar corona was observed in two experiments: first, employing a ground-based telescope from a high altitude site near Pulacayo, Bolivia, during the 93 second totality of the eclipse of 12 November 1966; and second, employing a stratospheric balloon package with an infrared coronagraph, flown to an altitude of 28 km, during a 5.25 hour period, on 9 January 1967. The design and evaluation of the infrared balloon-borne coronagraph is discussed in detail, and the various origins of stray light investigated. The completed flight coronagraph was found to introduce a stray radiance of less than $3\times10^{-12}B_{\odot}$ where $B_{\odot}$ is the radiance of the mean solar disk at wavelength 2.2μ. During eclipse the corona was observed from $2R_{\odot}$ to $6R_{\odot}$ in the ecliptic plane, and at a single point perpendicular to the ecliptic at $5R_{\odot}$. Balloon observations covered the range $3.7R_{\odot}$ to $10R_{\odot}$ at position angles from 20° north to 40° south of the ecliptic, on the east limb of the sun. Author

N68-20356*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
A FAST METHOD OF ORBIT COMPUTATION
Karl Stumpff and E. H. Weiss (IBM, Greenbelt, Md.) Washington Apr. 1968 41 p refs
(NASA-TN-D-4470) CFSTI: HC $3.00/MF $0.65 CSCL 22C

The problem of rapidly computing trajectories of spacecrafts from their initial conditions has become very important. Classical methods rely almost exclusively on precise integration techniques, but results thus obtained are too slow over extended arcs, even on high-speed computers. Moreover, great accuracy is often unnecessary. Here we present a new method of computing approximate ephemerides of a small body (minor planet or artificial satellite). This method is 10 to 15 times faster than the well-known methods of Encke or Cowell. The errors are small (e.g., of the order of one part in a thousand) and the results converge to the N-body point-mass solution for small time steps. It is also possible to account for non-point-mass effects; this, however, has not yet been implemented. Author

N68-20368*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYTICAL CALCULATION OF PARTIAL DERIVATIVES RELATING LUNAR AND PLANETARY MIDCOURSE CORRECTION REQUIREMENTS TO GUIDANCE SYSTEM INJECTION ERRORS
Fred Teren and Gary L. Cole Washington Apr. 1968 39 p refs
(NASA-TN-D-4518) CFSTI: HC $3.00/MF $0.65 CSCL 22C

This report describes a simplified analytical method for calculating partial derivatives relating midcourse correction velocity requirements to injection errors resulting from guidance system errors for lunar and planetary missions. The analytical method uses two-body equations of motion to describe the reference transfer orbit. These equations are linearized to obtain partial derivatives relating changes in terminal state conditions to changes at injection and midcourse. The partial derivatives are then used to calculate the required correction velocity. The analytical equations are easily programmed on a digital computer and require very little computer time. The only input variables required are the position and velocity components at injection from a reference trajectory. The analytical partial derivatives are compared to exact partial derivatives obtained from a detailed N Body computer simulation. A comparison of results is presented for two lunar and five planetary missions. The error in the approximate results is found to be less than 14 percent for all cases simulated. Author

N68-20449*# North American Aviation, Inc., Downey, Calif.
GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 8: BOOST GUIDANCE EQUATIONS
G. E. Townsend, A. S. Abbott, and R. R. Palmer Washington NASA Apr. 1968 134 p refs
(Contract NAS8-11495)
(NASA-CR-1007; SID-65-1200-8) CFSTI: HC $3.00/MF $0.65 CSCL 22C

Near optimum steering equations were developed for boost vehicles, with the constraint that solutions must be possible in less than real time on the small digital computer used in the guidance system of boost vehicles. Approaches discussed are path adaptive or iterative guidance, explicit guidance employing guidance polynomials, and perturbation guidance. The iterative and perturbation guidance approaches have been or are currently being applied to boost vehicles, and detailed equations are presented in both cases. Because of numerical problems implicit in the preflight simulation

and construction of the coefficients of the polynomial, the third approach is not being considered for application. M.W.R.

N68-20450*# North American Aviation, Inc., Downey, Calif.
GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 9: GENERAL PERTURBATIONS THEORY
B. Kampos Washington NASA Apr. 1968 205 p refs
(Contract NAS8-11495)
(NASA-CR-1008; SID-66-1678-1) CFSTI: HC $3.00/MF $0.65 CSCL 22C

Solutions obtained by general perturbations techniques were studied for applications to mission analysis and inflight phases of space programs. Data on oblateness, atmospheric drag, extraterrestrial gravitation, and solar radiation pressure perturbations are reviewed; and detailed analyses are presented for some of these. Dominant perturbations for most earth satellites are discussed in terms of the earth's oblateness; and development of the atmospheric perturbation and satellite motion is considered. A scheme for approximating the net result of all these perturbating influences is presented, along with a mechanization to effect the solution that is based on the optimum formulations of each phase of the analysis. M.W.R.

N68-20468*# North American Aviation, Inc., Downey, Calif.
GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 16: MISSION CONSTRAINTS AND TRAJECTORY INTERFACES
R. L. Robertson Washington NASA Apr. 1968 128 p refs
(Contract NAS8-11495)
(NASA-CR-1015; SID-66-1678-8, V. 16) CFSTI: HC $3.00/MF $0.65 CSCL 22C

Launch, rendezvous, spatial, deorbit, and entry trajectory phases are considered for earth orbital missions in order to formulate the more important constraints required for a realistic mission. Details are considered for the launch window, range safety, and ascent trajectories during boost and for direct ascent, rendezvous compatible orbits, intermediate orbit rendezvous techniques, and terminal maneuver during rendezvous. Perturbation and lifetime, earth trace and coverage, lighting and eclipse geometry, and radiation aspects of the rendezvous trajectory are noted. The general deorbit maneuver is discussed, as is minimum energy/time deorbit, deorbit timing, and deorbit via intermediate orbit. Entry dynamics and entry heating are noted; and direct entry, lifting entry and equilibrium glide path, and maneuverability are considered. Recommended procedures are mentioned in light of the discussion on mission constraints and their relationship to trajectories. M.W.R.

N68-21077*# North American Aviation, Inc., Downey, Calif.
GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 10: DYNAMIC PROGRAMMING
A. S. Abbott and J. E. Mc Intyre Washington NASA Apr. 1968 155 p refs
(Contract NAS8-11495)
(NASA-CR-1009; SID-66-1678-2, V. 10) CFSTI: HC $3.00/MF $0.65 CSCL 22C

Basic concepts of dynamic programming are presented along with their applications to simple multistage decision processes related to guidance, flight mechanics, and trajectory optimization. The principle of optimality and optimal value functions are discussed, as are the optimization of stochastic systems and the treatment of terminal constraints. Details are included for the limiting process in dynamic programming; with attention to the recursive and Bellman equations, Lagrange and Bolza problems, linear problem with quadratic cost, and the Pontryagin maximum principle. M.W.R.

N68-21182*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
DETERMINING THE SPIN AXIS OF A SPINNING SATELLITE
F. O. Vonbun Washington Apr. 1968 11 p refs
(NASA-TN-D-4483) CFSTI: HC $3.00/MF $0.65 CSCL 22A

Spin axis, a unit vector, is determined for a spinning satellite using ground tracking information. Range rate information is found to be adequate for this purpose. The determination of the unit vector is necessary to check onboard sensors once the spacecraft is in orbit. In the case of a slight onboard malfunction, the spin axis could not be determined without this vector. Author

N68-21228*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LOW VARIABLE THRUST INTERPLANETARY TRAJECTORY DATA
Edward J. Nime and John S. Mac Kay Washington Apr. 1968 88 p refs
(NASA-TN-D-4431) CFSTI: $3.00 CSCL 22C

The Newton–Raphson algorithm method is used to generate a large number of low-thrust trajectories between Earth and the other planets in the solar system. These paths assume the use of an ideal, variable-thrust rocket that operates at constant jet power. Trajectories include planet flyby, or capture from Earth, and Earth flyby from the other planets. In all cases, the heliocentric travel angle is varied between 30° and 330° for seven different trip times. The data presented include the performance parameter and all the initial values needed to recompute the path. Several terminal conditions, such as velocity components for the flyby cases, are also included. Analytical techniques with numerical examples are presented which consider the application of the data to a variety of manned and unmanned missions and mission profiles. Author

N68-21231*# North American Aviation, Inc., Downey, Calif.
GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 15: APPLICATION OF OPTIMIZATION TECHNIQUES
A. S. Abbott and A. L. Blackford Washington NASA Apr. 1968 163 p refs
(Contract NAS8-11495)
(NASA-CR-1014; SID-66-1678-7) CFSTI: HC $3.00/MF $0.65 CSCL 22C

Trajectory and guidance problems encountered in space flight are discussed in the context of three optimization techniques applied to their solution—the Pontryagin maximum principle, the calculus of variations, and dynamic programming. In the problems considered, the formulation is simple enough to allow an analytic solution along with a more general formulation which requires a numerical technique. Although both the calculus of variations and the Pontryagin maximum principle are applied, it is pointed out that the two formulations yield the same results in terms of the equations to be solved and can be considered as different means of looking at one formulation of an optimization technique. While these two techniques lead to a set of first-order ordinary differential equations (for the Mayer-type problem), the application of dynamic programming leads to a set of partial differential equations. It is generally felt that on a theoretical level dynamic programming is not as strong or as applicable as the other two methods. However, the difference in approach could provide a different perspective to the structure of the problem. M.G.J.

N68-21442*# North American Aviation, Inc., Downey, Calif.
GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 17: GUIDANCE SYSTEM PERFORMANCE ANALYSIS

D. R. Grier Washington NASA Apr. 1968 221 p refs
(Contract NAS8-11495)
(NASA-CR-1016; SID-66-1678-9) CFSTI: HC $3.00/MF $0.65 CSCL 22C

A study of the methodology of system performance analysis which forms the principles and techniques of direct applicability in assessing guidance system performance and requirements; is reported. Methodology considered is directly applicable to a guidance system which is dependent upon particular mission considerations. Discussed are basic concepts of randomness and probability among which are considered: (1) Gaussian random variables, the multivariate Gaussian probability density function, and probabilities for Gaussian random vectors; (2) functions of random variables with particular emphasis on transformations of probability density functions and statistical moments of functions of random variables; (3) several particular functions of Gaussian random variables with emphasis upon the probability density functions and statistical moments; (4) several basic probability bounds which can generally be used to bound random variables when only lower order statistical moments are known; (5) several basic limiting theorems which generally concern the limiting behavior of sums of statistically independent random variables; (6) statistical property determinations with particular emphasis on estimating moments and examining the validity of assumptions concerning probability density functions; (7) the particular case of estimating statistical moments for Gaussian random variables; (8) basic methods of correlation and regression analyses; and (9) the use of confidence intervals and the method of hypothesis testing. S.C.W.

N68-21685*# North American Aviation, Inc., Downey, Calif.
GUIDANCE, FLIGHT MECHANICS AND TRAJECTORY OPTIMIZATION. VOLUME 5: STATE DETERMINATION AND/OR ESTIMATION
G. E. Townsend, D. R. Grier, R. R. Palmer, R. J. Ruggiero, and A. S. Abbott Washington NASA Apr. 1968 255 p refs
(Contract NAS8-11495)
(NASA-CR-1004; SID-65-1200-5) CFSTI: HC $3.00/MF $0.65 CSCL 22C

Attention is focused on the basic problem of generalizing precise information regarding the trajectory of an observed vehicle and the coefficients of the mathematical model used in the prediction from a set of observations made of the vehicle. The task of generating a reliable first approximation to the true trajectory is discussed, and optimum estimates of the deviation vector are developed. The development of simple measures of the degree of optimality in the estimator, and the generation of the estimation equations and estimation error for these measures are discussed. The classical least squares, weighted least squares, and minimum variance estimators are derived, and consideration is given to modern estimation in a recursive mode. Filter concepts are assessed and tailored to problems where the statistics involved are Gaussian, where the dynamics can be approximated by the linear model, and where the optimum estimator is a linear function of the deviations in the observables. Matrices relating the dynamics at various times relative to the nominal trajectory, and the matrix presenting the error data for the observables are derived. Recommendations for applying these data are made. M.G.J.

N68-21733*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
A HUMMINGBIRD FOR THE L_2 LUNAR LIBRATION POINT
F. O. Vonbun Washington Apr. 1968 15 p refs
(NASA-TN-D-4468) CFSTI: HC $3.00/MF $0.65 CSCL 22C

This paper concerns a spacecraft not in a circumlunar orbit, but in a quasi-permanent position in the vicinity of the far-side lunar libration point L_2. Such a spacecraft would be a useful communications relay between the back of the moon and the earth. It could be so placed above the libration point as never to be occulted, thus making the communication link a continuous one, independent of time. The spacecraft would be in the lunar gravitational field and thus need permanent thrust to stay in place or to move slowly around a point in space like a hovering hummingbird. This report shows analytically the accelerations in the vicinity of L_2 and the specific impulses needed to keep a spacecraft there economically with a reasonable fuel-to-mass ratio ($m_f/m_o = 0.05$ to 0.15). This dictates the kinds of engines needed for such missions, where constant, small accelerations are needed over the lifetime of a spacecraft (in the order of 1 to 3 years). Author

N68-21802*# National Aeronautics and Space Administration, Washington, D. C.
PHYSICS OF PLANETS
V. I. Moroz Apr. 1968 416 p refs Transl. into English of the publ. "Fizika Planet" Moscow, Nauka Press, 1967
(NASA-TT-F-515) CFSTI: HC $3.00/MF $0.65 CSCL 03B

Planetary physics deals with the physical characteristics of the planets and their satellites: the temperature of the planet surface and atmosphere; the composition, density and vertical structure (i.e., the altitude dependence of temperature, composition and density) of the atmosphere, the nature of the cloud layer, circulation of the atmosphere, the nature of the observable surface features and surface layer, and lastly, the internal structure. Author

N68-21864*# Heliodyne Corp., Van Nuys, Calif.
NON-LINEAR ORBIT DETERMINATION METHODS
Ali Hasan Nayfeh Washington NASA May 1968 43 p refs
(Contract NAS1-6690)
(NASA-CR-1040) CFSTI: HC $3.00/MF $0.65 CSCL 22C

A non-linear correction method for orbit determination using range, azimuth, and elevation data is presented and justified mathematically and numerically. In contrast with conventional methods, such as the least-squares, the maximum likelihood, and the Kalman, this method holds in the non-linear, as well as in the linear regions. Moreover, this method does not require transition and normal matrices and, hence, avoids the problems associated with calculating and inverting them. The convergence and accuracy of the method have been demonstrated by calculations made on simulated orbits with varying levels of noise. The calculations demonstrate that the proposed method is non-linear and can be used as an editing procedure because it converges despite the combined effect of very bad reference orbits, extremely high levels of noise, wild data points, and critical orbits. The calculations show also that the errors of the resultant epoch state vectors are indeed very small. Author

N68-22202*# Virginia Polytechnic Inst., Blacksburg.
TIME-OPTIMAL RENDEZVOUS FOR ELLIPTIC ORBITS
Y. Kashiwagi and K. T. Alfriend Washington NASA May 1968 125 p refs
(Grant NGR-47-004-006)
(NASA-CR-1036) CFSTI: HC $3.00/MF $0.65 CSCL 22C

Time-optimal rendezvous maneuvers are studied. The system considered in this report consists of two space vehicles namely, a target vehicle (non-maneuvering vehicle) and an interceptor vehicle (maneuvering vehicle) under the influence of the earth gravity. An interceptor vehicle has propulsive jet systems which can produce a variable thrust (positive or negative) independently in three perpendicular directions. The case where the target vehicle is in the elliptic orbit is mainly considered and some analytical difficulties involved in the circular orbit case are discussed. Several time-optimal trajectories for different configurations are shown. Author

N68-22289*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SOME NUMERICAL COMPARISONS OF THREE-BODY TRAJECTORIES WITH PATCHED TWO-BODY TRAJECTORIES FOR LOW THRUST ROCKETS

William C. Strack Washington May 1968 30 p refs

(NASA-TN-D-4559) CFSTI: HC$3.00/MF$0.65 CSCL 22C

The n-body problem for low-thrust vehicles with optimal thrust control is formulated for the case of constant thrust with coast. A successive two-body approximation to the n-body problem is also developed under the assumption of tangential thrust during the planetocentric leg. This approximation involves one arbitrary parameter—the planetocentric radius at the patch point—whose best value can be determined by comparison with n-body solutions. Numerical solutions of several three-body problems indicate that the patch radius should be about 300 earth radii for either a circular or a parabolic initial earth orbit. Author

N68-22860*# St. Louis Univ., Mo.

RADIATIVE HEATING AND COOLING FUNCTIONS FOR THE LOWER MARTIAN ATMOSPHERE UNDER THE CONDITION OF LOCAL THERMODYNAMIC EQUILIBRIUM (LTE)

Albert J. Pallmann Washington NASA May 1968 47 p refs (Grant NGR-26-006-016)

(NASA-CR-1044; Rept.-101) CFSTI: HC $3.00/MF $0.65 CSCL 03B

The physics of planetary radiation fields has been reexamined to derive formulas describing analytically the heating and cooling processes of the Martian atmosphere in local thermodynamic equilibrium (LTE). The computational algorithm required for the numerical solution of the radiative heating and cooling in the Martian atmosphere has been outlined. Spectral data for near and far IR CO_2 bands have been provided. A model was assumed for the Martian atmosphere in LTE, characterized by 100% CO_2, plane-parallel stratification, with no particulates embedded, scattering by molecules excluded, and neglecting the reflection of solar radiation at the ground. However, radiative equilibrium has not been assumed, because this assumption would have made the heating and cooling rates identically zero. The radiative transfer theory, its computational algorithm, and the spectral data of CO_2 and solar radiation for the Martian atmosphere, as presented in this paper, provide the means for computing the radiative heating and cooling rates for the atmosphere of Mars at any latitude, once the temperature sounding is given for the location. Author

N68-22885*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

ON THE APPLICATION OF SPINORS TO THE PROBLEMS OF CELESTIAL MECHANICS

Karl Stumpff Washington May 1968 44 p refs

(NASA-TN-D-4447) CFSTI: HC$3.00/MF$0.65 CSCL 03C

Since Newton, the stumbling-block in celestial mechanics was the three-body problem. Only restricted cases have yielded solutions. This paper describes a new tool for solving the perturbation problem—"spinors," a vectorial concept (in the complex plane) originally used in atomic physics but now applied to celestial mechanics. The two-body problem is discussed and two devices are introduced: "pseudo-time" and the Levi–Cività transformations. Then spinors are shown to make possible the extension of these transformations to three dimensions. Perturbation problems are discussed; notably a body moving around the sun and being acted on by the orbital motion of a major planet. Author

N68-24371*# National Aeronautics and Space Administration. Electronics Research Center, Cambridge, Mass.

THE EQUATIONS OF MOTION FOR OPTIMIZED PROPELLED FLIGHT EXPRESSED IN DELAUNAY AND POINCARE VARIABLES AND MODIFICATIONS OF THESE VARIABLES

William E. Miner Washington May 1968 79 p refs

(NASA-TN-D-4478) CFSTI: HC$3.00/MF$0.65 CSCL 22C

This document presents methods for developing the ordinary differential equations of motion in canonical form equivalent to the forms of Delaunay and Poincare. It also presents modifications to these forms so that three variables, which are constants of motion, result while the forms remain canonical. The equations of motion are for a vehicle propelled by constant thrust magnitude with a constant mass flow rate. The vehicle is moving in a central force field. The trajectories are optimum in the sense of classical calculus of variations in a neighborhood definable by the boundary conditions of the specific problem. Specific problems are not discussed in this document. The value of the document lies in two major areas: (1) The possible economics in numerical calculations which may result from using these ordinary differential equations, and (2) The application of the general perturbation theory of classical celestial mechanics to approximate solutions of these ordinary differential equations. Author

N68-24486*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

ASPECT DETERMINATION IN LUNAR SHADOW ON EXPLORER 35

Harold E. Taylor Washington May 1968 12 p refs

(NASA-TN-D-4544) CFSTI: HC$3.00/MF$0.65 CSCL 22A

The Explorer 35 spacecraft experiences a small, temporary secular decrease in spin period (approximately 2 parts in 1000) during every pass through the lunar shadow. Because of this, the pseudo-sun pulse, generated when the spacecraft is in the shadow, no longer accurately indicates the sunward direction. Details are given on an empirical method of fitting a spin period of the form $a + b \exp(-t/t_0)$ to the aspect information available before and after the optical shadow (t is time since the spacecraft entered the shadow, and a, b, and t_0 are constants to be determined). The resulting aspect information is estimated to be within ±10 degrees of the true direction. Author

N68-24557*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

LANDING SITE DISPERSIONS OF AN UNCONTROLLED LANDER ON MARS

John S. White Washington May 1968 24 p refs

(NASA-TN-D-4587) CFSTI: HC$3.00/MF$0.65 CSCL 22A

A study was made to determine the accuracy with which a lander, descending from a bus orbit, can reach a specified landing site on Mars without using a range control system. This report considers both a lifting and a nonlifting lander—each with two different values of mass. Several different entry angles were considered, along with two different procedures for the deorbit maneuver: the use of the minimum deorbit velocity increment and the use of a constant deorbit velocity increment. The error sources considered are variations in the Martian atmosphere, variations in the actual lift of the vehicle, and errors in performing the deorbit maneuver. It is concluded that if minimum deorbit velocity increment is used with entry angles of −20° to −24°, the landing site accuracy will be on the order of 1°, which is of the same order as the present knowledge of the location of the landing site. Thus a range control system need not be included in the lander. Author

N68-25271*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SPACE TRAJECTORIES AND ERRORS IN TIME, FREQUENCY, AND TRACKING STATION LOCATION
F. O. Vonbun Washington Jun. 1968 22 p refs
(NASA-TN-D-4507; NASA-TM-X-55798) CFSTI: HC $3.00/MF $0.65 CSCL 09F

This paper demonstrates analytically how errors in tracking station time and frequency synchronization, as well as errors in station location, influence the accuracy of trajectory determination. Two systems, whose data are presently used for most of the more accurate orbit determination schemes, are described: a range and range rate system, and a radar system. All other systems are actually combinations of these two basic systems. Rather simple analytical expressions are derived relating measuring errors with those of time and frequency synchronization, as well as ground tracking station location. For the range and range rate system, the error in range rate $\delta\dot{r}$ is used as a yardstick, and all other quantities are derived from it. For the radar system (not measuring range rate directly), the total local position vector, as measured by such a system is used as the yardstick to determine the necessary time synchronization and station location accuracy. Numerical examples are presented. Author

N68-25385*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THEORY OF THE INVESTIGATION OF THE ATMOSPHERE OF BINARY STARS BY ANALOGY BETWEEN GAS DYNAMICS AND SHALLOW-WATER FLOWS
Ernst W. Adams and Burkhard Schulz-Jander (Deut. Versuchsanstalt fur Luft- und Raumfahrt, Freiburg, West Ger.) Washington Jun. 1968 22 p refs
(NASA-TN-D-4520) CFSTI: HC $3.00/MF $0.65 CSCL 03B

Approximate solutions of the differential equations of continuum isentropic gas dynamics may be obtained for flows in the equatorial plane of a binary star atmosphere, by analogy between gas dynamics and shallow-water flows in a rotating water tank. The local inclination of the tank's bottom is proportional to the resulting local gravitational force at the corresponding point in the binary-star atmosphere. The analogy requires a constant polytropic coefficient of two. This application of the analogy rests on its extension to rotating systems with external force fields. A theoretical evaluation of the analogy (for the earth's atmosphere under hydrostatic conditions with polytropic coefficient equal to two) yields the correct "maximum" height of the atmosphere—where density reaches zero. This study is motivated by the possibility that it may be applied to the early stages of the evolution of the earth–moon system after its hypothetical fission. Author

N68-25867*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
LOCAL-ERROR CONTROL AND ITS EFFECTS ON THE OPTIMIZATION OF ORBITAL INTEGRATION
C. E. Velez Washington Jun. 1968 24 p refs
(NASA-TN-D-4542) CFSTI: HC $3.00/MF $0.65 CSCL 22C

In the numerical integration of orbits by a multistep process, it has been suggested that the application of a local error control may increase the efficiency of the integration without any significant loss of accuracy. This study develops methods of controlling the local error and examines the effects of these controls on the integration. It is shown that for various orbit types, controlling the local error can optimize the integration while maintaining the desired accuracy. Author

N68-25895*# Arizona Univ., Tucson.
MULTISEGMENTED OPTIMAL TRAJECTORIES
Thomas L. Vincent Washington NASA Jun. 1968 31 p refs
(Grant NsG-580)
(NASA-CR-1103) CFSTI: HC $3.00/MF $0.65 CSCL 22C

The problem of Bolza from the calculus of variations in terms of modern control notation has been extended in scope to include situations in which a number of subarcs in the state variable trajectory may occur in a variety of ways. The subarcs are allowed to be overlapping and/or separated. This allows for several subarcs to occur in the same interval of the independent variable and for subarcs which are separated by jumps in the independent and state variables. In addition, the differential equations of constraint and the integral quantity to be extremized are allowed to be of different form from subarc to subarc. The necessary minimizing conditions for the extended Bolza problem are obtained by extremizing a new functional which is related to it. This allows the optimizing conditions for the state and control variables to be obtained by applying the usual calculus of variations procedures and the optimizing conditions for the endpoints of the subarcs to be obtained using the ordinary theory of maxima and minima. Author

N68-25902*# Michigan Univ., Ann Arbor.
TRAJECTORY OPTIMIZATION BY A DIRECT DESCENT PROCESS
L. E. Fogarty and R. M. Howe Washington NASA Jun. 1968 38 p refs
(Grant NASr-54(06))
(NASA-CR-1070) CFSTI: HC $3.00/MF $0.65 CSCL 22C

The problem considered is that of trajectory optimization using step-by-step descent to minimum cost along the direction of the cost gradient with respect to the control. Using a hybrid computer, the gradient is computed directly as the response to nearly impulsive control perturbations. A method is presented for computing the gradient when several terminal constraints are enforced. Examples of application of the method are presented. It is concluded that the direct gradient computation method has some significant advantages over other methods. Author

N68-26642*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
ON SOME POSSIBLE SIMPLIFICATIONS AND CHANGES IN HANSEN'S LUNAR THEORY
Peter Musen Washington Jun 1968 28 p refs
(NASA-TN-D-4562) CFSTI: HC $3.00/MF $0.65 CSCL 03B

Several devices which permit us to reduce the number of quantities which must be re-computed with each iteration cycle are introduced. We refer the motion of the satellite to an almost ideal system of coordinates with two axes lying in the mean orbital plane. The position of the satellite relative to the almost ideal system is determined by Hansen's coordinates $1 + \nu$ and $N_0 \delta z$ of the projection of the satellite on its mean orbital plane and by the "elevation" ζ of the satellite relative to this plane. The position of the almost ideal system itself with respect to an inertial system is determined by two uniform rotations, one around the normal to the orbital plane of the sun, and one around the normal to the mean orbital plane of the satellite. The problem of integration is reduced to solving a linear partial differential equation by means of successive approximation, or to expanding the integrating operator into a series of products of two linear operators. One of these operators is a linear partial differential operator and the other is the inverse of a linear partial differential operator with the constant coefficients. We propose here, as in the previous work, to compute Hansen elements ξ, Υ and Ψ separately and to fuse them into W bypassing Hansen's function W. Author

N68-26643*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

ON THE APPLICATION OF LIE-SERIES TO THE PROBLEMS OF CELESTIAL MECHANICS

Karl Stumpff Washington Jun. 1968 29 p refs

(NASA-TN-D-4460) CFSTI: HC $3.00/MF $0.65 CSCL 03C

Since Newton, the stumbling block in celestial mechanics has been the three-body problem. Only restricted cases have yielded solutions. This paper describes a device, the "Lie-Series," that first appeared in Lie's work on analytical transformations; Gröbner has shown that they can be used to solve systems of differential equations by applying differential operators to known functions or to invert systems of analytical functions. The series are applied to Kepler's problem of an undisturbed planet round the sun (two-body problem), to the study of perturbations, and to the process of obtaining the characteristics for any general dynamical problem. Author

N68-26689*# Northrop Corp., Hawthorne, Calif.

GENETIC STATES OF SIMULATED LUNAR ROCKS

Emanuel Azmon Washington NASA Jun. 1968 152 p refs

(Contract NAS7-358)

(NASA-CR-1081; NCL-67-44R) CFSTI: HC $3.00/MF $0.65 CSCL 03B

Concepts leading to beneficial uses of rocks on the moon were developed. Most of the raw materials used are commonly and abundantly available silicate rocks. It is hoped that similar silicates will be found to be common and abundant on the lunar surface. The concept developed in this study is that of a genetic state which is the state from which a rock of distinct characteristics is born. This state is a function of the pressure and temperature conditions that a rock material is exposed to, as well as of the history (time and rate of changes) of pressures and temperature. Specific genetic states of several rocks are shown as genetic diagrams in this report. Most of the phases that are shown in the diagrams to coexist are not in equilibrium with their system, but were "frozen" into existence by quenching prior to attainment of equilibrium. Author

N68-26702*# Lovelace Foundation for Medical Education and Research, Albuquerque, N. Mex.

THE INTANGIBLES OF HABITABILITY DURING LONG DURATION SPACE MISSIONS

T. M. Fraser Washington NASA Jun. 1968 83 p refs

(Contract NASr-115)

(NASA-CR-1084) CFSTI: HC $3.00/MF $0.65 CSCL 05E

The nature and meaning of habitability are discussed in relation to the requirements for long duration manned space missions. Several models of habitability are examined, and it is suggested that habitability can be considered as that equilibrium state, resulting from man-machine-environment-mission interactions which permits man to maintain physiological homeostasis, adequate performance, and psycho-social integrity. The attributes of habitability are examined, and indices of habitability are discussed. No attempt is made to examine all the requirements for optimum habitability, an exercise which would involve consideration of every aspect of the interactions occurring in the entire man-machine-environment-mission complex. Attention if focussed instead on some of the less common aspects, and a discussion ensues on requirements for free internal volume, configuration, privacy (territoriality), personal hygiene, illumination, decor, color, recreation, and the use of leisure time, during a long duration manned space mission. Author

N68-27475*# National Aeronautics and Space Administration, Washington, D. C.

THE ZODIACAL LIGHT AND THE INTERPLANETARY MEDIUM

J. L. Weinberg ed. (Hawaii Univ.) 1967 395 p refs Papers presented at the Symp. held in Honolulu, Hawaii, 30 Jan.–2 Feb. 1967

(NASA-SP-150) GPO: HC $3.00; CFSTI: MF $0.65 CSCL 03B

Conference papers on zodiacal light in the interplanetary medium deal with photometric and meteor observations, particle collection and impact, scattering properties, dynamics and the earth's dust cloud, solar wind, and the origin and evolution of zodiacal dust. For individual titles see N67-27475 to N67-27525.

N68-28113*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

MOTION OF AN ARTIFICIAL SATELLITE UNDER COMBINED INFLUENCE OF PLANAR AND KEPLERIAN FORCE FIELDS

Rowland E. Burns Washington Jul. 1968 57 p refs

(NASA-TN-D-4622) CFSTI: HC $3.00/MF $0.65 CSCL 22C

The development of the technology of artificial earth satellites has posed mathematical problems which heretofore were academic. One such problem is the radiation pressure perturbations of satellites with large area-to-mass ratios (i.e., Echo). The standard method of treatment of such a problem is a perturbational analysis of a purely Keplerian orbit which is disturbed by a radiation pressure field. It will be shown in this report that a generalized form of the two-body problem which more closely approximates the radiation pressure problem can be solved in closed form. Specifically, the problem of the motion of a satellite under the combined influence of Keplerian and planar force fields will be solved in terms of the elliptic functions. The assumption of a planar force field is still an approximation to the true radiation pressure problem because the divergence of the field is neglected. It is obvious that neglecting the divergence of the radiation pressure field is far less restrictive than disregarding the entire field. Perturbational treatment with the present solution as a model should converge far more readily than treatments which assume an initially Keplerian model. Author

N68-28192*# Arizona Univ., Tucson.

CHRONOLOGICAL CATALOG OF REPORTED LUNAR EVENTS

Barbara M. Middlehurst, Jaylee M. Burley, Patrick Moore (Armagh Planetarium), and Barbara L. Welther (Smithsonian Astrophys. Obs.) Washington NASA Jul. 1968 55 p refs

(NASA-TR-R-277) CFSTI: HC $3.00/MF $0.65 CSCL 03A

A catalog of reports of lunar events, or temporary changes on the moon, was compiled based on literature covering more than four centuries. In most cases, the original reference was consulted; Houzeau and Lancaster's *Bibliographie Général d'Astronomie* and the *Astronomischer Jahresbericht* were useful secondary sources. Each entry includes a brief description and date of the observation; the name of the observer(s), where these are known; and the reference. Author

N68-28251*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

ON THE PERTURBATIONS OF SMALL-ECCENTRICITY SATELLITES

T. L. Felsentreger Washington Jul. 1968 49 p refs

(NASA-TN-D-4531) CFSTI: HC $3.00/MF $0.65 CSCL 22C

Difficulties have been encountered in the orbit determination of nearly circular earth satellites when "first-order" analytic perturbation theories have been used. "First-order" usually means that periodic terms are developed to order J_2 (the second zonal harmonic coefficient in the earth's gravitational potential), the secular terms to order J_2^2. If these theories are extended to include periodic terms of order J_2^2 and higher, the appearance of eccentricity as a divisor in the perturbations of eccentricity, mean anomaly, and argument of perigee causes many of these "higher-order" terms to be comparable in magnitude with the J_2

terms (for small-eccentricity satellites). Thus, the aforementioned difficulties can be attributed, at least in part, to the omission of these terms from the orbit-determination models. Von Zeipel's method is used to derive all such "small divisor" terms inclusive of J_2^3 and $(J_1/J_2)^3$, when J_1 is any odd zonal harmonic coefficient. Author

N68-28275*# Boeing Co., Seattle, Wash.
LUNAR ORBITER 4. PHOTOGRAPHY
Washington NASA Jul. 1968 78 p
(Contract NAS1-3800)
(NASA-CR-1093; D2-100754-2, V. 2) CFSTI: HC $3.00/MF $0.65 CSCL 22A

Photographic mission design, actual photography, photographic supporting data, and operational performance for Lunar Orbiter 4 are detailed. Nearly complete coverage of the nearside and appreciable coverage of the farside of the moon were made at a resolution significantly better than earth-based observations. Nominal orbit parameters are included and general characteristics of mission photography along with meteoroid, energetic radiation, wind fogging, and light streaking effects are included. Perilune and apolune lunar landing sites are discussed and illustrated. Cameras, processor-dryer, and readout performances are summarized. M.W.R.

N68-28373*# Douglas Aircraft Co., Inc., Santa Monica, Calif.
ULTRAHIGH VACUUM ADHESION RELATED TO THE LUNAR SURFACE
Washington NASA Jul. 1968 95 p refs
(Contract NAS7-307)
(NASA-CR-1090) CFSTI: HC $3.00/MF $0.65 CSCL 22A

To represent possible bounds to the types of silicate surfaces which may be found on the moon, two types of silicate surface preparation were used. The first consisted of forming the surface in air, representing the contaminated surface case. The other consisted of forming the surface at ultrahigh vacuum by cleavage, representing the clean surface. Adhesion force was measured as a function of load force, temperature, surface roughness, type of material, crystalline orientation, and degree of surface cleanliness. The adhesion between ultrahigh vacuum-formed silicate surfaces was found to be orders of magnitude greater than that between the air-formed surfaces. A strong long-range attractive force, indicative of surface charing, was also noted. It was concluded: (1) Adhesion phenomena are critically dependent upon the surface state. (2) The highest magnitude adhesion may be caused through the action of the normal atomic bonding forces, but the surface charging makes a significant contribution. (3) Though random charge separation associated with bond breakage could contribute to surface charging, a major contributors are the defect structures in the crystal lattice. M.G.J.

N68-28408*# National Aeronautics and Space Administration, Manned Spacecraft Center, Houston, Tex.
USE OF PLANETARY OBLATENESS FOR PARKING-ORBIT ALINEMENT
Joseph R. Thibodeau, III Washington Jul. 1968 27 p refs
(NASA-TN-D-4657) CFSTI: HC $3.00/MF $0.65 CSCL 22C

A rapid analytical technique is used to determine simultaneously the possible configurations of an elliptical parking orbit at Mars. Both the geometry of planetary approach and departure and the effects of planetary oblateness are used to determine the characteristics of those orbits which shift into proper alinement for departure and require no discrete propulsive maneuvers. The technique makes use of the separable nature of the equations that express secular rotation of the orbit plane and major axis. Preliminary results indicate that the orbital inclinations fall into narrow bands which are widely distributed over the interval of possible inclinations. Author

N68-28409*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
CORRELATION STUDY OF LUNAR RADII OBTAINED FROM PHOTOGRAPHIC AND LUNAR GRAVITATIONAL FIELD DATA
James R. Williams and William R. Wells Washington Jul. 1968 19 p refs
(NASA-TN-D-4636) CFSTI: HC $3.00/MF $0.65 CSCL 03A

A study has been made to determine the correlation of local lunar radii as determined from recent earth-based photographic studies and from lunar gravitational field coefficients obtained from lunar satellite tracking data. The photographic study is a recent local radii determination performed by the Army Map Service at 734 points over the visible lunar surface. The lunar gravitational field coefficients used in the analysis are the most recent determinations from independent studies of tracking data from Lunar Orbiters I to IV and the Russian satellite LUNA-10. The general result of the study is that all the currently determined gravity models are little correlated with the visible surface features of the moon excpet in a few isolated regions. Author

N68-28841*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
DERIVATION OF APPROXIMATE EQUATIONS FOR SOLVING THE PLANAR RENDEZVOUS PROBLEM
Gene W. Sparrow and Douglas B. Price Washington Jul. 1968 31 p refs
(NASA-TN-D-4670) CFSTI: HC $3.00/MF $0.65 CSCL 22C

The desirability of obtaining simplified and accurate relative equations of motion for two-impulse rendezvous application resulted in the examination of the Clohessy and Wiltshire type of simplified equation. An analysis of these equations revealed that large errors were possible if the radial separation of the two vehicles was large. In an effort to develop more accurate equations for rendezvous, the apparent erroneous terms were replaced by exact terms. The resulting modified equations contained terms not present in the Clohessy and Wiltshire equations. When the modified equations were applied to the problem of rendezvous, they were found to be generally superior to the Clohessy and Wiltshire equations, particularly for long transfer angles. The scope of the investigation is limited to the case in which the target vehicle is in a circular orbit coplanar with the ferry vehicle's orbit. Author

N68-28884*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
GRAVITATIONAL EXPERIMENTS WITH A COLLISIONLESS TWO-DIMENSIONAL COMPUTER MODEL
Frank Hohl and Stephen K. Park Washington Jul. 1968 26 p refs
(NASA-TN-D-4646) CFSTI: HC $3.00/MF $0.65 CSCL 03B

A two-dimensional model is used to perform computer experiments for a collisionless self-gravitating system. The gravitational field is obtained by solving the Poisson equation and the system is advanced stepwise in time. Computer simulations have been performed for systems with an initially uniform distribution over a region in x,y space, zero thermal velocity, and various values of initial solid-body rotation. Up to 4000 stars were used in the calculations. Author

N68-29988*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
MARS LANDING MISSION MODE COMPARISON
James J. Taylor and John T. McNeely Washington Aug. 1968 49 p refs
(NASA-TM-X-1629) CFSTI: HC $3.00/MF $0.65 CSCL 22A

Four modes of landing a vehicle on Mars are compared in this document. In addition, several variations to these four basic

mission modes are suggested. The most efficient mission mode for a Mars landing depends on the type of trajectories used. Author

N68-30098*# Douglas Aircraft Co., Inc., Santa Monica, Calif.
PLANETARY FLIGHT HANDBOOK. PART 6: MARS STOPOVER MISSION USING VENUS SWINGBYS
Washington NASA 1968 98 p refs
(Contract NAS2-4175)
(NASA-SP-35, Pt. 6) GPO: HC $0.75; CFSTI: MF $0.65 CSCL 22C

Trajectory data are presented to aid in planning stopover missions to Mars that employ the Venus swingby mode, which yield substantial reductions in propulsive velocity and Earth entry speed requirements when used as part of a round trip stopover mission. Charts, graphs and tabular data are included for total round trip mission duration and stopover time at Mars. The tabular trajectory data are for inbound and/or outbound swingbys that are projected for the 1975 through 1999 period; and stopover times are of zero, 30, and 60 day duration. Data are restricted to those missions which combine a direct leg and a ballistic Venus swingby leg, and mission employing Venus swingbys on both outbound and inbound legs. Minimum mission velocity requirements and associated earth entry speeds for each opportunity are presented as a function of mission duration for both propulsive braking and aerodynamic braking at Mars. M.W.R.

N68-30244*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
LUMINOUS EFFICIENCIES OF THREE NICKEL ARTIFICIAL METEORS BETWEEN 9.8 AND 11.4 KILOMETERS PER SECOND
T. Dale Bess Aug. 1968 24 p refs
(NASA-TN-D-4666; L-5774) CFSTI: HC $3.00/MF $0.65 CSCL 03B

Results of the experimental measurements of luminous intensity and corresponding luminous efficiency parameters of three nickel artificial meteors are presented. These results are compared with experimental values of iron luminous efficiencies over the same velocity range. All data were reduced from photographs taken with ground-based meteor cameras located at three camera sites. All flights were from Wallops Island, Virginia, and Nike-Cajun rocket vehicles were used to reenter the artificial meteoroids. Light curves on blue-sensitive film were obtained for all three nickel meteors, whereas the light curve on panchromatic film was obtained only for the fastest meteor. Data from the third experiment indicated that the radiation for this nickel meteor was strongest in the ultraviolet region of the spectrum; the measured blue-light intensity was about twice that of the panchromatic intensity. The experiments showed that the luminous efficiencies of nickel and iron are about the same at velocities around 11 and 12 kilometers per second; however, for lower velocities the luminous efficiency of nickel is as much as a factor of 10 less than the corresponding iron efficiencies. Author

N68-30601*# National Aeronautics and Space Administration, Washington, D. C.
PLANETARY ATMOSPHERES Continuing Bibliography with Indexes, Jun. 1966–Dec. 1967
Jul. 1968 126 p refs
(NASA-SP-7017(02)) CFSTI: HC $3.00/MF $0.65 CSCL 03B

Bibliographic citations and informative abstracts are presented on the properties of the atmospheres of Mars, Venus, Jupiter, Mercury, and Saturn, along with references to such related subjects as extraterrestrial environments, planetary observation techniques, and theories of planetary origin. Also included are subjects and personal author indexes. The bibliography covers the reports and journal articles announced in NASA abstract journals during the period June 1966 through December 1967. M.G.J.

N68-31989*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A TRAJECTORY CODE FOR MAXIMIZING THE PAYLOAD OF MULTISTAGE LAUNCH VEHICLES
Omer F. Spurlock and Fred Teren Washington Aug. 1968 168 p refs
(NASA-TN-D-4729) CFSTI: HC $3.00/MF $0.65 CSCL 22C

A computer code is described that quickly maximizes the payload of a multistage launch vehicle. Calculus of variations chniques are used to optimize the trajectory and propellant loadings (optional) of one to six stages. The flow rate and vacuum thrust of each stage are constant. The jettison weight is a linear function of the propellant loading. The computer time is greatly reduced by minimizing the integration of atmospheric (booster) portions of the trajectory. A table of booster burnout conditions is formed from a limited number of boost trajectories. The table is used in conjunction with an interpolation scheme to obtain initial conditions for the vacuum portion of the trajectory. Author

N68-32094*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
EXPLICIT UPPER-BOUNDS FOR ERROR PROPAGATION IN THE N-BODY FIELD
Albert Rosen Washington Aug. 1968 18 p refs
(NASA-TN-D-4511) CFSTI: HC $3.00/MF $0.65 CSCL 22C

A simple means for bounding the propagated trajectory error induced by an impulsive initial error in the n-body field is developed. Formulas are derived for the maximum acceptable initial error, given the mission tolerances, and for the maximum time of negligible propagated error, given the initial impulses and mission tolerances. An example illustrates the use of the results within the solar system. Author

N68-32631*# National Aeronautics and Space Administration, Washington, D. C.
LUNAR SURFACE STUDIES *Continuing Bibliography With Indexes*
Jun. 1968 115 p refs
(NASA-SP-7003(04)) CFSTI: HC $3.00/MF $0.65 CSCL 22A

Subject coverage concentrates on theory of lunar origin, the lunar atmosphere, and the physical characteristics of the lunar surface, such as topography, geology, and stratigraphy. References are also included to techniques of lunar observation, measurement, and analysis, e.g., photography, photometry, and spectrophotometry, as well as references to the instrumentation and equipment used in lunar investigations. Author

N68-32744*# Westinghouse Electric Corp., Baltimore, Md.
DIGITAL PROGRAM FOR DYNAMICS OF NON-RIGID GRAVITY GRADIENT SATELLITES
James L. Farrel, James K. Newton, and James J. Connelly Washington Aug. 1968 99 p
(Contract NAS5-9753-10)
(NASA-CR-1119) CFSTI: HC $3.00/MF $0.65 CSCL 22A

A digital program has been written to determine the dynamic behavior of discretized models for gravity gradient satellite structures. Both passive (elastic reaction, damping) and active (controller) internal torques can be included in the computational model. The program can be utilized simply by observing straight-forward directions given in the introductory section of this report, and a concrete example (hinged assembly model of the Radio Astronomy Explorer satellite) of program adaptation is described in detail. To facilitate application to other configurations a clear separation is made between 1) computations applicable to a general gravity gradient satellite, and 2) specific RAE computations. Author

N68-32978*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

THEORY AND RESULTS ON COLLECTIVE AND COLLISIONAL EFFECTS FOR A ONE-DIMENSIONAL SELF-GRAVITATING SYSTEM

Frank Hohl Washington Aug. 1968 80 p refs

(NASA-TR-R-289) CFSTI: HC$3.00/MF$0.65 CSCL 03B

The equilibrium properties of one-dimensional self-gravitating systems are investigated analytically. One-dimensional models are used to perform computer experiments tracing the evolution of stellar systems. The stationary solution of the Vlasov equation for a one-dimensional system of stars as computed for an interesting class of initial conditions is found to correspond to a minimum-energy configuration. The results of the numerical experiments are compared with theory. For initial energies far from the minimum equilibrium energy the system becomes unstable and breaks up into smaller clusters. A variational principle was applied to the one-dimensional stellar system to show that stationary distribution functions which decrease monotonically in going outward from the center of the system are stable. The one-dimensional model is of interest as an approximation to the distribution of velocity and mass normal to the galactic plane of a greatly flattened galactic system. Observational results for the gravitational force normal to the galactic plane of the Galaxy agree with the results obtained from the one-dimensional model. Thermalization effects for systems containing small numbers of stars were investigated. The fluctuation of the kinetic energy was found to be inversely proportional to the square root of the number of particles in the system. Author

N68-33055*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

A METHOD FOR COMPUTING LUMINOUS EFFICIENCIES FROM METEOR DATA

Barrett S. Baldwin, Jr. and H. Julian Allen Washington Sep. 1968 70 p refs

(NASA-TN-D-4808) CFSTI: HC$3.00/MF$0.65 CSCL 22A

The details of a model for the ablation of a stone meteoroid passing through the atmosphere are presented. The model allows for a decrease in mean density due to frothing, which results from the intense heating at low atmospheric pressures. The present results are a refinement of a previously published analysis since new information on the properties of meteoritic materials has been utilized. A method was also found for taking into account a delay in light production resulting from the time required to vaporize chunks of froth in the meteor wake. The introduction of a frothing ablation model in an analysis of super-Schmidt meteor data allows an interpretation in terms of originally solid meteoroids for meteors previously thought to have been produced by fragile low-density meteoroids. At the same time, the computed luminous efficiency factor, τ_{op}, is found to vary substantially with velocity. Above 35 km/sec the value of τ_{op} is close to that recommended by Verniani. As the velocity is reduced below 25 km/sec τ_{op} increases to a level about six times greater. Author

N68-33169*# National Aeronautics and Space Administration, Washington, D. C.

AEROSPACE ELECTRONIC SYSTEMS TECHNOLOGY

1967 319 p refs Briefing for Ind. Held at MIT, 3–4 May 1967 Sponsored by the Electron. Ind. Assoc.

(NASA-SP-154) GPO: HC$1.25; CFSTI: MF$0.65 CSCL 22A

Conference papers are presented on NASA planning and requirements for electronic systems technology, with particular reference to mission goals; earth orbital, lunar, and planetary technologies; and avionics. For individual titles see N68-33169 through N68-33189.

N68-33371*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

ANALYSIS OF LAUNCH WINDOWS FROM CIRCULAR ORBITS FOR REPRESENTATIVE MARS MISSIONS

Larry A. Manning, Byron L. Swenson, and Jerry M. Deerwester Washington Sep. 1968 61 p refs

(NASA-TM-X-1651) CFSTI: HC$3.00/MF$0.65 CSCL 22C

Round-trip missions to Mars were investigated to define representative launch windows and associated ΔV requirements. The 1982 inbound and the 1986 outbound Venus swingby missions were selected for analysis and serve to demonstrate the influence of the characteristics of the heliocentric trajectories on the launch-window velocity requirement. The analysis investigated the use of optimum one- and two-impulse transfers, plus, a restricted three-impulse transfer employing an intermediate elliptic orbit to transfer from a circular parking orbit to the departure hyperbolic asymptote. Insertion at planet arrival was into an orbit coplanar with the arrival asymptote and any required plane change was performed during the planet departure phase. The study indicates that, with a three-impulse transfer, the ΔV penalty to provide a launch window of 20 days at Earth or 60 days at Mars is no more than 5 to 10 percent above the minimum coplanar requirement. Therefore, use in mission analyses of the coplanar ΔV requirements would not result in large errors if three-impulse transfers are acceptable. However, the results also show that the use of coplanar departure velocity requirements is not a good approximation for these launch windows with one- or two-impulse transfers. Author

N68-34086*# North American Rockwell Corp., Downey, Calif.

STUDY OF TECHNOLOGY REQUIREMENTS FOR ATMOSPHERE BRAKING TO ORBIT ABOUT MARS AND VENUS. VOLUME 1: SUMMARY, JANUARY–OCTOBER 1967

E. M. Repic Washington NASA Sep. 1968 28 p refs

(Contract NAS-2-4135)

(NASA-CR-1131; SD-67-994-1) CFSTI: HC $3.00/MF $0.65 CSCL 22C

A detailed investigation was conducted to evaluate the advantages and disadvantages of an integrated aerobraking spacecraft. Included were parameter and conceptual design studies to define the spacecraft weights and sensitivity to variations in the environmental models assumed, crew size, mission profile, propellants, etc., as well as internal packaging arrangements. A second objective was to analyze the requirements for system simulation, testing, and qualification. A typical mission profile was developed so that the various operations and systems involved in a Mars landing mission could be viewed in perspective. Figures are drawn to show schematically the mission and an inboard profile of the aerobraker vehicle. Study results showed that (1) the selected aerobraker configurations exhibit satisfactory performance and packaging characteristics and (2) there is considerable commonality between the spacecraft systems required to accomplish the Mars and Venus missions if the parking orbit eccentricity and probe payload parameters are adjusted appropriately. Significant results are discussed in relation to aerobraking vehicle requirements, configuration analysis, sensitivity analysis, and modular approach to vehicle synthesis. B.S.D.

N68-34870* National Aeronautics and Space Administration, Washington, D. C.

EXPLORING SPACE WITH A CAMERA

Edgar M. Cortright, ed. and comp. 1968 227 p

(NASA-SP-168) GPO: $4.25 CSCL 22A

Representative space photographs from among the thousands of pictures returned to earth during the past decade comprise this volume, which is presented in sections devoted to photography above the atmosphere, to the moon and beyond, and man's venture

into space. Some of the pictures were made by man-directed cameras, while others were relayed back to earth by unmanned spacecraft. Primarily a collection representing space accomplishments of the United States, the volume also includes some photographs taken during Soviet space probes. Cloud cover, storms, and other meteorological phenomena are shown in the photographs, for which written texts are included along with comments by NASA and other scientific personnel. Surveyor and Orbiter shots of the moon include photographs of craters, mares, and other formations. Shots from various Gemini flights depict the docking of the Agena target, man's space walk, the earth's features, and space phenomena. An appendix includes details of the major spacecraft launched by the United States. M.W.R.

N68-36077*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A SEMIGRAPHICAL METHOD FOR A DEORBIT TRAJECTORY DESIGN STUDY

Richard N. Green, William F. Hampshire II, and Sue W. Souders Washington Oct. 1968 25 p

(NASA-TN-D-4801) CFSTI: HC $3.00/MF $0.65 CSCL 20C

A semigraphical method to aid in the selection of a deorbit trajectory which is compatible with arbitrarily selected mission constraints is presented. The method is applicable to the case where the initial orbit about the planet and the deorbit trajectory are coplanar. Basically, the method consists of examining a family of candidate trajectories and eliminating, by a graphical cross plotting technique, those which violate the mission constraints. In addition, the trade offs which exist between the various demands on the trajectory become graphically obvious. The method is flexible in that the user is free to dictate the mission mode and the mission constraints. An example illustrating the use of the method for a Mars mission is presented. Author

N68-36459*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

SIMPLIFIED TECHNIQUE FOR DETERMINING PERICYNTHION ALTITUDE OF LUNAR ORBITS

L. Keith Barker Washington Oct. 1968 15 p refs

(NASA-TN-D-4811) CFSTI: HC $3.00/MF $0.65 CSCL 22C

A study has been made of a simplified technique for determining the pericynthion altitude of transfer orbits from a selenocentric circular orbit at 80 nautical miles (148 160 m) to a lower altitude. The transfer orbits had pericynthion altitudes ranging from 0 to 100,000 feet (30 480 m) and radial injection velocities between ±10 ft/sec (±3 m/sec). The technique consisted of measuring the angle between a reference vehicle in circular orbit and the lunar horizon at two specified times. Pericynthion altitude was then determined graphically from these measurements. The effects of errors in measuring the angles, in determining the sighting times, in the circular reference orbit, and in horizon uncertainties were considered. It appears that the technique would be useful for predicting the pericynthion altitude of the transfer orbits and, if necessary, for providing information for orbit corrections. Author

N68-37220*# National Aeronautics and Space Administration, Washington, D. C.

NASA SPACE VEHICLE DESIGN CRITERIA (ENVIRONMENT). MODELS OF MARS ATMOSPHERE (1967)

May 1968 24 p refs

(NASA-SP-8010) CFSTI: HC $3.00/MF $0.65 CSCL 03B

Three models of Martian atmosphere having minimum, mean, and maximum density profiles, respectively, were generated by NASA computer programs using temperature and molecular mass distributions, surface pressure, composition, radius of the planet, and acceleration of gravity at the planetary surface as computer inputs. Equations are included for the calculation of density, pressure, speed of sound, density scale height, number density, mean free path, and viscosity. Tables give these parameters for the minimum model for geometric altitudes from 0 to 190 km; for the mean model, 0 to 390 km; and the maximum model 0 to 2500 km. K.W.R.

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SPACE VEHICLES

Includes launch vehicles; manned space capsules; clustered and multistage rockets; satellites; sounding rockets and probes; and operating problems. For basic research see: 30 Space Sciences. For related information see also: 28 Propulsion Systems; and 32 Structural Mechanics.

N68-10192*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
ENVIRONMENTAL TEST CONTRIBUTION TO SPACECRAFT RELIABILITY
Kenneth R. Mercy Washington, NASA, Nov. 1967 17 p Presented at Inst. of Environ. Sci. Ann. Tech. Meeting, Washington, D. C., 11 Apr. 1967
(NASA-TN-D-4181) CFSTI: HC$3.00/MF$0.65 CSCL 22B

Typical problems that have a major impact on some space programs are discussed. These problems include those that involve the interdependence of equipment in a system complex. The experiences obtained in producing reliable spacecraft for several programs (Relay, Syncom, Tiros, etc.) are analyzed. The techniques used to control and appraise space programs differ and are influenced by the spacecraft design, target dates, and budget restrictions. The validity of these techniques is indicated by the results of the test programs. Problem occurrences are analyzed relative to program phase. The results of this study are discussed with regard to optimizing techniques of quality and reliability planning for space hardware. Author

N68-11476*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
A SIMULATOR STUDY OF PILOT CONTROL OF REMOTE ORBITAL DOCKING OF LARGE ATTITUDE-STABILIZED COMPONENTS
Donald R. Riley and William T. Suit Washington Dec. 1967 22 p refs
(NASA-TN-D-4263) CFSTI: HC$3.00/MF$0.65 CSCL 22A

A brief fixed-base-simulator study has been made to determine the ability of human pilots to perform orbital docking between two spherical tanks from a manned spacecraft positioned some distance away. All three vehicles were assumed attitude stabilized. The pilot was given translational control of the manned spacecraft and of one of the remotely located tanks by means of simple on–off reaction jets. Guidance cues were obtained from two light spots, displayed on a cylindrical screen, that symbolized the two fully illuminated spherical tanks. In the simulator, docking was considered complete when the two light spots were the same size and were positioned tangent to each other directly ahead of the pilot. The results of the investigation indicated that pilots could complete remote docking with acceptable terminal conditions except for longitudinal positioning. An upper limit to the energy exchange between tanks at contact was shown by the data for the three velocity components between tanks which were found to be of small magnitude and invariant with spacecraft range. Data on the longitudinal misalinement between tanks, however, indicated that, as range of the manned spacecraft was increased above a given value, docking success decreased. Author

N68-11520*# North American Aviation, Inc., Downey, Calif.
INFLUENCE OF STRUCTURE AND MATERIAL RESEARCH ON ADVANCED LAUNCH SYSTEMS' WEIGHT, PERFORMANCE, AND COST Summary Report, May 25, 1965–Jun. 30, 1967
J. A. Boddy and J. C. Mitchell Washington NASA Dec. 1967 61 p refs
(Contract NAS7-368)
(NASA-CR-974; SID-67-542-1) CFSTI: HC $3.00/MF $0.65 CSCL 22D

This report summarizes results of a two-phase study effort completed under a program focusing on the development of programmed assistance in directing structures research. Phase I of this program involved modifying and utilizing existing automated analytical techniques to determine significant structures and materials research areas in current and predicted future expendable launch vehicle systems. The Phase I study covers the parametric synthesis of expendable launch vehicles and a more detailed design synthesis of some of the structural components of these vehicle systems. A definition of the vehicle systems and structural synthesis of Phase I is also summarized. The Phase II effort was an extension of the design synthesis to advanced structural concepts, application to the base-line vehicle systems of Phase I and the evaluation of the relative merits to provide direction for worthwhile areas for structures and material research. Parametric vehicle synthesis was further adapted to encompass vehicle systems with recoverable first stages. The recoverable stages considered were expendable stages with recoverable features, i.e., winged body shapes with flyback propulsion and landing provisions. Author

N68-11641* National Aeronautics and Space Administration. Langely Research Center, Langley Station, Va.
INVESTIGATION OF TETHERED STATION KEEPING
James R. Williams and James J. Adams Washington Dec. 1967 31 p refs
(NASA-TN-D-4258) CFSTI: $3.00 CSCL 22A

A method of Gemini–Agena station keeping using a connecting tether has been investigated both by analysis and by static and moving-base piloted simulations. The method involves spinning the tethered combination about its common center of mass so that tension is maintained in the cable and the vehicles remain close to each other without contact. The analytical study shows that the tethered system is inherently stable while spinning about its axis of maximum moment of inertia. The simulations indicate that pilots can perform the maneuver and can minimize fuel usage with either of the two piloting techniques studied. Author

N68-11919*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
FLIGHT TEST OF A 40-FOOT-NOMINAL-DIAMETER MODIFIED RINGSAIL PARACHUTE DEPLOYED AT A MACH NUMBER OF 1.64 AND A DYNAMIC PRESSURE OF 9.1 POUNDS PER SQUARE FOOT
Clinton V. Eckstrom, Harold N. Murrow, and John S. Preisser Washington Dec. 1967 28 p refs
(NASA-TM-X-1484) CFSTI: HC$3.00/MF$0.65 CSCL 22B

A ringsail parachute, modified to provide a total geometric porosity of 15 percent of the reference area, was flight tested. The payload for the flight test was an instrumented capsule from which the test parachute was ejected by a deployment mortar when the system was at a Mach number of 1.64 and a dynamic pressure

of 9.1 pounds per square foot. The parachute deployed to suspension line stretch in 0.45 second with a resulting snatch force of 1620 pounds. Canopy inflation began 0.07 second later and the parachute projected area increased slowly to a maximum of 20 percent of that expected for full inflation. Because the parachute never reached the full-open condition, the large drag force normally associated with parachute inflation did not develop. The difference in rotation between the spinning payload and the deployed canopy has normally resulted in some twisting of the payload attachment bridle and riser system. The suspension lines also twisted, primarily because the partially inflated canopy could not restrict the twisting to the attachment bridle and risers. This twisting of the suspension lines hampered canopy inflation at a time when velocity and dynamic-pressure conditions were more favorable. It is concluded that the most probable cause of the failure of the parachute to inflate properly was excessive total porosity (geometric open area and cloth permeability) in the crown area of the canopy. Author

N68-11961*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

FLIGHT TEST OF A 15-FOOT-DIAMETER (4.6-METER) 120° CONICAL SPACECRAFT SIMULATING PARACHUTE DEPLOYMENT IN A MARS ATMOSPHERE

Wayne L. Darnell, Allen B. Henning, and Reginald R. Lundstrom Washington Dec. 1967 76 p refs

(NASA-TN-D-4266) CFSTI: HC $3.00/MF $0.65 CSCL 22B

An experiment was conducted in Earth atmosphere which simulated the deployment of an 85.3-foot-diameter (26.0-meter) ringsail parachute behind a spacecraft entering a Mars Atmosphere when at an altitude of about 18,000 feet (5.5 kilometers). The spacecraft was a 120° cone having a base diameter of 15 feet (4.6 meters) and weighing 1687 pounds (765 kilograms). It was carried to an altitude of 130,300 feet (39.7 kilometers) above the Earth by a 26,000,000-ft^3 (736240-m^3) balloon. After release from the balloon over the White Sands Missile Range, rockets propelled the spacecraft to a Mach number of 1.19 and a dynamic pressure of 6.4 lbf/ft^2 (306 N/m^2). The parachute was deployed by a parachute mortar. Onboard instrumentation consisted of motion picture cameras and a tape recorder which recorded the output from accelerometers and temperature sensors. Good data were obtained from all instrumentation. The parachute, which was deployed in a reefed condition, did not have sufficient drag to withdraw the instrumented payload from the spacecraft until it was disreefed. Temperatures measured at critical points in the spacecraft were within the desired operating range. Author

N68-13797*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

PERFORMANCE OF A 19.7-METER-DIAMETER DISK-GAP-BAND PARACHUTE IN A SIMULATED MARTIAN ENVIRONMENT

Richard J. Bendura, Earle K. Huckins, III, and Lucille C. Coltrane Washington Jan. 1968 38 p refs

(NASA-TM-X-1499) CFSTI: HC $3.00/MF $0.65 CSCL 22B

Inflation and drag characteristics of a 64.7-foot nominal-diameter disk-gap-band parachute deployed at a Mach number of 1.59 and a dynamic pressure of 11.6 psf (555 N/m^2) were obtained from the second balloon-launched flight test of the Planetary Entry Parachute Program. In addition, parachute stability characteristics during the subsonic descent portion of the test are presented. After deployment, the parachute rapidly inflated to a full condition, partially collapsed, and then reinflated to a stable configuration. After reinflation, an average drag coefficient of about 0.55 based on nominal surface area was obtained. The parachute exhibited good stability characteristics during descent. The only major damage to the parachute during the test was the tearing of two canopy panels; a loss of less than 0.5 percent of nominal surface area resulted. Author

N68-14092*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

PERFORMANCE OF A 16.6-METER-DIAMETER MODIFIED RINGSAIL PARACHUTE IN A SIMULATED MARTIAN ENVIRONMENT

Charles H. Whitlock, Allen B. Henning, and Lucille C. Coltrane Washington Jan. 1968 39 p refs Film Supplement Number L-984 is Available on Loan from NASA Langley Research Center

(NASA-TM-X-1500) CFSTI: HC $3.00/MF $0.65 CSCL 22B

Inflation, drag, and stability characteristics of a 54.5-foot nominal-diameter (16.6-meter) modified ringsail parachute deployed in the wake of a 15-foot-diameter (4.6-meter) spacecraft traveling at a Mach number of 1.6 and a dynamic pressure equal to 11.6 psf (555 N/m^2) were obtained from the third balloon-launched flight test of the Planetary Entry Parachute Program. After deployment, the parachute inflated rapidly to a full condition, partially collapsed, and reinflated to a stable configuration. After reinflation, an average drag coefficient near 0.6 based on nominal surface area was obtained. During descent, an aerodynamic trim angle was observed in a plane near several torn sails. Amplitude of the trim was approximately 15° and oscillation about trim was less than 11°. Author

N68-14638* General Motors Corp., Santa Barbara, Calif.

EXPERIMENTAL INVESTIGATIONS OF SIMULATED METEOROID DAMAGE TO VARIOUS SPACECRAFT STRUCTURES

A. R. McMillan Washington NASA Jan. 1968 145 p refs (Contract NAS9-3081)

(NASA-CR-915; TR-66-67) CFSTI: $3.00 CSCL 22B

A theoretical and experimental program has been performed to evaluate high-velocity impact damage to structures composed of two thin metallic sheets spaced some distance apart. The results of this study are applicable to the impact of meteoroids against space vehicles. A hydrodynamic treatment, combined with experiments, shows that the damage mechanisms to be considered for the second sheet are gross deformation, tensile failure, and spallation. Gross deformation and tensile failure were treated with a blast-loaded thin-shell analysis, and spallation with a two-dimensional elastic–plastic treatment. Multisheet (more than two simple sheets) structures were also analyzed and found to provide less protection within the same total structural thickness and weight than two-sheet structures. Honeycombs between the two sheets were found to be detrimental to the impact resistance of two-sheet structures. An analysis was also performed to assess the area-time of exposure for a 0.99 probability of no failure. This analysis is presented. Author

N68-14965*# National Aeronautics and Space Administration, Washington, D. C.

SCIENTIFIC SATELLITES

William R. Corliss 1967 828 p refs

(NASA-SP-133) GPO: $3.00 CSCL 22B

A detailed compilation of the equipment and instrumentation of scientific satellites is presented, along with the history, status, and objectives of satellite science. Satellite systems described include navigation, guidance and control, communication and data handling equipment, and subsystem integration. Earth-based facilities and operations are also considered. The role of satellite dynamics is assessed, and launch vehicle and satellite design data are given. Various aspects of satellite science are discussed in terms of the geophysical and solar physics instruments, biological experiments, and the experiments associated with satellite astronomy. A bibliography of engineering reports is included. B.S.D.

N68-15570*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

AUTOMATION IN SATURN 1 FIRST STAGE CHECKOUT

B. J. Funderburk Washington Jan. 1968 84 p refs

(NASA-TN-D-4328) CFSTI: HC $3.00/MF $0.65 CSCL 22D

The first section of the document describes the hardware and software systems that have been used for or in support of automatic vehicle checkout in the laboratory and at the Michoud assembly facility. The remaining sections summarize the test procedures and computer programs used in vehicle checkout and present some observations that have been made after a review of the automation effort. The document includes information on the checkout of the Saturn I Block I stages SA-1 through SA-4, Saturn I Block II stages SA-5 through SA-10, and the upgraded Saturn I stages SA-201 through SA-206. Author

N68-16240*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EXPERIMENTAL STABILITY AND CONTROL RESULTS AT MACH 19 OF AN ENTRY VEHICLE DESIGNED FOR AN INTERMEDIATE LIFT–DRAG RATIO
Patrick J. Johnston and Robert D. Witcofski Washington Feb. 1968 52 p refs
(NASA-TN-D-4337) CFSTI: HC$3.00/MF$0.65 CSCL 22A

An exploratory investigation of the longitudinal, lateral, and directional stability and control characteristics of a lifting entry vehicle was conducted at a Mach number of 19 and a Reynolds number, based on length, of 3.05×10^6. At these conditions the boundary layer is believed to be laminar over the model. The configuration, which was characterized by a large-volume fuselage, was designed to achieve a trimmed maximum lift-drag ratio of 2.0. Realistic centers of gravity dictated by packaging studies were employed to evaluate the stability results. The effects on stability and performance of wing planform shape and size, ventral body fins, wing-tip fins, and body camber were examined. The final configuration, which included a shoulder-height wing with tip fins, achieved a trimmed maximum lift-drag ratio slightly in excess of 2.0 and was stable in pitch and sideslip over the angle-of-attack range for which it could be trimmed in pitch. Author

N68-17094*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESCRIPTION AND FLIGHT PERFORMANCE RESULTS OF THE WASP SOUNDING ROCKET
Joseph A. Yuska, James F. de Pauw, and Lowell E. Steffens Washington Feb. 1968 35 p refs
(NASA-TM-X-1518) CFSTI: HC$3.00/MF$0.65 CSCL 22D

A general description of the design and construction of the WASP sounding rocket and of the performance of its first flight are presented. The purpose of the flight test was to place the 862 pound (391-kg) spacecraft above 250,000 feet (76.25 km) on free fall trajectory for at least 6 minutes in order to study the effect of "weightlessness" on a slosh dynamics experiment. The WASP sounding rocket fulfilled its intended mission requirements. The sounding rocket approximately followed a nominal trajectory. The payload was in free fall above 250,000 feet (76.25 km) for 6.5 minutes and reached an apogee altitude of 134 nautical miles (248 km). Flight data including velocity, altitude, acceleration, roll rate, and angle of attack are discussed and compared to nominal performance calculations. The effect of residual burning of the second stage motor is analyzed. The flight vibration environment is presented and analyzed, including root mean square (RMS) and power spectral density analysis. Author

N68-17498*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
AN INVESTIGATION OF LEAKAGE OF LARGE-DIAMETER O-RING SEALS ON SPACECRAFT AIR-LOCK HATCHES
Otto F. Trout, Jr. Washington Mar. 1968 38 p refs
(NASA-TN-D-4394) CFSTI: HC$3.00/MF$0.65 CSCL 22A

An investigation has been conducted to determine the leakage of large-diameter O-ring seals for operable hatch doors and static joints with a vacuum of 1.0×10^{-6} torr on one side and atmospheric pressure on the other. The measuring techniques employed made it possible to determine the leakage of any hatch component of an air-lock system. Tests of O-ring seals 28 to 30 inches in diameter have indicated that helium leakages of less than 1.0×10^{-5} cc/sec (STP) are attainable with butyl, viton, and neoprene elastomers for operable hatch doors and static seals. Silicone elastomeric O-rings allowed considerably greater leakages. The results indicate that the leakage of O-ring seals is sufficiently low for atmospheric containment on manned spacecraft under the conditions of this investigation. Author

N68-17844*# National Aeronautics and Space Administration, Washington, D. C.
SURVEYOR 5 Preliminary Report
Dec. 1967 162 p refs
(NASA-SP-163) CFSTI: HC$3.00/MF$0.65 CSCL 22A

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N68-18615*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
COMPUTING PROGRAM FOR AXIAL DISTRIBUTION OF AERODYNAMIC NORMAL-FORCE CHARACTERISTICS FOR AXISYMMETRIC MULTISTAGE LAUNCH VEHICLES
Ragan B. Madden Washington Mar. 1968 126 p refs
(NASA-TN-D-4342) CFSTI: HC$3.00/MF$0.65 CSCL 22D

This report describes a digital computer program which calculates the axial distribution of aerodynamic normal-force characteristics for axisymmetric, multistage launch vehicles in the linear angle-of-attack range. In calculating these characteristics for a particular configuration the program utilizes available experimental data. These data cover a wide range of Mach numbers and geometric parameters and can be readily utilized to obtain similar characteristics for most launch-vehicle configurations. Author

N68-18743*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
MARINER-MARS 1964 Final Project Report
Washington NASA 1967 356 p refs
(NASA-SP-139) GPO: HC$2.50; CFSTI: MF$0.65 CSCL 22B

This report presents the story of the Mariner-Mars 1964 project from the time of its inception until October 1, 1965, when

two-way communications with the spacecraft were interrupted. By this date, the objectives of the project had been completed. However, since that time, spacecraft continued to function properly and a follow on project, called Mariner 4, was established to continue operations with the spacecraft through 1966 and 1967. Plans for tracking Mariner 4 in its path around the sun and for obtaining additional telemetry data, as discussed in this report, were successfully culminated during this follow on project. Author

N68-18822*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

WATER PRESSURE AND ACCELERATIONS DURING LANDING OF A DYNAMIC MODEL OF THE APOLLO SPACECRAFT WITH A DEPLOYED-HEAT-SHIELD IMPACT-ATTENUATION SYSTEM

Sandy M. Stubbs Washington Mar. 1968 48 p refs Film Supplement Number L-980 to this report is available on loan from NASA, Langley Res. Center

(NASA-TN-D-4275) CFSTI: HC $3.00/MF $0.65 CSCL 22B

An experimental investigation was made to determine impact water pressures, accelerations, and landing dynamics of a 1/4-scale model of the command module of the Apollo spacecraft with a deployed heat shield for impact attenuation. The landing system consisted of four vertically oriented hydraulic struts and six horizontally mounted strain straps. A scaled-stiffness aft heat shield was used on the model to simulate the structural deflections of the full-scale heat shield. Landings were made at simulated vertical parachute-letdown velocities of approximately 30 ft/sec (9.1 m/sec) full scale. Horizontal velocities from 0 to 50 ft/sec (15 m/sec), full scale, were tested, and the pitch attitudes ranged from $-33°$ to $11°$. Roll attitudes were $0°$ and $180°$, and yaw attitude was $0°$. Author

N68-19085*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

AN ANALYTICAL PROCEDURE FOR PREDICTING THE TWO-DIMENSIONAL IMPACT DYNAMICS OF SPACECRAFT LANDING GEAR

James T. Howlett Washington Mar. 1968 42 p refs

(NASA-TN-D-4434) CFSTI: HC $3.00/MF $0.65 CSCL 22B

This paper presents a method for analyzing the dynamic behavior of two-dimensional impacting struts and trusses of the type presently used in the construction of landing gear for lunar landing vehicles. The struts and trusses may contain shock absorbers. The method uses lumped masses to represent the system, and two-dimensional motion is assumed. The equations of motion are numerically integrated to obtain response time histories of each of the mass points, and to allow detailed analysis of the dynamic behavior of the system. Application of the method to a particular strut and truss indicates that axial elasticity is much more important than lateral elasticity in the dynamic behavoir. The present limitation of the method is the large amount of computer time required for problems in which the time period of interest is large compared with the period of the highest natural frequency of the system. Author

N68-19226*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

EVALUATION OF LATERAL-DIRECTIONAL HANDLING QUALITIES OF PILOTED REENTRY VEHICLES UTILIZING A FIXED BASE SIMULATION

Frank J. van Leynseele Washington Mar. 1968 34 p refs

(NASA-TN-D-4410) CFSTI: HC $3.00/MF $0.65 CSCL 22B

A simulator investigation was conducted to evaluate the lateral-directional handling qualities of piloted reentry vehicles. The lateral-directional parameters were chosen to represent a sample of dynamic characteristics typical of reentry-vehicle configurations. The evaluations were made by using a three-degree-of-freedom fixed-base simulator with a pseudo-outside world visual display (contact analog). The investigation showed that the pilots preferred the ratio of the roll transfer function numerator frequency to the Dutch roll frequency to be unity, independent of the magnitude of bank angle to sideslip angle ratio. They objected to an excessive amount of sideslip-angle excitation with ailerons when the ratio of the roll transfer function numerator frequency to the Dutch roll frequency differed from unity, the bank angle to sideslip angle ratio was low, and the yawing moment due to aileron was large. The evaluation also established that large rolling-motion excursions led to pilot miscoordination when the roll transfer function numerator frequency to Dutch roll frequency was larger than unity and the bank angle to sideslip angle ratio was large. A comparison of the results obtained with the three-degree-of-freedom contact-analog simulator and results obtained during a related study with a five-degree-of-freedom variable-stability T-33 airplane showed good correlation. Author

N68-19275*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

VEHICLE ATTITUDE DETERMINATION WITH A SINGLE ONBOARD CAMERA

Richard J. Bendura, Allen B. Henning, and Robert E. Smith, Jr. Mar. 1968 27 p refs

(NASA-TN-D-4359) CFSTI: HC $3.00/MF $0.65 CSCL 17G

Application of a postflight photographic method for determining the attitude history of a vehicle equipped with a single onboard camera is presented. Also included is an appendix showing the equation and geometric relationships of the method. For application, a minimum of two earth-related points need be identified on each photograph and the location of the vehicle with respect to the earth must be determined. In addition, the orientation of the camera axes system with respect to the vehicle is required. The method requires no other onboard instrumentation. The method was applied in determining the spacecraft attitude for a portion of the first flight test of the Planetary Entry Parachute Program (PEPP). The spacecraft was equipped with two relatively lightweight and inexpensive 16-mm motion picture cameras which photographed the surface of the earth. Data were obtained for altitudes ranging from 130,000 to 143,000 feet (40 to 44 kilometers). A comparison is made of the results independently obtained from each camera with ground based tracking data and with an azimuth datum point from an onboard magnetometer direction finding system. Author

N68-20198*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

STRESSES CAUSED BY AN IN PLANE LINE LOAD USED TO ROTATE A THIN-WALLED SPHERICAL SATELLITE

W. Jefferson Stroud and Nancy P. Sykes Washington Apr. 1968 36 p refs

(NASA-TN-D-4425) CFSTI: HC $3.00/MF $0.65 CSCL 22B

The stress resultants and deformations which are brought about by a sinusoidal in-plane line load acting along a great circle of a spherical satellite of the Echo type are calculated and are presented in contour plots and in tabular form. The line load is applied in order to rotate the thin-walled spherical satellite for station-keeping purposes. The line load is induced by the interaction of a current-carrying wire with the geomagnetic field. Linear membrane theory and numerical methods are used in the analysis. Author

N68-20467*# General Dynamics Corp., San Diego, Calif.

EVALUATION OF THE EFFECTS OF SPACE ENVIRONMENT EXPOSURE ON INDEX OF REFRACTION AND EXTINCTION COEFFICIENTS OF APOLLO WINDOW MATERIALS

J. T. Neu, E. J. Philbin, P. Mahadevan, and J. Compton Washington NASA Apr. 1968 112 p refs

(Contract NAS9-4948)

(NASA-CR-1019; GDC-DBE-67-001) CFSTI: HC $3.00/MF $0.65 CSCL 20F

Temperature and radiation effects were studied on fused silica, Vycor, and aluminosilicate glass used for Apollo windows. Transmittance and index of refraction were measured as a function of wavelength at room and elevated temperatures prior to irradiation with a dosage that simulated a 30-day Apollo mission.

Transmittance measurements were repeated following this exposure, and additional measurements were made with a 3-day dose equivalent and also a 0.3-day dose. For the last, no change in transmittance was observed for any of the materials. For the prolonged exposure, there is a sizeable reduction in transmittance of all three materials in the ultraviolet region and very little change in the infrared at room temperature, and transmittance is lowered in both regions at elevated temperatures. While increased optical absorption in the ultraviolet lowers transmittance, the increased absorptance of the ultraviolet bands is not sufficiently high to affect refractive index. Extinction coefficients are also tabulated as a function of temperature for these Apollo window materials. M.W.R.

N68-21260*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FEASIBILITY STUDY OF OPTIMUM ON–OFF ATTITUDE CONTROL SYSTEM FOR SPACECRAFT

John D. Regetz, Jr. and Thomas M. Nelson Washington Apr. 1968 24 p

(NASA-TN-D-4519) CFSTI: HC$3.00/MF$0.65 CSCL 22B

Attitude control of orbiting spacecraft is generally performed in an on–off mode; no corrective thrust is provided until a preset angular error is obtained. For a given disturbance torque, the phase-plane trajectory then depends on the size of the angular impulse imparted during thrusting. For comparatively large angular impulses, the trajectory contacts both deadband limits alternately; for small impulses, the disturbance reverses the spacecraft angular rate before it can contact one side of the deadband. If the thrustor firing time is controlled, a limit cycle can be obtained in which the maximum angular excursion within the deadband is such that the spacecraft just misses contacting the opposite deadband limit. The fuel consumption is then minimum because a single-sided trajectory is maintained, and the number of thrust pulses during a given control period is minimized because the time between firings is a maximum. A single-axis control system that provides this optimum trajectory was functionally designed and investigated by simulation on an analog computer. The system calculates spacecraft angular velocity and acceleration of the deadband limit, and determines the thrustor "on" time which produces the optimum trajectory.

N68-21443*# National Aeronautics and Space Administration, Washington, D. C.

SURVEYOR 6. A PRELIMINARY REPORT

Mar. 1968 173 p refs

(NASA-SP-166) CFSTI: HC$3.00/MF$0.65 CSCL 22B

Preliminary results of analyses of scientific data gathered during the Surveyor VI mission are reported. Assessed are the following: television observations from Surveyor VI; lunar surface mechanical properties; lunar surface temperatures and thermal characteristics; astronomical observations; chemical analyses of the moon at the Surveyor VI landing site; electromagnetic properties (magnet test); theory and processes relating to the lunar maria; and the selenographic location of Surveyor VI. S.C.W.

N68-21758*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

AN ANALYTICAL INVESTIGATION OF THE AERODYNAMIC AND PERFORMANCE CHARACTERISTICS OF AN UNPOWERED ROTOR ENTRY VEHICLE

Alan D. Levin and Ronald C. Smith Washington Apr. 1968 43 p refs

(NASA-TN-D-4537) CFSTI: HC$3.00/MF$0.65 CSCL 22B

Analysis of the aerodynamic characteristics of a rotor in autorotative flight. These characteristics have been combined with those of a capsule to study the performance characteristics of a rotor entry vehicle. Performance parameters such as range, deceleration, and heating were determined for a vehicle entering the atmosphere from earth orbit. The effects of rotor to capsule diameter ratio on the entry parameters and the effect of delaying rotor deployment on the range capability were investigated. Substantial gains in lateral range can be obtained by the addition of a rotor to a lifting capsule while maximum deceleration changes very little. The aerodynamic heating on the rotor was found to be severe enough to require possibly delaying deployment of the rotor until after the peak heating region has been passed. Delaying rotor deployment reduced the lateral range capability. Author

N68-21778*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

FLIGHT TEST OF A 30-FOOT-NOMINAL-DIAMETER CROSS PARACHUTE DEPLOYED AT A MACH NUMBER OF 1.57 AND A DYNAMIC PRESSURE OF 9.7 POUNDS PER SQUARE FOOT

John S. Preisser and Clinton V. Eckstrom Washington Apr. 1968 53 p refs

(NASA-TM-X-1542) CFSTI: HC$3.00/MF$0.65 CSCL 22B

A 30-foot (9.1-meter) nominal-diameter cross-type parachute with a cloth area (reference area) of 709 square feet (65.9 square meters) was flight tested. The test parachute was ejected from an instrumented payload by means of a mortar when the system was at a Mach number of 1.57 and a dynamic pressure of 9.7 psf. The parachute deployed to suspension-line stretch in 0.44 second with a resulting snatch-force loading of 1100 pounds. Canopy inflation began at 0.58 second and a first full inflation was achieved at approximately 0.77 second. The maximum opening load occurred at 0.81 second and was 4255 pounds. Calculated values of axial-force coefficient during the deceleration portion of the test varied between 0.35 and 1.05, with an average value of 0.69. During descent, canopy-shape variations had reduced to small amplitudes and resultant pitch–yaw angles of the payload with respect to the local vertical averaged less than 10°. The effective drag coefficient, based on the vertical components of velocity and acceleration during system descent, was 0.78. An earlier test of a 25.2-foot nominal-diameter cross parachute is described in appendix A, along with a brief analysis of the riser-line failure suffered during the test. Author

N68-21833*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

PERFORMANCE OF A 16.6-METER-DIAMETER CROSS PARACHUTE IN A SIMULATED MARTIAN ENVIRONMENT

Reginald R. Lundstrom, Wayne L. Darnell, and Lucille C. Coltrane Washington Apr. 1968 38 p refs

(NASA-TM-X-1543) CFSTI: HC$3.00/MF$0.65 CSCL 22B

Inflation and drag characteristics of a 54.4-foot nominal-diameter cross parachute, deployed at a Mach number of 1.65 and a dynamic pressure of 12.68 lb/sq ft, were obtained from the fourth balloon-launched flight test of the planetary entry parachute program. These data as well as the stability characteristics of the parachute during subsonic descent are presented. After deployment the parachute quickly inflated to a full condition, partially collapsed, and then gradually reinflated while undergoing rapid oscillations between overinflation and underinflation. The oscillations began while the parachute was still at supersonic speeds and continued to low subsonic speeds well below an altitude of 90,000 feet. These canopy instabilities produced large cyclic variations in the parachute's drag coefficient. The average value of drag coefficient was about 0.8 to 0.9 at subsonic speeds and slightly lower at supersonic speeds. These drag coefficient values were based on the actual fabric surface area of the parachute canopy. The parachute sustained minor damage consisting of two canopy tears and abrasions and tears on the riser line. It is believed that this damage did not produce a significant change in the performance of the parachute. Author

N68-22213*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.

CHEMICALLY INDUCED IGNITION IN AIRCRAFT AND SPACECRAFT ELECTRICAL CIRCUITRY BY GLYCOL/WATER SOLUTIONS

W. R. Downs Washington Apr. 1968 17 p refs
(NASA-TN-D-4327) CFSTI: $3.00 CSCL 22B

Electrical circuitry of military aircraft and spacecraft consists, in part, of insulated silver-covered copper wires and components. This circuitry creates a potential flammability hazard when solutions of glycol/water come in contact with either a bare or a defectively insulated wire or component carrying direct current. The hazard arises from chemical reactivity of the silver-covered copper anode in contact with glycol/water solutions. Similar reactivity does not occur with pure copper, nickel-covered copper, or tin-plated copper elements in electric circuits. Some chemical and physical properties of glycol/water fluids are presented, and glycol-induced corrosion of metals and corrosion inhibitors are discussed. A tentative chemical mechanism for the reactions of glycol/water solutions with silver wire carrying direct current is proposed. Author

N68-22262*# National Aeronautics and Space Administration, Washington, D. C.
RUSSIAN ROCKETRY, A HISTORICAL SURVEY
I. A. Slukhai 1968 152 p refs Transl. into ENGLISH of the publ. "Rakety i Traditsii" Moscow, Voennoe Izd. Min. Oborony SSSR, 1965 Published by Israel Program for Sci. Transl. for NASA and NSF
(NASA-TT-F-426; TT-67-51363) CFSTI: HC $3.00/MF $0.65 CSCL 22A

The contribution of Soviet scientists and designers to rocket technology is recounted. Pre- and post-World War 2 activities are discussed, with emphasis placed on the role of the rocketeer in the Army, Air Force, and Navy. Space exploration achievements are noted, along with the use of meteorological rockets for studying the upper layers of the atmosphere. M.G.J.

N68-22301*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
DYNAMIC STABILITY OF A 4.6-METER DIAMETER 120° CONICAL SPACECRAFT AT MACH NUMBERS FROM 0.78 TO 0.48 IN A SIMULATED MARTIAN ENVIRONMENT
Charles H. Whitlock and Richard J. Bendura Washington May 1968 28 p refs
(NASA-TN-D-4558) CFSTI: HC $3.00/MF $0.65 CSCL 22B

Subsonic dynamic stability characteristics of the spacecraft were determined from flight data in a simulated Martian environment. The results cover a Mach number range from 0.78 to 0.48, and a Reynolds number range from 200,000 to 100,000 (based on 15-foot (4.6 meter) spacecraft diameter). Assumptions of the analysis include linear static aerodynamics and invariant dynamic stability derivative $C_{mg} + C_{m\alpha}$, with angle of attack. Reduction of the data on a cycle-by-cycle basis gives $C_{mg} + C_{m\alpha}$, values near -0.135 with an uncertainty of ± 0.105 over the range of the test. Trajectory simulation studies indicate that a reasonable simulation can be obtained by using a damping coefficient of -0.135, and that ± 0.105 is a realistic value for the accuracy limit. Author

N68-22742*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
WIND TUNNEL INVESTIGATION OF FLUCTUATING PRESSURES ON A 1/10-SCALE CENTAUR MODEL AT TRANSONIC SPEEDS
Bernard J. Blaha Washington May 1968 19 p refs
(NASA-TM-X-1574) CFSTI: HC $3.00/MF $0.65 CSCL 22D

Wind tunnel tests of a 1/10-scale Centaur model with a Surveyor nose cone were conducted over a range from Mach 0.55 to 1.95 to determine amplitudes and frequencies of fluctuating pressures that exist on the model surface at these speeds. Tests were conducted for roll angles of 0°, 90°, and 180° at 0° angle of attack. Peak-to-peak fluctuating pressure levels up to 30 percent of tunnel dynamic pressure were measured immediately downstream of the cone shoulder, the umbilical island, and on the boost pump fairing. Background noise in the tunnel made a detailed frequency analysis impractical. Author

N68-22953*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
STATIC LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF SEVERAL CONFIGURATIONS USED IN THE DEVELOPMENT OF THE LITTLE JOE 2-APOLLO TEST VEHICLE AT MACH NUMBERS FROM 0.056 TO 4.65
Robert H. Moore, Jr. Washington May 1968 225 p refs
(NASA-TN-D-4439) CFSTI: HC $3.00/MF $0.65 CSCL 22D

Investigations were conducted to determine the static longitudinal aerodynamic characteristics of several configurations of the Little Joe-Apollo and Little Joe II-Apollo test vehicles at angles of attack from 0° to 90° at the low-subsonic Mach numbers and at angles of attack from $-15°$ to $+15°$ at transonic and supersonic Mach numbers. The tests covered Mach numbers from 0.056 to 4.65. The Little Joe-Apollo configuration was unstable at the subsonic and low-supersonic speeds. Test results indicate that the production-model Little Joe II-Apollo configuration (with trailing-edge control surfaces on the booster fins) is stable throughout the Mach number range tested and that the trailing-edge control surfaces are effective for all Mach numbers tested. This configuration was used in the developmental tests of the Apollo launch escape system. Author

N68-23438*# Stanford Research Inst., Menlo Park, Calif.
DESIGN OF GUIDANCE AND CONTROL SYSTEMS FOR OPTIMUM UTILIZATION OF INFORMATION
L. Meier, J. Peschon, B. Ho, R. Larson, and R. Dressler Washington NASA May 1968 129 p refs
(Contract NAS2-3476; SRI Proj. 5967)
(NASA-CR-997) CFSTI: HC $3.00/MF $0.65 CSCL 09C

A comprehensive scheme is described for designing control systems in the presence of uncertainties about initial plant state and plant parameters, disturbance inputs, and measurement noises. The method is based upon treating these random effects as perturbations on a nominal trajectory corresponding to plant operation without the random effects and with a nominal control as input. As a first approximation, the deterministic optimum is used for the nominal control, with optimal linearized estimation and control of the plant about the nominal trajectory. Next, the sensitivity of system performance to the random effects is computed; if this sensitivity is too great, then improved performance may be obtained by use of adaptive control and modification of the nominal control. If adaptive control is not used, reduced sensitivity can also be obtained by modifying the linear estimation and control in addition to the nominal control. Performance computations are accurate to terms of second degree in the perturbations. Optimization of the measurement system from two points of view is considered. Author

N68-24738*# Boeing Co., Seattle, Wash.
LUNAR ORBITER 3: PHOTOGRAPHIC MISSION SUMMARY
Washington NASA May 1968 117 p
(Contract NAS1-3800)
(NASA-CR-1069) CFSTI: HC $3.00/MF $0.65 CSCL 22B

Summary information is given on the photographic mission of Lunar Orbiter III. The primary objective of the mission was to obtain, from lunar orbit, detailed photographic information of various lunar areas, to assess their suitability as landing sites for Apollo and Surveyor spacecraft, and to improve our knowledge of the moon. The performance of each of the subsystems is discussed along with the operational performance of the spacecraft. The general design of the spacecraft is given, and launch preparation and operations are delineated. The performance and function of each of the ground stations and facilities necessary to sustain mission operations are also considered. Details are given on the photographic, lunar environmental, tracking, and performance data obtained from the spacecraft. Tabulated data are presented on a comparison of predicted and actual performance. B.S.D.

N68-24945*# General Dynamics Corp., San Diego, Calif.
DYNAMIC STABILITY OF SPACE VEHICLES. VOLUME 12: RE-ENTRY VEHICLE LANDING ABILITY AND CONTROL
B. J. Kuchta Washington NASA May 1968 80 p refs
(Contract NAS8-11486)
(NASA-CR-946) CFSTI: HC$3.00/MF$0.65 CSCL 22B

The control and stability aspects of spacecraft just prior to and during touchdown are considered. The ground rules and requirements set forth for landing criteria are based upon present day knowledge. Low lift-over-drag ratio operational spacecraft with a parachute recovery system are discussed with respect to maneuverable and nonmaneuverable landing systems. A description of the Apollo re-entry and landing system is used to describe the general problem areas and constraints of a re-entry and landing system. Horizontal landing spacecraft of fixed and variable geometry are answered, and a method for evaluating landing characteristics of horizontal landing spacecraft is presented. A powered rotor and sustained-propulsive-lift system are two powered modes examined to assist powered landing spacecraft. B.S.D.

N68-24964*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
AERODYNAMIC CHARACTERISTICS OF A MODIFIED CONE-CONICAL-FRUSTUM ENTRY CONFIGURATION AT MACH 6.0
George C. Ashby, Jr. and W. Frank Staylor Washington, D. C. Jun. 1968 19 p refs
(NASA-TN-D-4598) CFSTI: HC$3.00/MF$0.65 CSCL 22B

An investigation of the internal arrangement and the stability and control of a modified cone-conical frustum entry vehicle has been conducted. The internal arrangement was made to house eight men in orbit for 24 hours and included a propulsive lift system for hover and landing. The experimental tests were conducted at Mach 6.0 and a Reynolds number based on model length of 6.3×10^6. Trailing-edge flaps symmetrically arranged were used to trim the vehicle. The results show that the configuration is stable about all axes and can be trimmed about a center of gravity at 60 percent of the length with a maximum lift-drag ratio of 1.57 and a static margin of 3.5 percent. Calculations made by using a basic Newtonian computer program predicted the forces very well but overestimated the moments. Author

N68-25358*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
LUNAR FAR-SIDE COMMUNICATION SATELLITES
P. E. Schmid Washington, D. C. Jun. 1968 23 p refs
(NASA-TN-D-4509) CFSTI: HC$3.00/MF$0.65 CSCL 22B

This report discusses a lunar communication satellite relaying signals to and from points up to 200 km above the lunar far side surface. Two lunar satellite geometries are considered, namely, a libration point satellite anchored 65,000 km behind the moon and a 1000 km lunar orbiting relay satellite. Author

N68-25577*# McDonnell-Douglas Co., St. Louis, Mo.
PROJECT GEMINI: A TECHNICAL SUMMARY
P. W. Malik and G. A. Souris Washington, D. C. NASA Jun. 1968 350 p
(Contract NAS9-170)
(NASA-CR-1106) CFSTI: HC$3.00/MF$0.65 CSCL 22B

Spacecraft and major systems, overall mission planning, and experiments are detailed for the Gemini project. Following an introduction that notes the modular design concept, presents the major objectives, and stresses safety first; the spacecraft reentry module, adapter module, and heat protection are described. The structural qualification testing and the reliability and quality assurance programs are summarized. Attention is given to the electrical, communication and tracking, rendezvous radar, digital command, and time reference systems; as well as to the instrumentation and recording, guidance and control, propulsion, environmental control, escape, and landing and recovery systems. Pyrotechnics and the crew station are also considered, as are details for the target docking adapter and the augmented target docking adapter. M.W.R.

N68-25820*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
THE FABRICATION AND TESTING OF PAGEOS 1
Louis A. Teichman Washington, D. C. Jun. 1968 55 p refs
(NASA-TN-D-4596) CFSTI: HC$3.00/MF$0.65 CSCL 22B

As an aid in assuring the successful construction and deployment of PAGEOS I, detailed fabrication process specifications were prepared and an extensive testing program was conducted. This large body of information on fabrication processes, testing techniques, and material properties is summarized herein as an indication of the present state of the art of inflatable sphere technology. Author

N68-26645*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
ANALYTICAL INVESTIGATION OF EFFECTS OF PHYSICAL AND AERODYNAMIC PARAMETERS ON DYNAMIC BEHAVIOR OF PROJECT FIRE REENTRY VEHICLE
Jacob H. Lichtenstein Washington Jun. 1968 57 p refs
(NASA-TM-X-1589) CFSTI: HC$3.00/MF$0.65 CSCL 22B

The heat-transfer characteristics of a body entering the earth's atmosphere at superorbital velocities are important in the consideration of any planetary mission. In an attempt to measure these characteristics experimentally, Project Fire was undertaken. During the design phase of the reentry vehicle, information was necessary as to whether certain physical and aerodynamic parameters would become important design considerations. Consequently, an analytical study was undertaken to evaluate the effects of these parameters on the dynamic behavior of the reentry vehicle. The results of the investigation showed that changes in most of the parameters considered, for instance, ±21 percent in the moments of inertia and ±50 percent in the spin rate, would not affect the dynamic behavior during the main heat-measuring period (the first 40 seconds) enough to cause serious design problems. However, mass-distribution asymmetry that would displace the center of gravity 1/8 inch (0.003 meter) or more from the vehicle axis of symmetry would create angle-of-attack disturbances large enough to be significant. Author

N68-26814*# Boeing Co., Seattle, Wash.
LUNAR ORBITER 4: PHOTOGRAPHIC MISSION SUMMARY, VOLUME 1
Washington NASA Jun. 1968 126 p
(NASA-CR-1054; D2-100754-1, V. 1) CFSTI: HC $3.00/MF $0.65 CSCL 22B

The objectives, launch preparation, and operations of the Lunar Orbiter 4 mission are described. The primary objective was to perform a broad systematic photographic survey of lunar surface features to serve as a basis for selecting sites for more detailed scientific study by subsequent orbital and landing missions. All mission objectives were accomplished. Some of the more significant accomplishments of the mission included: (1) the first photographic mapping mission of a celestial body, other than earth, from an orbiting spacecraft; (2) photographic coverage (over 99%) of nearside of the moon of resolutions at least 10 times better than Earth-based observations; (3) the first detailed near vertical photos of the geologic formations of the Orientale basin at the western limb; and (5) photo data by which photo sites for the Lunar Orbiter 5 mission were relocated to optimize and maximize the scientific data requirements. A.L.

N68-28198*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
THE EXPLORER 23 MICROMETEOROID SATELLITE. DESCRIPTION AND RESULTS FOR THE PERIOD NOVEMBER 6, 1964, THROUGH NOVEMBER 5, 1965

Robert L. O'Neal, comp. Washington Jun. 1968 111 p refs
(NASA-TN-D-4284) CFSTI: HC $3.00/MF $0.65 CSCL 22A

The Explorer XXIII was placed in orbit on November 6, 1964, with a perigee of 464 km and an apogee of 980 km. It carried stainless-steel pressurized penetration detectors, impact detectors, and cadmium sulfide cells to provide data on the near-earth meteoroid environment. In addition, the spacecraft was designed to provide data on the effects of the space environment on the operation of capacitor type of penetration detectors and solar-cell power supplies. The spacecraft operated satisfactorily during the 1-year design life, and the objectives of the mission were accomplished. The puncture rates obtained for stainless steel on Explorer XXIII are close to the puncture rates obtained for beryllium copper on Explorer XVI. The confidence limits include the data points obtained from Explorer XVI. A total of two counts were recorded by the capacitor-detector experiment during the 1-year reporting period. No conclusions can be reached concerning the effects of the space environment on the detector operation. The capacitor-detector monitoring circuit indicated that both detectors maintained bias voltage during the 1-year period. The counting rates on the high- and medium-sensitivity meteoroid-impact-detection systems when converted to equivalent puncture rates gave much higher averages than did the pressurized-cell puncture rates. The data from these two systems appear questionable. A meteoroid penetration model was developed, and defined for stainless steel. Author

N68-28202*# Boeing Co., Seattle, Wash.
LUNAR ORBITER 5: PHOTOGRAPHY Final Report
Washington NASA Jun. 1968 229 p
(Contract NAS1-3800)
(NASA-CR-1094; D2-100755-2, V. 2) CFSTI: HC $3.00/MF $0.65 CSCL 22A

This Lunar Orbiter final report contains a description of Mission V planning, its conduct with respect to photography, and an evaluation of the photographic results. Data pertinent to analysis and interpretation of the photographs by the user are included. Near-vertical, convergent telephoto stereo-scopic, and oblique photography was used to obtain the desired data. Either single- or multiple-frame sequences were taken for coverage appropriate for the particular site. All photography planned for the mission was accomplished and the photographs were reconstructed. Author

N68-28379*# National Aeronautics and Space Administration, Washington, D. C.
COMMUNICATIONS SATELLITES. A CONTINUING BIBLIOGRAPHY WITH INDEXES
Jul. 1968 38 p refs
(NASA-SP-7004(04)) CFSTI: HC $3.00/MF $0.65 CSCL 22B

Annotated references on communications satellites are taken from the reports and journals announced in the NASA abstract journals between April and December 1967. All aspects of communications satellite theory and technology are covered in the 100 abstracts presented; and topics covered include television broadcasting, telemetry, multistation systems, economic and legal problems, and specific satellites. A subject index and a personal author index are included for the references. M.W.R.

N68-28426*# Systems Technology, Inc., Hawthorne, Calif.
A STUDY OF FULLY-MANUAL AND AUGMENTED-MANUAL CONTROL SYSTEMS FOR THE SATURN 5 BOOSTER USING ANALYTICAL PILOT MODELS
H. R. Jex, G. L. Teper, D. T. Mc Ruer, and W. A. Johnson
Washington NASA Jul. 1968 105 p refs
(Contract NAS2-1868-5)
(NASA-CR-1079; TR-152-1)CFSTI: HC $3.00/MF $0.65 CSCL 22D

The preliminary design of manual control systems for large flexible boosters of the Saturn V class was investigated by manual control systems analysis techniques. The approach employed empirically based mathematical models for the pilot mission-derived design criteria and constraints; and a set of efficient control system analysis and synthesis tools. Two roles for the pilot were studied in detail: fully-manual control and a series pilot plus stability-augmented booster. The control system characteristics evolved included the different describing functions likely to be adopted by the pilot, and the best loop structure from the criteria of simplicity, good handling qualities, wind load relief, and attention of the pilot's remnant. It was shown that fully-manual control of one axis was feasible, but that tracking performance, load relief, and handling would be poor. The augmented-manual control system included lead-double-lag pitch equalization in the inner loop, an integrating filter downstream of the pilot in the outer loops, and pilot-selected switching between trajectory and load relief control modes by shifting his attention from the attitude to the accelerometer display. Author

N68-28690*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THRUST-VECTOR CONTROL REQUIREMENTS FOR LARGE LAUNCH VEHICLES WITH SOLID-PROPELLANT FIRST STAGES
Fred Teren, Kenneth I. Davidson, Janos Borsody, and Carl J. Daniele Washington Jul. 1968 49 p refs
(NASA-TN-D-4662) CFSTI: HC $3.00/MF $0.65 CSCL 22D

Thrust vector deflection (TVD) requirements are calculated for control of two solid-based launch vehicles—the 260-inch solid-SIVB (with a family of payload shapes and densities) and a large two-stage clustered solid vehicle (SSOPM) designed to deliver 450,000 kg of payload to orbit. TVD requirements for 99 percent wind loads were found to be 2.4° and 1.17° for 260-inch solid-SIVB and SSOPM, respectively. Requirements for other effects added about 0.35° for both vehicles. About 1° of TVD is required for control during tailoff for SSOPM. The TVD requirements for winds are reduced by using stationary basefins or movable canards. Author

N68-28891*# Boeing Co., Seattle, Wash.
LUNAR ORBITER 5. PHOTOGRAPHIC MISSION SUMMARY
Washington NASA Jul. 1968 157 p
(Contract NAS1-3800)
(NASA-CR-1095; D2-100755-1, V. 1) CFSTI: HC $3.00/MF $0.65 CSCL 22B

The mission of Lunar Orbiter 5 was to provide additional photography of specific candidate Apollo landing sites to complete the NASA photographic requirements for each site. In addition, specific areas and features were to be photographed to provide data for overall lunar scientific investigation. Presented in this report is a large number of selected lunar photographs obtained on this mission, including wide angle and telephoto frames. The report also contains program objectives and descriptions; launch vehicle and spacecraft preparations and operations; mission profile; spacecraft and subsystem performances; ground system performance; spacecraft and flight path control; photographic, environmental, and tracking data; performance telemetry; and mission evaluation. K.W.

N68-28997*# Boeing Co., Seattle, Wash.
LUNAR ORBITER 4. EXTENDED-MISSION SPACECRAFT OPERATIONS AND SUBSYSTEM PERFORMANCE
Washington NASA Jun. 1968 107 p
(Contract NAS1-3800)
(NASA-CR-1092; D2-100754-4, V. 4) CFSTI: HC $3.00/MF $0.65 CSCL 22B

This volume describes the spacecraft, its mission, flight and control operations, and spacecraft performance during the extended mission. Spacecraft command activities, telemetry, and flight path control are discussed, and data are presented on radiation and micrometeoroids. The purposes and functioning of special experiments on lunar surface conductivity, voice relay, ionosphere effects, and the Manned Space Flight Network/Apollo Goss Navigational Qualification Support are stated. Spacecraft subsystem performance data and results derived from periodic monitoring of

spacecraft telemetry are provided. Also given are performance data of special flight tests on gyro drift, Canopus and star tracking, traveling wave tube amplifier operation and cycling, battery discharge, antenna rotation, camera functioning, and paint degradation. K.W.

N68-29962*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EXPERIMENTAL INVESTIGATION OF THE USE OF SOFT SIDE LEGS TO IMPROVE TOUCHDOWN STABILITY OF LEGGED LANDING VEHICLES
Robert W. Herr Washington Aug. 1968 23 p refs
(NASA-TN-D-4680) CFSTI: HC$3.00/MF$0.65 CSCL 22B

The effectiveness of a concept to improve the landing stability of lunar-module-type vehicles has been investigated experimentally by utilizing a 1/6-scale model of an early engineering version of the lunar module. Results of landing-stability tests made with equal-force shock absorbers in all four leg assemblies are compared with results obtained with very soft shock absorbers in the side legs. This comparison indicates that landing stability can be greatly improved with the use of soft side struts if the fore and aft feet are roughly alined with the flight path at touchdown. For touchdowns at large yaw angles, the landing stability with soft side shock absorbers was at least as good as that obtained with equal-force shock absorbers. Author

N68-29993*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
FLIGHT TEST OF A 40-FOOT-NOMINAL-DIAMETER DISK-GAP-BAND PARACHUTE DEPLOYED AT A MACH NUMBER OF 2.72 AND A DYNAMIC PRESSURE OF 9.7 POUNDS PER SQUARE FOOT
Clinton V. Eckstrom and John S. Preisser Washington Aug. 1968 41 p refs
(NASA-TM-X-1623) CFSTI: HC$3.00/MF$0.65 CSCL 22B

A 40 foot nominal diameter (12.2 meter) disk-gap-band parachute was flight tested as part of the NASA Supersonic Planetary Entry Decelerator (SPED-1) Program. The test parachute was deployed from an instrumented payload by means of a deployment mortar when the payload was at an altitude to 158,500 feet (48.2 kilometers), a Mach number of 2.72, and a free stream dynamic pressure of 9.7 pounds per foot^2 (465 newtons per meter^2). Suspension line stretch occurred 0.46 second after mortar firing and the resulting snatch force loading was -8.1g. The maximum acceleration experienced by the payload due to parachute opening was -27.2g at 0.50 second after the snatch force peak for a total elapsed time from mortar firing of 0.96 second. A calculated average nominal axial force coefficient ranged from about 0.25 immediately after the first canopy opening to about 0.50 as the canopy attained a steady inflated shape. Although the canopy damage caused by the deployment bag penetration had no apparent effect on the functional capability of the test parachute, it may have affected parachute performance since the average effective drag coefficient of 0.48 was 9 percent less than that of a previously tested parachute of the same configuration. Author

N68-29995*# Boeing Co., Seattle, Wash.
LUNAR ORBITER 3: EXTENDED-MISSION SPACECRAFT OPERATIONS AND SUBSYSTEM PERFORMANCE
Washington NASA Jul. 1968 128 p
(Contract NAS1-3800)
(NASA-CR-1109; D2-100753-4) CFSTI: HC $3.00/MF $0.65 CSCL 22B

This report covers spacecraft control and flight path analysis and control operations conducted during the Lunar Orbiter 3 extended mission and discussed spacecraft performance during these operations. Complete data packages have been prepared for each experiment. The highlights of each special exercise and experiment are summarized. The primary objective of the Lunar Orbiter 3 extended mission was to secure information that may be used to increase the scientific knowledge of the size and shape of the Moon, the properties of its gravitational field, and the lunar environment. Secondary objectives were to conduct special exercises to determine the limits of spacecraft capabilities, develop standard operating procedures, conduct experiments to provide additional scientific data, and explore the use of Lunar Orbiter subsystems for other applications. Author

N68-30032*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
A QUASI-STEADY STATE ANALYSIS OF THE DYNAMIC BEHAVIOR OF A CONIC BODY MOVING IN A NONUNIFORM WAKE
John De Fife and Theodore F. Hughes (ITT/Federal Elec. Corp.) Washington Aug. 1968 57 p refs
(NASA-TN-D-4691) CFSTI: HC$3.00/MF$0.65 CSCL 22C

During reentry, the Apollo command module creates a wake of turbulent and reverse-flow conditions. When the earth-landing-system protective cover (forward heat shield) of the command module is jettisoned and moves within this wake, the kinetic energy of the cover is substantially reduced because of the reverse flows. Equations were developed which allowed vectorial additions of wake velocities to those velocities of the forward heat shield. From these resultant vectors and from wind-tunnel aerodynamic data, forces and accelerations were calculated, and trajectories were generated which indicated that the reverse flows within the wake had a significant effect on the dynamic behavior of the protective cover and therefore caused recontact for low initial separation velocities. Author

N68-30631*# Boeing Co., Seattle, Wash.
LUNAR ORBITER 5. EXTENDED-MISSION SPACECRAFT OPERATIONS AND SUBSYSTEM PERFORMANCE
NASA Aug. 1968 121 p
(Contract NAS1-3800)
(NASA-CR-1142; D2-100755-4, V. 4) CSCL 22 A

The Lunar Orbiter V spacecraft was tracked from the start of its extended mission on August 28, 1967 until it was intentionally crashed into the moon's nearside on January 31, 1968. During this period, the primary objectives of selenodetic data acquisition and lunar environment sampling were accomplished by ranging, tracking, and spacecraft telemetry monitoring. Included here are also descriptions of the spacecraft's flight and guidance control systems, and data on the performance of its subsystems. Author

N68-31477*# Boeing Co., Seattle, Wash.
LUNAR ORBITER 2: EXTENDED MISSION SPACECRAFT OPERATIONS AND SUBSYSTEM PERFORMANCE
NASA Aug. 1968 158 p CSCL: 22B
(NAS1-3800)
(NASA-CR-1141; D2-100752-4, V. 4) CFSTI: HC $3.00/MF $0.65

The Lunar Orbiter II spacecraft was tracked from the start of its extended mission until it was intentionally crashed on the Moon. Following this launch, Lunar Orbiter II was used primarily for Doppler and ranging calibrations. Selenodetic data that could be used in developing a lunar gravitational model that would be more meaningful were obtained by changing the Lunar Orbiter II orbit inclination from 11.9 to 17.5 degrees at the beginning of the extended mission. Lunar environmental events of significance were proton events indicated by telemetry. Looper radiation increased 39 rads during the first event and 32.5 rads during the second. Seven micrometeoroid hits were recorded during the extended mission.

Special tests were conducted to obtain additional data on performance characteristics of the various subsystems with the spacecraft in unique attitudes and/or environmental configurations. Author

N68-31978*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE DYNAMIC CHARACTERISTICS OF SATELLITES HAVING LONG ELASTIC MEMBERS
Harold P. Frisch Washington Aug. 1968 42 p refs
(NASA-TN-D-4576) CFSTI: HC$3.00/MF$0.65 CSCL 22B

Many satellites, such as ATS-A, ATS-D, DODGE, RAE, etc., have clamped to the surface of their central body long elastic members which when set into vibratory motion can significantly influence the motion of the central body. If such a satellite is reasonably symmetrical, we can predict its dynamic characteristics by modeling the entire satellite as a symmetric double-beam system; that is, by a rigid symmetric central body having clamped to its surface two long, diametrically opposed uniform elastic beams with tip weights possessing identical physical and geometrical properties. In this paper, dimensionless equations which define the natural modes and frequencies of such a satellite system are derived and solved. The solutions are outlined in graphical form and then used to solve the equations that describe the elastic response of the satellite to an arbitrary periodic forcing function. The results in both graphical and analytical form make it possible to predict with slide-rule accuracy the natural frequencies of any satellite that can be modeled as a symmetric double-beam system. Author

N68-33008*# Boeing Co., Seattle, Wash.
MAINTAINABILITY OF MANNED SPACECRAFT FOR LONG-DURATION FLIGHTS. VOLUME 1: SUMMARY REPORT
Washington NASA Aug. 1968 57 p refs
(Contract NAS2-3705)
(NASA-CR-1108; D2-113204-1) CFSTI: HC $3.00/MF $0.65 CSCL 22B

A 99% probability of crew survival is a basic constraint in the analysis. Spacecraft of four representative but widely varying missions, one Earth-orbital and one interplanetary each in the mid-1970 and mid-1980 time periods, are examined to the replaceable component level. Detailed maintenance analyses of subsystems and components, vehicle configuration optimizations performed with a unique computer program, and statistical results of several hundred mission simulations are described and evaluated. The effects of hardware reliability and failure rates, skills, environmental factors, mission durations and resupply potential, and various resources are considered in many interrelationships. Optimum distributions of redundant and spare items to be included on board each spacecraft configuration for assuring mission success are identified, and their implications as to operational requirements and design philosophies are discussed. Tables, charts, and graphs summarizing analytical results and displaying parametric sensitivities are provided. Gross cost estimates are also included to indicate trends and place the respective missions in context relative to each other. Author

N68-33332*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ATLAS-CENTAUR FLIGHT PERFORMANCE FOR SURVEYOR MISSION B
Washington Sep. 1968 152 p refs
(NASA-TM-X-1616) CFSTI: HC$3.00/MF$0.65 CSCL 22D

The second operational Atlas-Centaur launch vehicle AC-7, with Surveyor SC-2, was launched on September 20, 1966. The flight profile was a direct-ascent mission to inject the Surveyor into a lunar intercept trajectory. Subsequent to injection, a vernier engine on the Surveyor failed to fire. The spacecraft tumbled out of control and failed to complete the mission. This report includes a flight performance evaluation of the Atlas-Centaur launch vehicle systems from lift-off through spacecraft separation and Centaur retromaneuver. Author

N68-33553*# National Aeronautics and Space Administration, Washington, D. C.
SURVEYOR 7 Preliminary Report
May 1968 304 p refs
(NASA-SP-173) CFSTI: HC$3.00/MF$0.65 CSCL 22B

Principal scientific results are presented on the Surveyor 7 which successfully landed on the outer rim flank of the large crater Tycho in the southern part of the moon. The extensive data obtained from television observations and measurements of the lunar surface are analyzed to determine the mechanical properties, surface temperatures and thermal characteristics, electromagnetic properties, and radar reflectivity. Details are also given on the surface sampler and the alpha scattering experiment; preliminary results of the chemical analyses of these lunar soil samples are presented. Implications of the alpha scattering experiment are discussed in relation to lunar landing sites. Postlanding tracking acquisition and analysis to determine the selenocentric location of the probe are described. The ability of earth stations to direct very narrow laser beams to a specific location on the lunar surface was verified. B.S.D.

N68-33683*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUCCESSFUL RESTART OF A CRYOGENIC UPPER-STAGE VEHICLE AFTER COASTING IN EARTH ORBIT
Kenneth W. Baud, Steven V. Szabo, Jr., Ronald W. Ruedele, and James A. Berns Washington Sep. 1968 44 p refs
(NASA-TM-X-1649) CFSTI: HC$3.00/MF$0.65 CSCL 22D

Successful engine restart in space of an upper stage vehicle using cryogenic propellants was accomplished for the first time with the flight of the Atlas-Centaur vehicle, AC-9. The problems unique to the restart of a vehicle using cryogenic propellants and the design concepts for solving these problems on Centaur are discussed. AC-9 flight data pertinent to the problems are also presented. Author

N68-35022*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
FIRST U.S. MANNED SIX-PASS ORBITAL MISSION (MERCURY-ATLAS 8, SPACECRAFT 16)
John H. Boynton, ed. Washington Sep. 1968 225 p refs
(NASA-TN-D-5807) CFSTI: HC$3.00/MF$0.65 CSCL 22A

The results and analyses of the third U.S. manned orbital mission are presented. The mission was accomplished October 3, 1962, as a phase of Project Mercury. Spacecraft and launch-vehicle descriptions, mission operations, and postflight analyses are included. Particular treatment is given to the investigations of spacecraft systems performance and aeromedical analyses of the pilot. Author

N68-35357*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE EVALUATION OF ATLAS-CENTAUR RESTART CAPABILITY IN EARTH ORBIT
Washington Sep. 1968 213 p refs
(NASA-TM-X-1647) CFSTI: HC$3.00/MF$0.65 CSCL 22D

The flight of Atlas-Centaur launch vehicle AC-9 on October 26, 1966 was the final flight in the Centaur research and development program. The vehicle carried a mass model of the Surveyor spacecraft. The mass model was boosted into a simulated lunar intercept trajectory using a parking-orbit mode of ascent. This mode of ascent placed the Centaur in a circular orbit. After coasting under low-gravity conditions, the Centaur main engines were restarted to supply energy to attain the proper simulated lunar intercept trajectory. This report includes a flight performance evaluation of the Atlas-Centaur systems for the total launch vehicle mission. Author

N68-36056*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

ENTRIES FROM EARTH ORBIT THAT SIMULATE ACCELERATION STRESSES OF MANNED PLANETARY MISSIONS

Frederick G. Edwards Washington Oct. 1968 35 p refs

(NASA-TN-D-4847) CFSTI: HC $3.00/MF $0.65 CSCL 22C

The ability to duplicate the acceleration stress during a portion of the earth return of a planetary mission vehicle by appropriate control of an earth orbital vehicle is investigated. The results show that during the entry of an orbital spacecraft it is possible to approximately match the accleration profile corresponding to the initial dive, the capture maneuver, and part of a constant altitude deceleration phase of a planetary mission return entry. A two-step approach to the solution is examined: the analytical step results in a closed form approximate solution for the lift control. An analog computer simulation of the entries uses results from the analytical step and gives a more precise solution for the control. It also permits an evaluation of the cost to the earth entry vehicle in terms of the aerodynamic heating, range capability, and retro velocity requirements. Emphasis is placed on simulating the planetary mission entry at twice orbital velocity, but the results also apply to entry at other supercircular velocities. An Apollo type lifting entry vehicle was used for the examples presented. Author

N68-36106*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

AN EXPLORATORY STUDY OF PARALLEL STAGE SEPARATION OF REUSABLE LAUNCH VEHICLES

John P. Decker and Joseph Gera Washington Oct. 1968 62 p refs

(NASA-TN-D-4765) CFSTI: HC $3.00/MF $0.65 CSCL 22D

An exploratory study was made of the separation of parallel staged reusable launch vehicles. Static longitudinal aerodynamic data were obtained for a representative two stage rocket powered reusable launch vehicle concept when the stages were in close proximity to each other. The effects of vertical spacing, longitudinal spacing, and incidence angle were determined at Mach numbers 3 and 6. To identify the problems associated with mutual stage interference during the separation maneuver, the equations of longitudinal motion were numerically integrated. The calculation was carried out for a limited number of initial conditions by using a portion of the wind tunnel data along with estimated values of the dynamic derivatives. The experimental results indicated large interference increments on the static stability and normal force characteristics of both vehicle stages. The static aerodynamic data were found to be dependent on the position and attitude of the second stage, the Mach number, and the relative sizes of the two stages. The relative sizes are dependent on the launch mode, the mission requirements, and the choice of propulsion system for the launch vehicle. The trajectory results indicated a strong dependence of the dynamic derivatives, initial attitude, and dynamic pressure on the separation maneuver. Author

N68-36971*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ELECTROMAGNETIC COMPATIBILITY VERIFICATION FOR THE CENTAUR AND SURVEYOR SPACE VEHICLES

John P. Quitter and J. Robert Reiss Washington Oct. 1968 42 p refs

(NASA-TM-X-1673) CSCL 22B

A series of five instrumented electromagnetic compatibility tests were performed on interface circuits between the Surveyor spacecraft and Atlas-Centaur launch vehicle. These tests were performed to verify that the spacecraft would not be susceptible to conductively induced effects from the launch vehicle and complex electromagnetic environment. Initial tests employed spacecraft and launch vehicle simulators in conjunction with their complementary vehicle. The final test was performed on completely assembled flight configuration equipment. Test results indicated the spacecraft, launch vehicle, and launch complex were compatible and that conducted interference levels were below specified limits. Numerical data are presented. Author

N68-37074*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

TRANSONIC AERODYNAMIC CHARACTERISTICS OF POWERED MODELS OF SEVERAL APOLLO LAUNCH-ESCAPE VEHICLE CONFIGURATIONS

Bobby Lee Berrier and Odis C. Pendergraft, Jr. Washington Oct. 1968 43 p refs

(NASA-TN-D-4843) CFSTI: HC $3.00/MF $0.65 CSCL 22B

An investigation of several models of Apollo launch escape vehicle configurations was made at Mach numbers from 0.70 to 1.30. The effects of command module strakes, a flow separation device, escape rocket tower modifications, nozzle cant angle, and offset thrust vector were investigated. The escape rocket exhaust was simulated with a hydrogen peroxide rocket mounted upstream of the command module. The angle of attack range was $-5°$ to $31°$, and the average Reynolds number based on the maximum command module diameter was 4.34×10^6 at a Mach number of 0.90. The results of the investigation indicate that axial force (drag) was decreased because of favorable jet interference by adding strakes to the command module, by using a ring attachment type of escape rocket tower, or by increasing nozzle cant angle. Author

N68-37900*# Astro Research Corp., Santa Barbara, Calif.

LARGE LOW-FREQUENCY ORBITING RADIO TELESCOPE

Hans U. Schuerch and John M. Hedgepeth Washington NASA Oct. 1968 56 p 10 refs

(Contract NAS7-426)

(NASA-CR-1201; ARC-R-282) CFSTI: HC $3.00/MF $0.65 CSCL 22B

Studies have been performed of the feasibility of a large (1500-meter) orbiting paraboloidal antenna for use in low-frequency (< 10 MHz) radio astronomy. Such a radio telescope would be extremely useful in a variety of scientific astronomical studies. A conceptual configuration has been evolved which consists of a tenuous conductive paraboloidal network which is deployed and stiffened by centrifugal forces due to spin about the axis of symmetry. Meridional tension forces are produced in the net by means of an extremely long deployable mast which runs along the axis of symmetry and forms the backbone of the structure. The entire configuration is deployed from a package suitable for launch on such vehicles as the Titan III. Results of the various theoretical and experimental analyses which have led to this baseline concept are summarized. Author

N68-37942*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL LONGITUDINAL DYNAMICS OF AN EMPTY STUB D ATLAS VEHICLE

William G. Costakis and Carl F. Lorenzo Washington Nov. 1968 56 p refs

(NASA-TM-X-1682) CFSTI: HC $3.00/MF $0.65 CSCL 22D

A test was conducted to determine the longitudinal dynamic characteristics of the Stub D Atlas without propellants or payload. The dynamic characteristics obtained are given in terms of modal damping ratios, vehicle mode shapes, and acceleration responses to a force input over the frequency range of 1 to 120 Hz. Natural frequencies were determined by comparing the acceleration response results with the mode shape and orthogonality test results. The results showed that a one-dimensional model may not be sufficient to predict the behavior of the vehicle. Author

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STRUCTURAL MECHANICS

Includes structural element design and weight analysis; fatigue; thermal stress; impact phenomena; vibration; flutter; inflatable structures; and structural tests. For related information see also: 17 Materials, Metallic; and 18 Materials, Nonmetallic.

N68-10231*# General Dynamics Corp., San Diego, Calif.
DYNAMIC STABILITY OF SPACE VEHICLES. VOLUME I: LATERAL VIBRATION MODES
G. B. Paddock Washington NASA Nov. 1967 86 p refs
(Contract NAS8-11486)
(NASA-CR-935; GD/C-DDF-65-001) CFSTI: HC $3.00/MF $0.65 CSCL 20K

The lateral model development and modal calculations for a cylindrical space vehicle system and systems using clustered tanks are discussed along with the relative importance of physical characteristics and methods used to solve modal parameters. Emphasis is given to parameters important in control and stability analyses for which the system frequency of interest is generally below 20 cycles/second and quite often below 10 cycles/second. The general approach for dynamic solutions of these large systems is to develop a mathematical model describing the system's mass and structure, to calculate its normal modes of vibration, and, using normal mode theory, to apply the external forces and couple in the control system to obtain total response. The space vehicle in the lateral direction is represented by a series of lumped masses connected by elastic beams. By successive refinements, such as branch beams to include multiple load paths, concentrated masses attached to the beam by translational and rotational springs, or other possible independent structures or components, the model can simulate all significant motions. R.N.A.

N68-10233*# General Dynamics Corp., San Diego, Calif.
DYNAMIC STABILITY OF SPACE VEHICLES. VOLUME IX: THE EFFECT OF LIFTOFF DYNAMICS ON LAUNCH VEHICLE STABILITY AND CONTROL
L. C. Engbrenghof Washington NASA Nov. 1967 30 p refs
(Contract NAS8-11486)
(NASA-CR-943; GD/C-BTD-67-031) CFSTI: HC $3.00/MF $0.65 CSCL 20K

The analysis of liftoff dynamics concerns both rigid body and elastic motions of a rocket vehicle in the vicinity of the launch site. The analysis begins at engine ignition and ends when the vehicle clears all launch site facilities. Engine thrust, winds, launcher restraints, umbilical disconnects, and ducts are the forcing functions for the elastic and rigid body motions. Liftoff dynamics are analyzed to evaluate the possibility of a launching mishap, and to attain the highest value of launch availability (ratio of safe launch days over days in a given period) based on ground wind restrictions. The airborne system parameter variations used to solve liftoff dynamics problems include flight control system activation time, engine thrust vector angular alignment at liftoff, engine ignition sequence, and thrust buildup time histories. Launch site parameter variations used to solve liftoff dynamics problems include removal of nonessential hardware that might offer a flight path constraint, specification of acceptable retraction times for umbilical booms and other moving parts, and specification of force-time histories of launcher constraints. R.N.A.

N68-10280*# General Dynamics Corp., San Diego, Calif.
DYNAMIC STABILITY OF SPACE VEHICLES. VOLUME II: DETERMINATION OF LONGITUDINAL VIBRATION MODES
J. A. Staley Washington NASA Nov. 1967 65 p refs
(Contract NAS8-11486)
(NASA-CR-936; GD/C-BTD-67-053) CFSTI: HC $3.00/MF $0.65 CSCL 22D

Elastic longitudinal models of multistage liquid and solid propellant vehicles, and vehicles with clustered tanks, are discussed, and methods are described for determining the dynamic characteristics needed for analyzing vehicle response and stability. The longitudinal model is considered to provide a mathematical representation of the real physical system, and the dynamic characteristics are determined from the mass, stiffness, and dynamic matrices. The equations for solution are formulated. The problems to be analyzed using longitudinal models include response to engine ignition and shutdown transients, release of a vehicle from its launcher, and the stability of engine-structure coupled oscillations. A second stability problem peculiar to liquid propellant vehicles with thin-skinned tanks involves coupling between structural motions and the tank pressure regulation system. It is pointed out that each of these problems may require different emphasis on details of the model used. M.G.J.

N68-10407*# Israel Program for Scientific Translations, Ltd., Jerusalem.
RIB-REINFORCED PLATES AND SHELLS
G. N. Savin and N. P. Fleishman 1967 342 p refs Transl. into ENGLISH of the Publ. "Plastinki i Obolochki s Rebrami Zhestkosti" Kiev, Nauk. Dumka, 1964 Prepared for NASA and NSF
(NASA-TT-F-427; TT-67-51364) CFSTI: HC $3.00/MF $0.65 CSCL 20K

Theoretical and analytical data are presented on the stress concentrations in plates and shells reinforced by stiffening ribs. The general theory of bending of thin plates is reviewed, and the fundamental differential equation and representation of the general solution are given. Detailed consideration is given to such problems as bending of thin plates reinforced by curved stiffening ribs; bending of thin plates with reinforced edges; plates reinforced by very thin ribs; inverse problems of plates with holes whose edges are reinforced by thin ribs; and shells with stiffening ribs. The most important results referring to the interaction between stiffening ribs and plates or shells are given as simple formulas, graphs, and tables. The data provided are discussed from the viewpoint of efficient design of the reinforcing elements, and the optimum structure of thin plates and shells with ribs. M.G.J.

N68-10568*# General Dynamics Corp., San Diego, Calif.
DYNAMIC STABILITY OF SPACE VEHICLES. VOLUME III: TORSIONAL VIBRATION MODES
R. Gieseke, R. Schuett, and D. Lukens Washington NASA Nov. 1967 63 p refs
(Contract NAS8-11486)
(NASA-CR-937; GD/C-DDF65-003, Vol. III) CFSTI: HC $3.00/MF $0.65 CSCL 22B

This monograph discusses the torsional model development and modal calculations for the cylindrical space vehicle system and also systems employing clustered tanks. Relative importance of physical characteristics is discussed as well as methods used by the industry for the solution of modal parameters. Primary attention

is focused on parameters important in control and stability analyses for which the system frequency is generally below twenty cycles per second and quite often below ten cycles per second. Application for loads analysis follows the same principles outlined herein but may require more detailed representation in areas where loads or deflections can be critical. The models described are concerned with gross vehicle torsional motions and do not include the shell tangential deflection modes which do not contribute to gross vehicle control and stability. Related monographs describe lateral, longitudinal, and sloshing models. Stability and loads analytical methods using these models and modal parameters are also subjects of other monographs. Author

N68-10574*# General Dynamics Corp., San Diego, Calif.
DYNAMIC STABILITY OF SPACE VEHICLES. VOLUME IV: FULL SCALE TESTING FOR FLIGHT CONTROL PARAMETERS
David R. Lukens Washington NASA Nov. 1967 50 p refs
(Contract NAS8-11486)
(NASA-CR-938; GDC-BTD-67-049) CFSTI: HC $3.00/MF $0.65 CSCL 22B

This monograph on flight control testing is primarily concerned with the major thrust vector control system and its principal components. The types of data that can be determined from full-scale tests are: frequency response, deadbands, friction, nonlinearities, limits, and the effect of structural resonances. Control system test data are required because the response characteristics of the flight control system are influenced by the total system. Most flight control systems are sufficiently complicated and responsive as to require tests to verify performance. The underlying basis for all first-of-a-kind launch vehicle flight readiness assertions must be analytical in nature. The only reason that an analytical stability derivation can be used is based on the premise that the analytical model used in analysis and synthesis can be verified by tests. This requires that the flight control system be analyzed for several test configurations and that agreement between model and test be obtained for each configuration. Then and only then can the final design verification be performed with confidence. Author

N68-11054* General Dynamics Corp., San Diego, Calif.
DYNAMIC STABILITY OF SPACE VEHICLES. VOLUME 6: FULL SCALE DYNAMIC TESTING FOR MODE DETERMINATION
D. R. Lukens, R. L. Turney, R. L. Fefferman, J. W. Kittle, and T. E. Reed Washington NASA Dec. 1967 62 p refs
(Contract NAS8-11486)
(NASA-CR-940) CFSTI: $3.00 CSCL 22B

This monograph discusses the concepts, techniques, and problems associated with full-scale dynamic test programs of large booster vehicles, both solid and liquid fueled. This discussion is aimed toward the measurement of the elastic modes that can affect control system analysis. It includes definitions of various excitation systems, suspension systems, mounting systems, instrumentation, data reduction methods, problem areas, and test planning. Author

N68-11089*# General Dynamics Corp., San Diego, Calif.
DYNAMIC STABILITY OF SPACE VEHICLES. VOLUME 8: ATMOSPHERIC DISTURBANCES THAT AFFECT FLIGHT CONTROL ANALYSIS
B. A. Appleby and T. E. Reed Washington NASA Nov. 1967 40 p refs
(Contract NAS8-11486)
(NASA-CR-942; GD/C-BTD-67-057, V. 8) CFSTI: HC $3.00/MF $0.65 CSCL 22B

The exit phase of flight must, by definition, originate on or near the earth's surface and terminate at some point in space, which will be above the sensible atmosphere. Therefore, all or part of the exit phase of flight occurs in the sensible atmosphere. The analysis of space vehicle systems for this phase of flight must necessarily include the effect of the atmosphere upon the launch vehicle. The atmosphere is non-stationary with respect to the earth's surface and its properties (e.g., density and temperature) vary with respect to time and altitude. These deviations of the non-stationary atmosphere from the stationary position are termed atmospheric disturbances. This monograph is concerned with data on atmospheric disturbances, the criteria derived from the data, and the analyses to be performed to determine the vehicle and control system response to atmospheric disturbances. Specifically excluded from the monograph are the methods of determining loads on the space vehicle structure and the details of analyses. The loads on space vehicle structures, while of great significance, are adequately covered in other literature. The details of analyses are covered in another monograph. The intent here is to discuss what analyses are to be performed and what atmospheric disturbances are to be used, not to present methods of analysis. Author

N68-11133*# General Dynamics Corp., San Diego, Calif.
DYNAMIC STABILITY OF SPACE VEHICLES. VOLUME 11: ENTRY DISTURBANCE AND CONTROL
F. D. Steketee Washington NASA Nov. 1967 61 p refs
(Contract NAS8-11486)
(NASA-CR-945; GD/C-BTD-67-023, V. 11) CFSTI: $3.00/MF $0.65 CSCL 22B

This monograph is divided into three basic sections. The first discusses handling qualities, disturbances, and re-entry corridor boundaries. These subjects define the required vehicle/control system characteristics and are considered as design criteria. The second section describes present state-of-the-art control systems for the fixed- and variable-lift vehicles and contains material on possible problem areas as well as a discussion of some new experimental control techniques. The purpose of this second section is to illustrate how re-entry control systems are currently being designed and to point out some of the problem areas that the designer should be aware of. The third section develops the small perturbation equations that are required for the analysis/synthesis problem. This section also expands the pitch mode equation to include density as an exponential function of altitude. Author

N68-11191*# Allied Research Associates, Inc., Concord, Mass.
STRUCTURAL DESIGN SYNTHESIS APPROACH TO FILAMENTARY COMPOSITES
George Gerard and C. Lakshmikantham Washington NASA Nov. 1967 40 p refs
(Contract NASw-1378)
(NASA-CR-964; ARA-327-6) CFSTI: HC $3.00/MF $0.65 CSCL 20K

Developments of analysis methods for filamentary composites are discussed. Theoretical predictions of the stiffness and strength properties of a unidirectional composite based on a knowledge of the constituent properties are correlated with experiments for both tensile and compressive loadings. The analysis of multilayer or laminated composites based upon the unidirectional composite properties then requires the rather straightforward use of classical anisotropic shell theory. Some structural aspects of filamentary composites designed for biaxial loads are considered. In particular, certain design restrictions inherent in the use of such composites become evident when compared with the more familiar isotropic sheet. Some of these restrictions can be overcome by a close matching of filament orientations and stress field. These factors serve to emphasize the overwhelming importance of creative structural concepts in the design of successful filamentary composites. Author

N68-11282*# Allied Research Associates, Inc., Concord, Mass.
MINIMUM WEIGHT DESIGN ASPECTS OF STIFFENED CYLINDERS UNDER COMPRESSION

C. Lakshmikantham and H. Becker Washington NASA Nov. 1967 20 p refs
(Contract NASw-1378)
(NASA-CR-963; ARA-327-5) CFSTI: HC $3.00/MF $0.65 CSCL 20K

The effects of minimum weight design on structural stability are reviewed based on a literature survey. The influence of stiffener eccentricity and location on minimum weight design of stiffened cylinders is emphasized. Expressions are cited for determining the critical stress associated with local instabilities of a deep stiffened cylinder; and a governing equation for the general instability of deep-stiffened cylinders is considered. Tables summarize theoretical and experimental data on the effect of stiffener location on the critical stress. The importance of stiffener location is further examined in a comparison of the efficiencies of symmetrical and asymmetrical designs. E.C.

N68-11355*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
BALLISTIC LIMIT OF ALUMINUM PLATES DETERMINED BY AN EXPLODING FOIL GUN TECHNIQUE
Emilio Aifaro-Bou and Robert G. Thomson Washington Dec. 1967 17 p refs
(NASA-TN-D-4259) CFSTI: HC $3.00/MF $0.65 CSCL 20K

An understanding of the perforation of finite-thickness plates is essential to the proper design of spacecraft to insure protection from meteoroid impact. An investigation was therefore initiated to determine the ballistic limits of finite-thickness plates and to compare these results with existing theoretical predictions. The impact of meteoroids on thin aluminum plates is simulated in an exploding foil gun facility. The exploding foil gun can fire a large number of shots in a relatively short time with a range of projectile velocities from 1 to 8 km/s. The exploding foil gun facility is used in an experimental program to determine the ballistic limits of aluminum plates of varying thickness. The information gathered from this experimental program indicates that the ballistic limit is linearly dependent on the plate thickness and the experimental data correlate well with the theory of ballistic limit developed from a visco-plastic model. Hence, the current practice of using semi-infinite penetration data in predicting the ballistic limits of thin plates is incorrect. Author

N68-11485*# General Dynamics Corp., San Diego, Calif.
DYNAMIC STABILITY OF SPACE VEHICLES. VOLUME 5: IMPEDANCE TESTING FOR FLIGHT CONTROL PARAMETERS
David R. Lukens Washington NASA Dec. 1967 27 p refs
(Contract NAS8-11486)
(NASA-CR-939; GD/C-BTD-67-045) CFSTI: HC $3.00/MF $0.65 CSCL 20K

Ways of determining equivalent rates that describe the local flexibility of launch vehicle control system structures and their mounting and associated brackets are presented. Recommended practices are enumerated and include impedance methods, typical forms of the impedance plot, determination of mechanical impedance by test, force and motion requirements, instrumentation requirements, use of impedance in stability and control analysis, and simulation of equivalent systems. It is noted that these spring rates and impedance techniques used to determine them may also be used to evaluate motions for clearance and environmental studies. C.T.C.

N68-11489*# Bolt, Beranek, and Newman, Inc., Cambridge, Mass.
PANEL LOSS FACTORS DUE TO GAS-PUMPING AT STRUCTURAL JOINTS
G. Maidanik and E. E. Ungar Washington NASA Nov. 1967 62 p refs
(Contract NAS5-9694)
(NASA-CR-954; Rept.-1475) CFSTI: HC $3.00/MF $0.65 CSCL 13M

The recently observed fact that the high-frequency structural damping due to riveted joints is associated with "gas-pumping" in the space between overlapping surfaces is subjected to theoretical and experimental study. A theory is developed, which attributes the damping of plates with riveted-on beams to viscous losses associated with the tangential gas motions in the beam-plate interspace that are generated by normal relative motions of the adjacent beam and plate surfaces. Reasonable agreement is found between theoretical predictions and experimental data obtained for three different gases over a wide range of pressures. Author

N68-11967*# North Carolina State Coll., Raleigh.
MODAL DENSITY OF THIN CIRCULAR CYLINDERS
David K. Miller and Franklin D. Hart Washington NASA Dec. 1967 66 p refs
(Grant NGR-34-002-035)•
(NASA-CR-897) CFSTI: HC $3.00/MF $0.65 CSCL 20M

A combined analytical and experimental study is made of the modal density of a thin cylindrical shell. Previous analytical work is discussed and an integral form solution is presented and evaluated numerically. Having cognizance of the experimental results, it is concluded that the integral form solution gives an accurate method for computing the cumulative number of resonant modes and the modal density of a thin cylindrical shell. Author

N68-12370*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STRUCTURAL FEASIBILITY STUDY OF PRESSURIZED TANKS FOR LIQUID-METHANE FUELED SUPERSONIC AIRCRAFT
Rene E. Chambellan, Joseph F. Lubomski, and William A. Bevevino Washington Dec. 1967 48 p refs
(NASA-TN-D-4295) CFSTI: HC $3.00/MF $0.65 CSCL 20K

Light-weight pressurized tanks for the storage of liquid-methane fuel in the wings of supersonic transport aircraft were evaluated. Three types of tank structures were studied: (1) membrane tanks where the only loads in the tank skin are tensile, (2) modified semimonocoque tanks composed of a framework of rings and stringers covered by a pressure-tight skin, and (3) filamentary restrained membrane tanks where the outer skins of either metal or sealed fabric are restrained by wires or threads attached to the opposite skin. A typical wing void space having an approximately rectangular prismoidal shape was assumed as a tank envelope. The various tank designs were compared by the use of two numerical ratios, namely, the volumetric efficiency and tank-weight to contained-fuel-weight ratio. Volumetric efficiency is defined as the ratio of the volume of fuel stored in the tank to the storage void volume into which the tank is fitted. For the designs considered, exclusive of insulation, volumetric efficiencies ranged from 81.1 to 99.6 percent and tank-weight to contained-fuel-weight ratios ranged from 0.0241 to 0.0556. Author

N68-12864*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
NONLINEAR FLUTTER OF A CIRCULAR CYLINDRICAL SHELL IN SUPERSONIC FLOW
David A. Evensen and Mervyn D. Olson (Natl. Aeron. Estab.) Washington Dec. 1967 30 p refs Prepared by National Research Council of Canada
(NASA-TN-D-4265; NRC-LR-486) CFSTI: HC $3.00/MF $0.65 CSCL 20K

A nonlinear analysis is presented for calculating the limiting amplitudes of cylindrical shell flutter by using a four-mode approximation for the shell deflection. The aerodynamic pressure is approximated by linear piston theory, and the nonlinearity enters the problem through the nonlinear shallow-shell equations for the cylinder. The governing equations are reduced to four modal equations by applying Galerkin's method, and limit cycle solutions are obtained by the method of harmonic balance. Stability of the limit cycles is investigated numerically by integrating the modal equations on a digital computer. Two types of limit cycle flutter are obtained: two-mode standing-wave flutter, and four-mode circumferentially traveling-wave flutter. Under most conditions, the two-mode standing-wave flutter becomes unstable and transforms into four-mode traveling-wave flutter. The analysis indicates that flutter can occur at aerodynamic pressures below the linear flutter boundary. This fact may explain why recent results indicate a difference between experiments and linear theory for the flutter of cylindrical shells. Author

N68-14091*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

INFLUENCE OF DISCRETE RING STIFFENERS AND PREBUCKLING DEFORMATIONS ON THE BUCKLING OF ECCENTRICALLY STIFFENED ORTHOTROPIC CYLINDERS

David L. Block Washington Jan. 1968 70 p refs

(NASA-TN-D-4283) CFSTI: HC $3.00/MF $0.65 CSCL 20K

The buckling of eccentrically stiffened perfect orthotropic cylinders is the subject of an analytical investigation in which prebuckling deformations and the influence of discretely located ring stiffeners are taken into account. By using energy principles, nonlinear prebuckling equations and linear buckling equations are derived. Solutions for simply supported and clamped boundary conditions and for loadings of axial compression and internal or external pressure are obtained by the method of finite differences and a modified Gaussian elimination technique. Computed results for two types of simply supported large-diameter stiffened cylinders loaded in axial compression illustrate the influence on the buckling load of prebuckling deformations, discrete rings, and eccentricity of applied axial compressive loads; results for clamped longitudinally stiffened cylinders are compared with previous test results. The results show that the predicted buckling load may be substantially affected by consideration of prebuckling deformations, eccentric loading, and discreteness of rings and that agreement with experiment may be improved by including these factors. Author

N68-14584* Dynamic Science Corp., Monrovia, Calif.

A GEOMETRICALLY NONLINEAR ANALYSIS OF ARBITRARILY LOADED SHELLS OF REVOLUTION

R. E. Ball Washington NASA Jan. 1968 218 p refs

(Contract NAS1-5804)

(NASA-CR-909) CFSTI: $3.00 CSCL 20K

A digital computer program for the geometrically nonlinear analysis of thin elastic shells of revolution subjected to arbitrary load and temperature distributions was developed to predict snap buckling of spacecraft shell structures due to asymmetric loads such as those imposed by reentry flow or landing impact. The analysis was based upon Sanders' nonlinear shell theory for the condition of small strains and moderately small rotations. The nonlinear partial differential equations are reduced to a sequence of linearized uncoupled ordinary differential equations by expanding the variables into Fourier series in the circumferential direction, and treating the nonlinear terms as pseudo loads. The linearized equations are repeatedly solved, using a finite difference formulation in conjunction with a Gaussian elimination procedure, until the solution converges. Author

N68-14640*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

PLASTIC BEHAVIOR OF CIRCULAR PLATES UNDER TRANSVERSE IMPULSE LOADINGS OF GAUSSIAN DISTRIBUTION

Robert G. Thomson Washington Jan. 1968 33 p refs

(NASA-TR-R-279) CFSTI: HC $3.00/MF $0.65 CSCL 20K

An analytical study of the plastic response of a circular plate of uniform thickness subjected to a normal axisymmetric impulse of Gaussian distribution is presented. The Gaussian impulse loading is assumed initially to impart a momentum to the plate. The plate is thereafter prescribed as free from external loads. The kinetic energy of motion is assumed to be dissipated in plastic deformation. The radial and circumferential strain and strain-rate distributions of the plastically deforming plate are determined as a function of time and space from derived deflection expressions. Only the bending action of the plate is taken into account and the plate material is assumed to behave as a perfectly plastic-rigid continuum. The possibility of a fracture or separation of the plate material occurring during deformation is discussed. Maximum values of strain and strain rate are shown to occur in the circumferential components, and a mode of failure by radial fractures is indicated. Author

N68-15476*# Boeing Co., Renton, Wash.

FATIGUE-CRACK PROPAGATION AND FRACTURE-TOUGHNESS CHARACTERISTICS OF 7079 ALUMINUM-ALLOY SHEETS AND PLATES IN THREE AGED CONDITIONS

S. H. Smith, T. R. Porter, and W. D. Sump Washington NASA Feb. 1968 96 p refs

(Contract NAS1-6474)

(NASA-CR-996) CFSTI: HC $3.00/MF $0.65 CSCL 11F

Tensile property, fatigue crack propagation, and fracture toughness tests were conducted to determine the effects of aging temperature and time, material thickness, specimen width, and configuration and physical environments of dry air, liquid nitrogen (−65°F), and distilled water on these properties. Residual strength characteristics were determined with surface-flawed specimens; precracked Charpy impact toughness tests also were conducted. The results showed that 7079 peak-age material has a faster rate of fatigue crack growth and a lower fracture toughness and residual strength than underaged and overaged materials. Underaged material exhibited the greatest fracture toughness and essentially the same rate of fatigue crack growth as that of overaged material. A slower fatigue crack growth rate was found for a decrease in plate thickness, an increase in panel width, a dry-air environment compared to distilled water, and a −65°F temperature. High fracture toughness and residual strength values were found for a decrease in plate thickness, an increase in panel width, a longitudinal grain direction, and an increase from −65°F to room temperature. Author

N68-15769*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ELASTOPLASTIC ANALYSIS OF CIRCULAR CYLINDRICAL INCLUSION IN UNIFORMLY STRESSED INFINITE HOMOGENEOUS MATRIX

Alexander Mendelson Washington Jan. 1968 24 p refs

(NASA-TN-D-4350) CFSTI: HC $3.00/MF $0.65 CSCL 20K

Equations have been derived and a method has been presented for performing an elastoplastic analysis of a system consisting of a circular cylindrical inclusion in a homogeneous matrix uniformly stressed at infinity and in a condition of generalized plane strain. The material properties of the inclusion and the matrix, including their stress–strain curves are assumed to be arbitrary and independent of each other. Several examples, including the limiting cases of a hole and a rigid inclusion, are presented. It is shown that the constraints imposed by the rigid inclusion sharply reduce both the stress and strain concentration factors over those for the hole. The

results for a system roughly approximating a graphite fiber in a resin matrix indicate that the fiber acts nearly as a rigid inclusion and that strain hardening properties of the matrix play only a minor role in determining the plastic strain concentration factor for the case of plane strain. Author

N68-15796*# Scientific Translation Service, La Canada, Calif.
COMPUTATIONS OF ELASTIC TENSOMETRIC ELEMENTS
G. F. Malikov, A. L. Shneyderman, and A. M. Shulemovich Washington NASA Feb. 1968 182 p refs Transl. into ENGLISH of the book "Raschety Uprugikh Tenzometricheskikh Elementov" Moscow, Mashinostr., 1964
(Contract NASw-1496)
(NASA-TT-F-513) CFSTI: HC$3.00/MF$0.65 CSCL 20K

The calculations for present-day elastic tensometric elements, and present methods for utilizing them are presented. Along with calculations for strength and rigidity, the problems of determining the nonlinearity of certain elastic elements are examined. Great attention is devoted to the use of statistical methods for experimentally determining several parameters characterizing the meterological properties of elastic elements. Author

N68-17045*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ELASTIC-PLASTIC TORSION PROBLEM FOR STRAIN-HARDENING MATERIALS
Alexander Mendelson Washington Feb. 1968 23 p refs
(NASA-TN-D-4391) CFSTI: HC$3.00/MF$0.65 CSCL 20K

A simple and straightforward procedure is presented for solving the elastic-plastic problem for the torsion of a solid prismatic bar made of a strain-hardening material. The procedure is based on the method of successive elastic solutions or successive approximations. For circular cross sections, the problem reduces to the solution of a nonlinear algebraic equation. For the case of a circular cross section with linear strain hardening, the solution is obtained in closed form. Results are presented for bars of rectangular and circular cross sections with linear strain hardening. Author

N68-17068*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
ACCURACY STUDY OF FINITE DIFFERENCE METHODS
Nancy Jane Cyrus and Robert E. Fulton Washington Jan. 1968 29 p refs
(NASA-TN-D-4372) CFSTI: HC$3.00/MF$0.65 CSCL 20K

A method for studying the accuracy of finite difference approximations for linear differential equations is presented and utilized. Definitive expressions for the error in each approximation are obtained by using Taylor series to derive the differential equations which exactly represent the finite difference approximations. The resulting differential equations are accurately solved by a perturbation technique which yields the error directly. This method is used to assess the accuracy of two alternate forms of central finite difference approximations for solving boundary value problems in structural analysis which are governed by certain equations containing variable coefficients. A "half station approximation" in which finite difference approximations are made before expanding derivatives of function products is compared with a "whole station approximation" in which derivatives of function products are expanded first for string, beam, and axisymmetric circular plate problems. An example of a square membrane is given as an application of the method to partial differential equations. Author

N68-17588*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
RESIDUAL-STATIC-STRENGTH AND SLOW-CRACK-GROWTH BEHAVIOR OF DUPLEX-ANNEALED Ti-8Al-1Mo-1V SHEET
I. E. Figgee Mar. 1968 29 p refs
(NASA-TN-D-4358) CFSTI: HC$3.00/MF$0.65 CSCL 20K

Tests were conducted at room temperature on centrally cracked Ti–8Al–1Mo–1V duplex-annealed sheet specimens 2, 4, 8, and 20 inches wide. Tests were also conducted on specimens 8 inches wide in which cracks had been propagated either at various cyclic-stress levels or at various temperatures prior to static testing. The residual strength (based on net section prior to loading) for a given ratio of crack length to specimen width was less for wide specimens than for narrow ones. No effect of prior stress or temperature history on the residual static strength was found. The slow-crack-growth data obtained were approximated reasonably well by an equation of the form $a_c/a = 1 + A(w/2a - 1)^B$ where a_c is the half-length of the critical crack, a is the half-length of the initial crack, w is the specimen width, and A and B are constants which are determined empirically. Analysis of the residual-strength data by both the unified notch-strength analysis method and a modified version of this method is discussed. Author

N68-17651*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
FLUTTER OF BUCKLED, SIMPLY SUPPORTED, RECTANGULAR PANELS AT SUPERSONIC SPEEDS
Robert W. Fralich and John A. McElman Washington Mar. 1968 17 p refs
(126-14-02-24-23)
(NASA-TN-D-4357) CFSTI: HC$3.00/MF$0.65 CSCL 20K

A theoretical flutter analysis is presented for buckled, simply supported panels subjected to supersonic flow over one surface. The analysis employs the Von Karman large-deflection plate theory and linearized static aerodynamic strip theory. A Galerkin procedure using four static mode shapes is employed to determine a set of differential equations which is programed on an analog computer. The character of the output of the analog is used to determine the flutter speed. Results are obtained for panels with ratios of length in the streamwise direction to length in the cross-flow direction equal to 1/2 and 1 for three specified in-plane edge-loading conditions. An assessment of effects of cross-flow coupling of the modes is made by comparison of the results with those obtained when cross-flow coupling between the modes is neglected. Author

N68-18721*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AN EXPERIMENTAL STUDY OF THE INFLUENCE OF THE TURBULENT BOUNDARY LAYER ON PANEL FLUTTER
Lado Muhlstein, Jr., Peter A. Gaspers, Jr., and Dennis W. Riddle Washington Mar. 1968 55 p refs
(NASA-TN-D-4486) CFSTI: HC$3.00/MF$0.65 CSCL 20K

Flutter dynamic pressure and flutter frequency were obtained for a rectangular unstressed isotropic panel with all edges clamped for the following sets of parameters: (a) Panel length-to-width ratio of 0.5, Mach number range of 1.05 to 1.40, and ratio of boundary-layer thickness to panel length of 0.032 to 0.111; (b) panel length-to-width ratio of 2.0, Mach number of 1.20, and ratio of boundary-layer thickness to panel length of 0.016 to 0.056. For the configurations tested, it is shown that the turbulent boundary layer has a large stabilizing influence on the flutter of flat panels. The effect on flutter dynamic pressure is maximum near M = 1.20 and decreases rapidly with increasing Mach number. The effect on flutter frequency is minimum near M = 1.20 and increases with increasing Mach number. Author

N68-18769*# General Dynamics Corp., San Diego, Calif.
DYNAMIC STABILITY OF SPACE VEHICLES. VOLUME 7: THE DYNAMICS OF LIQUIDS IN FIXED AND MOVING CONTAINERS

L. L. Fontenot Washington NASA Mar. 1968 149 p refs
(Contract NAS8-11486)
(NASA-CR-941; GDC-BTD67-056) CFSTI: HC $3.00/MF $0.65 CSCL 22C

This analytic review on stability and control of liquid-rocket powered missiles and space vehicles discusses theoretical hydrodynamics necessary to describe the motion of a heavy liquid enclosed in a rigid vessel which is itself in motion. An energy formulation for the system is written for six degrees of freedom and the concept is then extended to the case of the planar motion of a liquid propellant vehicle having a single tank and engine. Planar equations of motion are used to obtain the perturbation equations and to identify the role of the liquid motions. By replacing the liquid in the propellant tank with a simple mechanical system, the planar perturbation equations for the whole vehicle are obtained. Comparison of liquid motions and mechanical system motions show that the mechanical systems can duplicate the action of the liquid. G.G.

N68-18825*# General Dynamics Corp., San Diego, Calif.
DYNAMIC STABILITY OF SPACE VEHICLES. VOLUME 10: EXIT STABILITY
R. F. Ringland Washington NASA Mar. 1968 166 p refs
(Contract NAS8-11486)
(NASA-CR-944; GD/C-BTD-67-029) CFSTI: HC $3.00/MF $0.65 CSCL 22A

Described are techniques in use for the stability analysis of launch vehicles during their flight through, and upon exit from, the earth's atmosphere. Indicated are analytical tools and techniques used in the analysis and synthesis of launch vehicle flight control systems during the actively propelled and controlled flight phases. The object of this presentation is to illustrate the applicability of standard computational techniques to the solution of complex flight control problems associated with large launch vehicles. Current space boosters are characterized, from the flight dominated by parasitic modes of response (elastic vehicle bending and, if liquid propelled, propellant sloshing). Reliance is placed on active flight control by means of thrust vector deflection for stability; fins are used, if at all, as passive elements to decrease the degree of instability in those instances where it proves impractical to adequately stabilize the vehicle with the control system gains allowable by consideration of system parasitics. Also fins may be indicated where abort systems require a reduced rate of attitude divergence in the event of a flight control system failure. Large in the above context refers to vehicles whose dynamic parameters vary slowly over a wide range. The rates of change of these parameters are far less than those of the dependent variables associated with the short-period modes of response. The analytical techniques presented are limited to systems that are, or can be approximated by, continuous systems; sampled data systems, digital autopilots, and the like are not considered. There is no coverage of the long-period modes due to guidance system action and guidance commands; rather, the guidance system is treated in a fashion similar to atmospheric disturbances: as a source of system excitation. Author

N68-19143*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
FLUTTER OF CORRUGATION STIFFENED PANELS AT MACH 3 AND COMPARISON WITH THEORY
Herman L. Bohon Washington Mar. 1968 29 p refs
(NASA-TN-D-4321) CFSTI: HC $3.00/MF $0.65 CSCL 20K

Details of an experimental study on flutter of corrugation-stiffened panels are presented. The panels were tested at Mach 3 in the Langley 9- by 6-foot thermal structures tunnel under aerodynamic heating conditions. Flutter boundaries presented include a flat-panel portion and a thermally buckled panel portion. Comparison of the results from this investigation and other available data on corrugation-stiffened panels with conventional theory for panels simply supported on all edges indicates that theory is highly unconservative. However, accounting in the theory for the deflectional flexibility of the corrugations and supports at the ends of the corrugations brings theory and experiment into fair agreement. These results indicate that seemingly small details of edge conditions of corrugation-stiffened panels may cause drastic reductions in the dynamic pressure for flutter. Author

N68-19311*# Syracuse Univ. Research Inst., N. Y.
PLANE STRESS ANALYSIS OF AN EDGE-STIFFENED RECTANGULAR PLATE, TAKING INTO ACCOUNT BENDING AND SHEAR STIFFNESS OF THE STIFFENERS
Yu-wen Hsu and Charles Libove Washington NASA Mar. 1968 178 p refs
(Grant NsG-385)
(NASA-CR-978; ME-1065-678) CFSTI: HC $3.00/MF $0.65 CSCL 20K

A plane stress analysis, by means of Fourier series, is presented for an isotropic or orthotropic elastic rectangular plate bounded by four uniform edge stiffeners and subjected to any prescribed temperature distribution and boundary loads. Both the extensional and flexural (including transverse shear) stiffnesses of the stiffeners are considered, and the possibility is included that the plate is attached to the stiffeners along lines which are offset from their centroidal axes. At each corner the junction between the two meeting stiffeners is assumed to consist of a hinge and a coil spring. By varying the stiffness of the coil spring, any degree of joint rigidity, from that of a pure hinge to a perfectly rigid joint, can be simulated. Using this analysis, numerical results were obtained for a number of specific cases involving prescribed force loading or prescribed temperature distributions. As a check on the validity of the method, stresses were measured on a doubly symmetric edge stiffened square plate subjected to stiffener-end loads. Good agreement was obtained between the measured and computed values of the plate and stiffener stresses. Author

N68-20364*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
RESPONSE CHARACTERISTICS OF IMPACTING PENETROMETERS APPROPRIATE TO LUNAR AND PLANETARY MISSIONS
John Locke McCarty and Huey D. Carden Washington Apr. 1968 81 p refs
(NASA-TN-D-4454) CFSTI: HC $3.00/MF $0.65 CSCL 20K

The objectives of this study were to evaluate the capability of the penetrometers to identify structural characteristics which potentially might exist for materials on the surface of the moon and planets and to study the effects of variations in both the penetrometer design and the conditions at impact. The effects on penetrometer impact characteristics—primarily acceleration time histories—of such variables as impact velocty and angle, penetrometer size and mass, environmental pressure, and target structure and penetration resistance were examined. The target materials included a rigid nonyielding plate, a cobble–pebble agglomerate, two grades of quartz and basalt sands, fine silica powder, and a low-density open-cell foam. The results demonstrate that suitably designed penetrometers perform satisfactorily over a wide range of impact conditions on a rigid surface and have ample sensitivity to permit the detection of low-density materials having a bearing strength considerably below that required to support manned landings. Author

N68-20954*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EXPERIMENTAL MODES OF VIBRATION OF 14° CONICAL-FRUSTUM SHELLS WITH FREE ENDS
John S. Mixson Washington Apr. 1968 18 p refs
(NASA-TN-D-4428) CFSTI: HC $3.00/MF $0.65 CSCL 20K

In experimental studies of the vibrations of conical and cylindrical shells, some modes having different numbers of circumferential waves at different locations along the shell meridian have been obtained. (Such modes are termed "mixed modes" herein.) To investigate the occurrence of such modes, five conical-frustum shells were vibrated and their resonant frequencies and nodal patterns determined. The shells had a half-angle of 14° and three wall thicknesses. Three shells had butt-welded seams and two had lap-welded seams. The suspension-system stiffness was varied, and two types of excitation were used. Experimentally determined frequencies and the location of the circumferential node line are shown to be in good agreement at low frequencies with values calculated by means of inextensional shell theory. Mixed modes occurred when the shell or test setup departed substantially from ideal conditions. Examples of nonideal conditions include imperfections or lap-welded seams on the shell, stiff suspension systems, and forced response of two modes at nearly the same frequency. It is shown that the experimental nodal patterns of these modes can be obtained by superposition of theoretical modes of an ideal conical shell. Author

N68-21099*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EXPERIMENTAL STUDY OF AEROELASTIC INSTABILITY OF OVEREXPANDED ROCKET NOZZLE EXTENSIONS

W. J. Tuovila and Norman S. Land Washington Apr. 1968 18 p refs

(NASA-TN-D-4471) CFSTI: HC$3.00/MF$0.65 CSCL 21H

A brief exploratory investigation was conducted to study possible aeroelastic-instability phenomena which might occur for overexpanded flow through flexible nozzle extensions which are being considered for use in increasing the thrust of rocket engines at very high altitudes. Five conical extensions with a 22.5° half-angle and area ratios of 54 and 100 were fabricated from varying thicknesses of steel and glass-fiber laminates. Studies were conducted at constant stagnation pressure. Flow through the nozzle and extension started in an underexpanded condition but gradually changed to an overexpanded condition as the quiescent-flow ambient pressure increased. Two rigid aluminum-alloy models with geometry similar to that of the flexible models were used for pressure measurements and for visualization of flow across the exit and interior surface. For some flexible extensions, dynamic instability was observed which could be related by means of flow measurements to an overexpanded flow condition that caused buckling loads. The experimental data are summarized graphically to indicate nozzle-extension parameters in the stable region for different loading conditions. The data may be useful as a guide for the preliminary design of nozzle extensions. Author

N68-21293*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

THE PENETRATION OF POROUS PROJECTILES IN ALUMINUM AND PLASTIC TARGETS

Richard H. Fish Washington Apr. 1968 11 p refs

(NASA-TN-D-4505) CFSTI: HC$3.00/MF$0.65 CSCL 20K

Cylindrical projectiles of polyurethane plastic, with a fineness ratio of 2/3 and densities ranging from 1.17 gm/cc for the solid material to 0.065 gm/cc for the lightest porous material, impacted targets of 2024-T351 aluminum alloy and polycarbonate plastic at velocities from 3.45 to 7.08 km/sec. Solid projectiles with the fineness ratio appropriately reduced to give the same mass as some of the porous projectiles were also tested for comparison with the porous projectiles. The results of the investigation indicated that the solid projectiles penetrated as deeply as the porous projectiles of the same mass, but their crater shapes and volumes were different. The depths of penetration in the two different target materials could be correlated on the basis of the density ratio raised to the 2/3 power, without considering other physical properties such as strength. Comparison of the data of the present investigation with other plastic-projectile data indicated that the present data fall in low-speed or transition regions of impact. Author

N68-21767*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

REMARKS ON IMPERFECTIONS OF AXIALLY LOADED CYLINDERS

Robert E. Reed, Jr. Washington Apr. 1968 13 p refs

(NASA-TM-X-1552) CFSTI: HC$3.00/MF$0.65 CSCL 20K

A simple hypothesis is offered as an explanation for the large discrepancy between theory and experiment of axially compressed cylindrical shells. It is suggested that the very low experimental buckling loads (when buckling does not occur at the ends) are caused by local "flat spots." A critical size of imperfection is given and the buckled mode shape is discussed. These arguments are also applied to other common shell buckling problems. Author

N68-21869*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EXPERIMENTAL INVESTIGATION OF THE LONGITUDINAL VIBRATION OF A REPRESENTATIVE LAUNCH VEHICLE WITH SIMULATED PROPELLANTS

James A. Schoenster and Robert R. Clary Washington May 1968 67 p refs

(NASA-TN-D-4502) CFSTI: HC$3.00/MF$0.65 CSCL 22D

The results of an experimental investigation of the longitudinal vibration of a full-scale representative launch-vehicle structure are presented. The vibration characteristics of the vehicle supported upright were determined for frequencies between 5 and 100 hertz by means of force-controlled vibration techniques. Resonant frequencies, resonant response accelerations, and damping values were determined and the degree of nonresonant vibration was investigated. Static deflections of the propellant tanks due to various levels of simulated propellants were also measured. The vibration characteristics of the vehicle were influenced by the simulated propellants. The acceleration data were not always sufficient to identify and to separate the various modes of the vehicle. In these cases, a definition of the effect of the contained liquid on the vehicle structure was required for proper association of the modes. In general, there was good agreement between the resonant frequencies selected for detailed study when one source of excitation, two sources of excitation, or the Kennedy–Pancu method of data interpretation were used. However, data obtained from the two sources of excitation and the Kennedy–Pancu plots indicate significant nonresonant amplitude contributions to the total response amplitude obtained with a single source of excitation. Author

N68-22275*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

METHOD FOR DETERMINING NORMAL MODES AND FREQUENCIES OF A LAUNCH VEHICLE UTILIZING ITS COMPONENT NORMAL MODES

James D. McAleese Washington May 1968 50 p refs

(NASA-TN-D-4550) CFSTI: HC$3.00/MF$0.65 CSCL 22D

The launch vehicle is idealized as a one-dimensional structure consisting of a main beam to which several flexible branches are attached. The normal modes of both the unrestrained main beam and the cantilevered branches are determined. An energy approach is then employed in which the displacement of the vehicle is expressed as the superposition of a finite number of free–free normal modes of the main beam and cantilever normal modes of the branches. Langrange's equations are then used to derive the equations of motion in matrix form, and an iterative method of solution is included for completeness. Author

N68-23355*# Lockheed Aircraft Corp., Sunnyvale, Calif.
BUCKLING OF SHELLS OF REVOLUTION WITH VARIOUS WALL CONSTRUCTIONS. VOLUME 3: USER'S MANUAL FOR BOSOR
D. Bushnell, B. O. Almroth, and L. H. Sobel Washington NASA May 1968 120 p refs
(Contract NAS1-6073)
(NASA-CR-1051; Rept.-4-17-67-4) CFSTI: HC $3.00/MF $0.65 CSCL 20K

Presented is a comprehensive computer program for the analysis of shells of revolution with axisymmetric loading. The program includes nonlinear prebuckling effects and is very general with respect to geometry of meridian, shell wall design, edge conditions, and loading. Despite its generality the program is easy to use. Branches are provided such that for commonly occurring cases the input data involves only basic information such as geometrical and material properties. The computer program was verified by comparisons with other known solutions. Author

N68-23399*# IIT Research Inst., Chicago, Ill.
HIGH PERFORMANCE STRUCTURES
Ralph L. Barnett and Paul C. Hermann Washington NASA May 1968 124 p refs
(Contract NASr-65(16))
(NASA-CR-1038) CFSTI: HC $3.00/MF $0.65 CSCL 20K

Materials selection, structural geometry development, prestressing, proof testing and statistical screening, and system energy were used as general design tools for studying optimum tension members, columns, and trusses. A design philosophy based on proof testing or statistical screening is introduced that turns the characteristic scatter in fracture and yield strengths into an asset by emphasizing the strong elements in a sample. Proof testing is considered to recast the performance aspects of brittle design into an economic framework. A statistical load redistribution for ductile tension members is proposed that takes size effect into account, and prestressing is used to eliminate local buckling in a tubular column. Two classical column designs were investigated which required the optimum longitudinal distribution of a specified total mass to prevent Euler buckling, energy-strength tradeoffs were considered, and the design of statically determinate trusses for minimum weight and deflection was studied. Optimum stiffness/weight beam, constant stress trusses, and end and triangular loaded cantilevers were investigated. M.W.R.

N68-23451*# Lockheed Aircraft Corp., Sunnyvale, Calif.
BUCKLING OF SHELLS OF REVOLUTION WITH VARIOUS WALL CONSTRUCTIONS. VOLUME 2: BASIC EQUATIONS AND METHOD OF SOLUTION
D. Bushnell, B. O. Almroth, and L. H. Sobel Washington NASA May 1968 83 p refs
(Contract NAS1-6073)
(NASA-CR-1050; LAC-4-17-67-1, V. 2) CFSTI: HC $3.00/MF $0.65 CSCL 20K

Basic equations are formulated for the computer program used in prebuckling and stability analysis of the axisymmetric collapse and nonsymmetric bifurcation buckling behavior of cylinders, cones, and spherical and toroidal shell segments subjected to axial compressive loads. The method used in solving these equations is described. A set of more general stability equations is appended. E.J.S.

N68-23452*# General Dynamics Corp., San Diego, Calif.
DYNAMIC STABILITY OF SPACE VEHICLES. VOLUME 13: AERODYNAMIC MODEL TESTS FOR CONTROL PARAMETER DETERMINATION
David R. Lukens Washington NASA May 1968 26 p refs
(Contract NAS8-11486)
(NASA-CR-947; GD/C-BTD-67-112, V. 13) CFSTI: HC $3.00/MF $0.65 CSCL 22B

Introductory data are presented on, and procedures recommended for, aerodynamic model testing of control parameters required in the design and analysis of spacecraft flight control systems. Items to be considered in planning, designing, and conducting a model test for the determination of aerodynamic forces and moments are discussed in terms of wind tunnel apparatus and facilities. Force and pressure testing techniques are described as well as commonly used procedures for control effectiveness testing. Captive and free flight models used in dynamic stability tests are described. E.J.S.

N68-23453*# General Dynamics Corp., San Diego, Calif.
DYNAMIC STABILITY OF SPACE VEHICLES. VOLUME 15: SHELL DYNAMICS WITH SPECIAL APPLICATIONS TO CONTROL PROBLEMS
L. E. Penzes Washington NASA May 1968 197 p refs
(Contract NAS8-11486)
(NASA-CR-949; GD/C-BTD-67-120) CFSTI: HC $3.00/MF $0.65 CSCL 20K

The purpose of this monograph is to explain the foundations of thin-walled elastic shells and the basis of theoretical derivations. An attempt is made to fill the gap between the contents of dynamics textbooks and recently published literature and to explain the differences in their treatment of the subject. Examples and problems are given to demonstrate the use of the theories. Some static problems are discussed to compare them with equivalent dynamic problems. In addition, the applicability of shell vibration theory to missiles and launch vehicles is described. Attention is focused on calculation of dynamic model parameters affecting stability and control. Emphasized are modes for which the system frequency falls within the bandwidth of the control system, i.e., below 20 Hz for a large space booster. K.W.

N68-23454*# General Dynamics Corp., San Diego, Calif.
DYNAMIC STABILITY OF SPACE VEHICLES. VOLUME 14: TESTING FOR BOOSTER PROPELLANT SLOSHING PARAMETERS
D. M. Eggleston Washington NASA May 1968 37 p refs
(Contract NAS8-11486)
(NASA-CR-948; GD/C-BTD-67-089, V. 14) CFSTI: HC $3.00/MF $0.65 CSCL 22B

Summary data are presented on the state-of-the-art in booster propellant slosh testing and a mathematical model, defined as that set of differential and functional equations used to represent the forces and moments exerted on the vehicle due to the liquid propellants, is formulated. Known digital computer programs for generating parameters for a pendulum or spring-mass model of the basic fluid motion are reviewed, and together with known data and techniques, are organized for convenient use in new situations and for new launch vehicles. Recommendations are included for the establishment of test objectives and planning criteria, facility design and instrumentation, test operations and disturbance effects, and data reduction and scaling techniques. E.J.S.

N68-24481*# Lockheed Aircraft Corp., Sunnyvale, Calif.
BUCKLING OF SHELLS OF REVOLUTION WITH VARIOUS WALL CONSTRUCTIONS. VOLUME 1: NUMERICAL RESULTS
B. O. Almroth, D. Bushnell, and L. H. Sobel Washington NASA May 1968 58 p refs
(Contract NAS1-6073)
(NASA-CR-1049; Rept.-4-17-67-1) CFSTI: HC $3.00/MF $0.65 CSCL 20K

Results are presented on a parameter study performed with the computer program BOSOR (Buckling of Shells of Revolution). The axisymmetric collapse and the nonsymmetric bifurcation buckling behavior is studied for cylinders, cones, and spherical and toroidal

shell segments subjected to axial compressive loads. Particular emphasis is placed on the effects of eccentricity in load application and on the influence of elastic end rings. Author

N68-24508*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
FLUCTUATING PRESSURES ON THE AFTERBODIES OF FIVE BLUNT ATMOSPHERE ENTRY VEHICLES
Robert C. Robinson, Bruno J. Gambucci, and Robert E. George Washington May 1968 56 p refs
(NASA-TN-D-4591) CFSTI: HC$3.00/MF$0.65 CSCL 22B

Pressure fluctuations were measured on the afterbodies of entry-vehicle configurations at angles of attack from $-14°$ to $+14°$ and Mach numbers from 0.60 to 3.50. The Reynolds number range was 2.0×10^6 to 6.5×10^6 based on model diameter. The models were typical of configurations which have been considered as entry vehicles for the Mars atmosphere. Forebody fineness ratios were 1/3 and 1/8 and the afterbodies were conical with half angles of 30°, 60°, and 80°. The pressure fluctuations measured at subsonic Mach numbers were of low reduced frequency (below 0.30) and were highly correlated. At supersonic Mach numbers the bandwidth of the fluctuations increased and the degree of correlation decreased with increasing Mach number. Author

N68-24802*# North American Aviation, Inc., Downey, Calif.
SHELL ANALYSIS MANUAL
E. H. Baker, A. P. Cappelli, L. Kovalevsky, F. L. Rish, and R. M. Verette Washington NASA Apr. 1968 849 p refs
(Contract NAS9-4387)
(NASA-CR-912) CFSTI: HC$3.00/MF$0.65 CSCL 20M

This shell analysis manual provides specific instructions, procedures, basic solutions, and recommendations to facilitate the expedient static structural analysis of shell-type spacecraft structures. It also provides an introduction to and reference for the practical static structural analysis of shells. Author

N68-24971*# North American Aviation, Inc., Columbus, Ohio.
INFRARED RADIOMETRIC STRESS INSTRUMENTATION APPLICATION RANGE STUDY
Milo H. Belgen Washington NASA May 1968 144 p refs
(Contract NAS1-6082)
(NASA-CR-1067) CFSTI: HC$3.00/MF$0.65 CSCL 20K

Research was utilized to develop a simplified method for evaluating infrared stress measurement applications and to study typical attainable spatial resolutions and detectable stresses (for selected detectors and windows) as a function of test part temperature and stress oscillation frequency. It appears that room temperature infrared measurements might have accuracies of the same general magnitude as conventional instrumentation, and infrared is likely to be more favorable than conventional instrumentation relative to accuracy and other factors at elevated temperatures. Since infrared measurements yield data on the sum of principal stresses, various combinations of infrared and conventional strain instrumentation could yield many (undefined) types of data not previously within the state of the art. Infrared permits rapid spatial data acquisition by scanning with an analog electronic signal output. Author

N68-25104*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PENETRATION RESISTANCE OF DOUBLE SHEET STRUCTURES AT VELOCITIES TO 8.8 KM/SEC
C. Robert Nysmith Washington May 1968 17 p refs
(NASA-TN-D-4568) CFSTI: HC$3.00/MF$0.65 CSCL 20K

Small pyrex glass spheres were launched into aluminum double-sheet targets at velocities to 8.8 km/sec to determine the effects of total sheet thickness and sheet spacing upon penetration resistance. The ballistic limit of double-sheet structures consisting of two equally thick aluminum sheets was found to increase with increasing total sheet thickness and sheet spacing. In addition, for a particular ratio of total sheet thickness to projectile diameter, the effectiveness of sheet spacing increases with increasing impact velocity. The data indicate that for impacts at a given velocity the ratio of front-sheet thickness to projectile diameter that causes maximum vaporization or fragmentation or both will result in the most efficient meteor bumper. It is concluded that the double-sheet structure most efficient in resisting penetration will use that thickness for a front sheet and the remaining available mass in the rear sheet. Measurements were also made of the front-sheet hole diameter and the front-sheet mass loss. It was determined that the front-sheet hole diameter varies with the square root of the impact velocity and the 0.45 power of the front-sheet thickness and the front-sheet mass loss various with impact velocity and the square of the front-sheet thickness. Author

N68-25421*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CRITICAL-SPEED ANALYSIS OF FLEXIBLY MOUNTED RIGID ROTORS
Richard H. Cavicchi Washington Jun. 1968 54 p refs
(NASA-TN-D-4607) CFSTI: HC$3.00/MF$0.65 CSCL 13I

A general solution of the frequency equation for rigid rotors in undamped bearings is derived for forward and backward precession. The solution is applied to a wide range of speeds and shapes, with variation in center-of-gravity location, to obtain maps of the frequency characteristics and locate major and nonsynchronous critical speeds. When the center of gravity is at the bearing centerline midpoint, a set of two solutions exists. An additional set of two solutions appears, however, when the center of gravity is away from this point. No forward-precession high-frequency critical speeds exist if the moment-of-inertia ratio equals or exceeds the critical-speed ratio. With the center of gravity midway between single-row ball bearings and the polar and diametral moments of inertia equal, a nonsynchronous critical speed exists at all rotor speeds. Author

N68-25819*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TARGET PRESSURE AND DAMAGE DATA FROM IMPACTS BY EXPLOSIVELY PROPELLED PROJECTILES
A. B. Wenzel and Nestor Clough Washington, D. C. Jun. 1968 21 p refs
(NASA-TM-X-1597) CFSTI: HC$3.00/MF$0.65 CSCL 20K

Data on maximum shock-generated pressures at several axial positions in 1100-0 aluminum and on crater dimensions in 316-stainless steel were obtained from impacts by explosively-fired aluminum projectiles. The aluminum projectiles with mass ranging from 0.408 to 0.626 grams, impacted the targets at velocities of 11 km/sec. Comparisons of pressure data with similar data from light-gas gun impacts are included, together with a discussion of the "throw-off pellet" technique used to obtain axial pressures. Author

N68-28238*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
USE OF WIRE LACING TO REDUCE BLADE VIBRATION IN AN AXIAL-FLOW COMPRESSOR ROTOR
Roy D. Hager, George W. Lewis, and Jack M. Wagner Washington Jul. 1968 22 p refs
(NASA-TM-X-1603) CFSTI: HC$3.00/MF$0.65 CSCL 20K

The experimental axial-flow compressor rotor had a diameter of 20 inches (50.8 cm), a hub-tip ratio of 0.4, and a blade aspect ratio of 3.6. The rotor was tested with lacing wires installed near

the blade leading and trailing edges close to the blade tip. The wires were installed to reduce a severe bending vibration encountered at approximately 45 percent of design speed. Blade vibratory stresses were reduced from approximately ±110,000 psi (±75.902 × 10^7 N/m^2) for the undamped blade to approximately ±1550 psi (±1.070 × 10^7 N/m^2) for the blade with lacing wires. An estimated reduction in the overall rotor efficiency of 1.6 percentage points resulted from the use of the wires. Author

N68-28330*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STUDY OF VIBRATION INDUCED STRESSES IN DESIGN OF FUEL-ELEMENT SUPPORT ASSEMBLY FOR TUNGSTEN WATER-MODERATED NUCLEAR REACTOR

Ivan B. Fiero and Donald W. Adams Washington Jul. 1968 49 p refs

(NASA-TM-X-1608) CFSTI: HC$3.00/MF$0.65 CSCL 18I

The results of vibration tests on a concentric-tube fuel-element support structure for the Tungsten Water-Moderated Reactor are presented. The assembly is a composite material inner tube separated from a concentric aluminum outer tube by springs. The tests show that the assembly must be supported on both ends and at the center of the aluminum tube by the reactor structure. With a cold reactor, only one spring is necessary to ensure that the support tube will withstand lateral vibrational loads. When the reactor is hot, three springs are required. Stress distributions and parameters affecting bending vibration response are discussed. Author

N68-28335*# North American Rockwell Corp., Downey, Calif.

INFLUENCE OF STRUCTURE AND MATERIAL RESEARCH ON ADVANCED LAUNCH SYSTEMS WEIGHT, PERFORMANCE, AND COST. PHASE 3: DESIGN SYNTHESIS OF RECOVERABLE LAUNCH VEHICLE STRUCTURES

J. A. Boddy Washington NASA Jul. 1968 60 p refs

(Contract NAS7-368)

(NASA-CR-1116; SD-67-1204-1) CFSTI: HC $3.00/MF $0.65 CSCL 22D

To obtain a realistic series of basepoint vehicle systems, a structural synthesis was conducted for the major structural shell components of the recoverable first stages. Conventional constructions such as skin stringer, waffle, and honeycomb sandwich, were considered for the pressurized and unpressurized shells. The synthesis accounted for the thermal environment evaluation and protection system synthesis for the reentry mode of the recoverable first stages of a series of multistage launch vehicles. Relative benefits to be derived from structures/materials improvements when applied to these recoverable stages were considered in terms of their weight reductions, performance improvements, and cost reductions. The computer programs for vehicle synthesis and structural design synthesis were consolidated with a master executive control program and the total program was demonstrated. B.S.D.

N68-28806*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va

REDUCTION OF WIND-TUNNEL-MODEL VIBRATION BY MEANS OF A TUNED DAMPED VIBRATION ABSORBER INSTALLED IN THE MODEL

William B. Igoe and Francis J. Capone Washington Jul. 1968 28 p refs

(NASA-TM-X-1606) CFSTI: HC$3.00/MF$0.65 CSCL 20K

Some experimentally determined performance characteristics have been presented for a tuned damped vibration absorber which was designed to reduce the undesirable rigid body vibrations of a conventional wind tunnel force model. The model vibration was due to random excitation by wind tunnel airstream turbulence and buffeting. A tuned vibration absorber was used for this purpose because it was compact and did not require any force linkages across the force balance. The absorber was tuned to reduce vibrations in both the pitch and yaw planes simultaneously, but its effectiveness in yaw was restricted because the mass center of the absorber was near the node of the yaw vibration mode. In the pitch plane, the peak and root mean square amplitudes of the rear normal force component fluctuations of the balance were reduced by approximately 50 percent at some wind-tunnel test conditions. Author

N68-28832*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

MEMBRANE ANALYSIS OF SCALLOPED SHELLS

Ravindra K. Vyas Washington Jul. 1968 53 p refs

(NASA-TN-D-4687) CFSTI: HC$3.00/MF$0.65 CSCL 20K

The main objective of this report is to contribute to the understanding of membrane forces in scalloped shells, particularly scalloped paraboloids. It is shown how the stress function approach can be applied to the scalloped paraboloids. In order to demonstrate the technique, two scalloped structures having practical significance as structural models for parachutes are discussed in detail. In the cases considered, it is shown that the stress function must satisfy a linear second-order partial-differential equation with variable coefficients. The basic method for solving this equation is given in the first appendix. These results show that the hoop and meridional stresses in the parachute type structure are lower than those in a corresponding shell of revolution. More significantly, the meridional stress in the parachute type shell decreases remarkably, and even becomes compressive, as the bulge of the scallop, defined by a positive parameter β, is increased. It is shown how a critical value, β_{cr} of this bulge parameter can be obtained below which the shell would remain in a compressionless state. A singular solution used in prescribing rope tension near the opening of the parachute type shell may also be useful in other aspects of parachute analysis. Author

N68-30045*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A NUMERICAL PROCEDURE FOR CALCULATING STRESS AND DEFORMATION NEAR A SLIT IN A THREE-DIMENSIONAL ELASTIC-PLASTIC SOLID

David J. Ayres Washington NASA Aug. 1968 31 p refs

(NASA-TN-D-4717) CFSTI: HC$3.00/MF$0.65 CSCL 20K

A finite difference procedure for the computation of the stress in a three dimensional solid is presented. This iterative technique, based on Newton's method for determining the roots of a system of polynomials, is applicable to both linear and nonlinear problems. The sample problems that are treated are the analysis of a plate in plane strain with a slit at its center, the analysis of a thick plate with a rectangular slit through its thickness, and the analysis of a thick plate containing a semielliptical slit which extends only halfway through its thickness. The loading condition in all sample problems is uniaxial tension normal to the slit. Author

N68-30505*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EXPERIMENTAL STUDY OF VERTICAL IMPACTS OF AN LM-TYPE LANDING GEAR ASSEMBLY UNDER SIMULATED LUNAR GRAVITY

John Locke McCarty and Huey D. Carden Washington Aug. 1968 55 p refs

(NASA-TN-D-4711) CFSTI: HC$3.00/MF $0.65 CSCL 22B

A study made to evaluate the response of a landing gear system on several penetrable target materials and to relate this response to that of penetrometers impacting the same materials. Testing included vertical impacts of a single landing gear unit at velocities up to approximately 3 m/sec. The test apparatus included a full-scale boilerplate pad and a vertical strut with stroking characteristics similar to those of LM. The mass of the system

approximated 25, 50 and 100% of the anticipated vehicle landing mass. The target materials consisted to two grades of quartz sand (one in a densely packed state) and an open cell urethane foam. The results show that the maximum anticipated accelerations sensed by the vehicle occupants and equipment would not exceed 3.3g (earth) in a vertical landing. During strut compression, which is intensified with increasing target bearing strength, with system mass and with impact velocity, these accelerations are shown to be a function of only the crushing strength of the collapsible strut and the system mass. Pad accelerations increase with increasing impact velocity and increasing target penetration resistance and, during strut compression, are independent of the system mass. Data are presented which show that the penetration of the landing pad into particulate target materials can be reasonably estimated. Author

N68-31602*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

INVESTIGATION OF A COMPARTMENTED-GAS-BAG LANDING SYSTEM HAVING MULTIPLE IMPACT CAPABILITIES

John R. McGehee Washington Aug. 1968 38 p refs

(NASA-TN-D-4710) CFSTI: HC$3.00/MF$0.65 CSCL 22B

The principles of the proposed landing system were investigated experimentally to determine the kinetic energy dissipating capability of the system. A simplified test vehicle, using unidirectional gas bags, was tested with both sharp-edged and fabric covered orifices between the compartments. A supplementary experimental investigation was conducted to determine the discharge parameters associated with various fabrics. In addition, equations were derived for computing time histories of acceleration, velocity, stroke, and compartment pressures to extend the usefulness of the investigation by permitting variation of the landing environment and test vehicle parameters. The results show a kinetic energy dissipation capability for the initial impact as great as 93 percent of the vehicle touchdown kinetic energy. Tests performed with aircraft fabric covered orifices yielded a slightly greater (approximately 5 percent) kinetic energy dissipation capability than was obtained with the sharp-edged orifices. The analytical investigation resulted in a computational procedure which provides fair agreement between computed and experimentally determined accelerations, pressures, and kinetic energy dissipation for the ranges of velocity and bag initial pressures investigated. Author

N68-31912*# General Electric Co., King of Prussia, Pa.

PLATE-GAP MODEL OF A POROUS SOLID AND ITS APPLICATION TO IMPACT BY REDUCED DENSITY PROJECTILES

J. F. Heyda Washington NASA Aug. 1968 39 p refs

(Contract NAS3-8512)

(NASA-CR-1140 CFSTI: HC$3.00/MF$0.65 CSCL 20K

The sensitivity of the peak axial profiles, obtained using the impact model of an earlier report, to a change in the Hugoniot function assumed for the reduced density projectiles is examined briefly. The previous Hugoniot function, based on the Los Alamos equation of state for aluminum, is replaced by one based on the Plate-Gap model of a porous solid due to Thouvenin. A modification of this model is described in detail and its comparison with existing experimental data for six porous materials and the predictions of the theoretically based equation of state due to Wagner and Bjork for aluminum is noted. Comparison is also made of calculated peak axial pressures obtained using the impact model for the case of normal density aluminum projectiles impacting aluminum with experimental data obtained from corresponding jet projector impact shots. Author

N68-31946*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

PLASTIC BUCKLING OF PLATES AND SHELLS UNDER BIAXIAL LOADING

James P. Peterson Washington Aug. 1968 32 p refs

(NASA-TN-D-4706) CFSTI: HC$3.00/MF$0.65 CSCL 20K

Available elastic buckling equations are used in making the plastic buckling calculation by substituting wall stiffnesses derived from a plastic buckling theory for the elastic orthotropic wall stiffnesses associated with the elastic buckling equations. This method permits the calculation of the buckling load of many structures of current interest which cannot be handled by available methods. Buckling loads of cylinders and plates of conventional, sandwich, and laminated construction are easily calculated. The cylinders and plates may have stiffening members which may be eccentric (one-sided) and which may be made of a different material than the skin. For many structures, the effect of transverse shear can be taken into account in the buckling calculations. Author

N68-32051*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A THEORETICAL AND EXPERIMENTAL INVESTIGATION OF THE THRE-DIMENSIONAL VIBRATION CHARACTERISTICS OF A SCALED MODEL OF AN ASYMMETRICAL LAUNCH VEHICLE

Ellwood L. Peele, William M. Thompson, Jr., and Christine G. Pusey Washington Aug. 1968 56 p refs

(NASA-TN-D-4707) CFSTI: HC$3.00/MF$0.65 CSCL 20K

The three-dimensional vibration characteristics of a dynamically scaled model of an asymmetrically clustered launch vehicle were investigated both analytically and experimentally. The matrix Holzer analysis formulated specifically for this model configuration is identified as being three-dimensional because it renders possible the analysis of motion which is coupled in three planes: lateral bending motion in two planes (pitch and yaw), torsional motion, and longitudinal motion. Previous two-dimensional analyses of similar configurations considered pitch-torsion uncoupled from yaw-longitudinal motion. The suitability of the analysis is evaluated by comparison of computed vibration characteristics with measured response of a near-replica scaled model to lateral excitation. On the basis of these comparisons, the procedure was found to be capable of predicting the major vibration characteristics. Additional comparison is made between computed data based on a coupled and uncoupled mathematical model. These comparisons indicate that for this configuration, the coupled and uncoupled analysis yielded essentially the same results. Author

N68-32074*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

PREDICTION OF FATIGUE-CRACK-PROPAGATION BEHAVIOR IN PANELS WITH SIMULATED RIVET FORCES

I. E. Figge and J. C. Newman, Jr. Washington Aug. 1968 33 p refs

(NASA-TN-D-4702) CFSTI: HC$3.00/MF$0.65 CSCL 20K

Analytical and experimental studies were conducted to determine the rates of fatigue crack propagation in 7075-T6 aluminum alloy sheet specimens containing either symmetric or nonsymmetric cracks subjected to uniform end loads, concentrated loads, or combinations of both. The concentrated loads simulated rivet forces and were applied by a special hydraulic fixture which is described. These studies indicate that the curve of stress-intensity factor against crack growth rate obtained from tests on simple specimens of a given material tested at load ratios of 0.05 to −1 can be successfully used to predict the crack propagation behavior of complex specimens of the same material tested over the same range of load ratios. It was also observed that better predictions of life were obtained for panels subjected to concentrated forces when the stress intensity factors were obtained by using the measured strains on the uncracked panels rather than by using those obtained from the theoretical point load solutions. Author

N68-32976*# Fundamental Methods Associates, Inc., New York.
APPLICATION OF DUST FOR SPACE STRUCTURES
Carl N. Klahr, Sylven N. Cutler, and Kalman Kalikstein Washington NASA Aug. 1968 61 p ref
(Contract NASw-1374)
(NASA-CR-1136) CFSTI: HC $3.00/MF $0.65 CSCL 22A

This report is concerned with the physical properties and applications of small particles—particles whose masses range from 100 micrograms to 1 micro-microgram. A dust structure will be defined to be a spatial distribution of discrete particles whose relative geometry is maintained by the particle trajectories or by individual particle motion, and not by conventional cohesive forces which hold solids or liquids together. Therefore, dust configurations can be considered a new type of physical structural material, having properties often unlike those of solids, liquids, or gases. Various means can be used to maintain the cross relative geometry of the spatial distribution which constitutes the dust structure. Dust structures have unique properties across the entire thermal and electromagnetic energy spectrum, from optical frequencies through microwave and radio frequencies. Their inertial and mechanical properties as well as their gross material behavior are also quite unusual. Author

N68-33057*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
ON THE PREDICTION OF THE VIBRATORY BEHAVIOR OF FREE-FREE TRUNCATED CONICAL SHELLS
Eugene C. Naumann Washington Sep. 1968 34 p refs
(NASA-TN-D-4772) CFSTI: HC $3.00/MF $0.65 CSCL 20K

An analytical procedure is described for the prediction of the frequencies and mode shapes for free-free truncated conical shells. The method utilizes simple power series modal assumptions in a Rayleigh–Ritz type solution procedure. Excellent agreement was obtained when analytical results were compared with experimentally obtained frequencies and meriodional mode shapes. Comparisons between analytical and experimental results are presented for truncated conical shells over the following range of parameters: (1) semivertex angles from 3.4° to 60.5°, (2) shell thicknesses from 0.0178 cm to 0.0813 cm, (3) shell truncation ratio (minimum radius/maximum radius) from 1/8 to 6/7, (4) shell maximum radius from 15.43 cm to 60.96 cm, and (5) materials—aluminum alloy, cold rolled steel, and stainless steel. Author

N68-33092*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
A MATRIX METHOD FOR STUDYING MOTIONS OF SPACECRAFT CONSISTING OF INTERCONNECTED RIGID BODIES
Richard E. Turner Washington Sep. 1968 47 p refs
(NASA-TN-D-4749) CFSTI: HC $3.00/MF $0.65 CSCL 20K

A system of matrix equations was developed which describes the interaction between two rigid bodies joined at a point. The relative motion of the bodies is treated by projection matrices. A projection matrix is found which determines the angular acceleration allowed by relative angular motion about a common attachment point. Another projection matrix is found which determines the components of relative angular acceleration of the two bodies caused by physical constraints on their relative angular motion. By using these matrices, an automatically applied. This equation, the translational momentum equation, the angular momentum equation, and the translational constraint equation form a set of equations which can be used to add rigid rotating bodies to a dynamical system to achieve a new dynamical system of any desired complexity. This method is useful when constraint forces and torques must be calculated. An example dynamical system which consists of a central hub with four rigid wings connected to the hub at four different attachment points is studied. The equations of motion for this system were integrated numerically, and some parameters which describe the motion of the system are presented graphically Author

N68-33168*# Southampton Univ. (England).
THE RESPONSE OF A SIMPLY SUPPORTED PLATE TO TRANSIENT FORCES. PART 2: THE EFFECT OF N-WAVES AT OBLIQUE INCIDENCE
Anthony Craggs Washington NASA Sep. 1968 25 p refs
(Grant NGR-52-052-003)
(NASA-CR-1176) CFSTI: HC $3.00/MF $0.65 CSCL 20K

A numerical method is used to compute the response of a simply supported plate to an 'N' wave arriving at oblique incidence. The factors influencing the response under these conditions are: (1) the ratio of the pulse duration to the fundamental period of the plate and (2) the convection forcing terms which are different for each mode. Also, asymmetric modes are excited, which do not make any contribution when the wave is at normal incidence to the plate. The computed results show that both the convection terms and the asymmetrical modes make a significant contribution to the form of the response for the displacements, velocities, and accelerations, though their effects are more dominant in the accelerations than for any other parameter. Author

N68-33191*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF RESIDUAL STRESS ON FRACTURE STRENGTH OF AISI 301 STAINLESS-STEEL AND Ti–5Al–2.5Sn ELI TITANIUM CRACKED THIN WALL CYLINDERS
Frederick D. Calfo Washington Sep. 1968 27 p refs
(NASA-TN-D-4777) CFSTI: HC $3.00/MF $0.65 CSCL 20K

Six-inch- (15.2-cm-) diameter cylinders containing through-cracks were fabricated from 0.020-inch- (0.051-cm-) thick Ti–5Al–2.5Sn ELI titanium and 0.022-inch(0.056-cm-) thick AISI 301 stainless steel. Stress-relieved and non-stress-relieved cylinders were pressurized to burst at −423° and −320°F (20° and 77°K). The residual bending stresses in the titanium alloy were reduced from 65,000 to 6000 psi (45,000 to 4000 N/cm^2) by means of a stress-relieving heat treatment. The effect was an increase in fracture strength of about 10,000 to 15,000 psi (6900 to 10,400 N/cm^2). A reduction of residual stresses from 60,000 to 30,000 psi (42,000 to 21,000 N/cm^2) in the stainless-steel cylinders did not appreciably change their fracture strength. Author

N68-33225*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
FREE VIBRATION OF A ROTATING BEAM-CONNECTED SPACE STATION
James La Mar Milner Washington Sep. 1968 99 p refs
(NASA-TN-D-4753) CFSTI: HC $3.00/MF $0.65 CSCL 20K

The free vibration of a rotating beam-connected space station is analyzed with a mathematical model of the space station which represents the general three-dimensional motion of the various components of the system. The space station is composed of two space modules connected by flexible beam, and the system is caused to spin in the plane of its orbit in order to produce an artificial gravity environment within the space modules. The kinetic energy and potential energy of the space station are used to develop a Lagrangian function of the system. Hamilton's principle is used to determine a set of governing equations, and a set of boundary conditions representing a clamped-clamped attachment of the beam to each space module is applied to the ends of the beam. Within the limits of small deflection theory, the motion of the space station is shown to be uncoupled into two separate types of motion, one in the plane of rotation and the other perpendicular to the plane of rotation. An exact solution is obtained for the beam deflection in the plane of rotation. The application of the nonhomogeneous boundary conditions leads to a set of simultaneous equations in the frequency p^2, from which a characteristic determinant is developed. A procedure to solve for the zeros of the characteristic determinant is programmed for digital solution on the IBM 7094. Author

N68-33226*# California Inst. of Tech., Pasadena.
THE BUCKLING OF THIN-WALLED CIRCULAR CYLINDERS UNDER AXIAL COMPRESSION AND BENDING
F. R. Stuart, J. T. Goto, and E. E. Sechler Washington NASA Sep. 1968 48 p refs
(Grant NsG-18-59)
(NASA-CR-1160) CFSTI: HC $3.00/MF $0.65 CSCL 20K

A series of tests was conducted on both electroplated copper and Mylar cylinders under combined axial compression and bending. Great care was taken to assure that the cylinders were as perfect as was possible and loading and boundary conditions were carefully controlled. For the Mylar cylinders, corrections were made for both area and stiffness of the lap joint. Under these conditions, much higher values of the buckling stress were obtained than had been reported on by previous investigators. Author

N68-33266*# North Carolina State Coll., Raleigh.
NOISE REDUCTION SHAPE FACTORS IN THE LOW FREQUENCY RANGE
J. Ronald Bailey and Franklin D. Hart Washington NASA Sep. 1968 52 p refs
(Grant NGR-34-002-035)
(NASA-CR-1155) CFSTI: HC $3.00/MF $0.65 CSCL 20A

An analysis is made of noise reduction of small enclosures in the low-frequency range where both panel and volume are stiffness controlled. The strong dependence on geometry of the compliance of flexible panels is illustrated. Shape factors for low-frequency noise reduction are established through expressions for the acoustic compliance of enclosures and the compliances of rectangular, circular, cylindrical, and spherical panels. A comparison is made of the noise reduction of enclosures involving these elements and having equal volume, panel thickness, and exposed surface area. It is observed that the stiffer, membrane-controlled spherical and cylindrical enclosures have greater noise reduction than enclosures having flexure-controlled flat panels. A companion experimental investigation is described and the results are discussed and compared with the theory. Author

N68-33419*# California Inst. of Tech., Pasadena.
ALMOST SURE STABILITY OF LONG CYLINDRICAL SHELLS WITH RANDOM IMPERFECTIONS
Rena Scher Fersht Washington NASA Aug. 1968 24 p refs
(Grant NsG-18-59)
(NASA-CR-1161) CFSTI: HC $3.00/MF $0.65 CSCL 20K

A Lyapunov method is used to obtain sufficient conditions *for the buckling stability* of cylindrical shells with axisymmetric random imperfections. A perturbed system of equations in the neighborhood of the prebuckling solution is investigated. By reducing the problem to a system of integral equations, the stability boundary value problem of a long shell is similar to that of a dynamical system with random parametric excitations. The method has been tested numerically for the case of *axisymmetric random* imperfections of a cylindrical shell under axial compression. Initial imperfections were assumed to have Gaussian distribution and an exponential cosine correlation function. The critical load was obtained as a function of the root mean square of the imperfections. Author

N68-33737*# Southampton Univ. (England). Inst. of Sound and Vibration Research.
THE RESPONSE OF A SIMPLY SUPPORTED PLATE TO TRANSIENT FORCES. PART 1: THE EFFECT OF N-WAVES AT NORMAL INCIDENCE
Anthony Craggs Washington NASA Sep. 1968 34 p refs
(Grant NGR-52-025-003)
(NASA-CR-1175) CFSTI: HC $3.00/MF $0.65 CSCL 20K

A numerical method is presented for determining the response of a structure to transient forces of arbitrary form. It is used to evaluate the response of a simply supported plate to an 'n' wave at normal incidence. Three response parameters are considered: the displacement, the acceleration and the stress at a particular point on the plate. It is shown that the fundamental mode dominates the *displacement and stress responses* in all cases. However, there is a significant contribution from the higher modes in the accelerations. The maximum response occurs when the duration of the wave is equal to the fundamental period of the plate. Author

N68-33738*# National Aeronautics and Space Administration. *Langley Research Center, Langley Station, Va.*
AN EXPERIMENTAL AND ANALYTICAL VIBRATION STUDY OF THIN CYLINDRICAL SHELLS WITH AND WITHOUT LONGITUDINAL STIFFENERS
John L. Sewall and Eugene C. Naumann Washington Sep. 1968 56 p refs
(NASA-TN-D-4705) CFSTI: HC $3.00/MF $0.65 CSCL 20K

Aluminum alloy cylindrical shells with and without external or internal integral longitudinal stiffeners for four end-support conditions were investigated. The stiffeners were of rectangular cross section and were closely spaced over the shell surface. Analytical results were obtained by application of the energy method employing the Rayleigh–Ritz procedure, in which longitudinal modal components were approximated by an arbitrary number of elementary beam-vibration functions chosen to satisfy prescribed end conditions. Results show the minimum frequencies of the externally stiffened shell, in all cases, to be significantly higher than the minimum frequencies of *the corresponding internally stiffened* shells. Agreement between measured and calculated frequencies was significantly improved when the analysis included local transverse bending stiffness due to the stiffeners, and additional beam modes for support conditions other than simply supported. The effect of including stiffener rotatory inertia in the analysis was found to be negligible. Applications of the analysis to two ring-stiffened shells are included to show the extent to which the averaged-stiffener assumption is valid for these configurations. Author

N68-35071*# National Aeronautics and Space Administration. *Lewis Research Center, Cleveland, Ohio.*
ULTRASONIC DETECTION AND MEASUREMENT OF FATIGUE CRACKS IN NOTCHED SPECIMENS
Stanley J. Klima and John C. Freche Washington Sep. 1968 31 p refs To be Presented at the SESA Fall Meeting, San Francisco, 28 Oct.–1 Nov. 1968
(NASA-TN-D-4782) CFSTI: HC $3.00/MF $0.65 CSCL 13H

An ultrasonic technique was developed and used to observe the formation and growth of fatigue cracks in notched cylindrical specimens subjected to reversed axial fatigue loading. Fatigue curves showing cycles to initially detectable cracks as well as cycles *to fracture were obtained* for an aluminum-, a titanium-, and a cobalt-base alloy and for a maraging steel. Depth of initially detectable cracks ranged between approximately 0.0005 and 0.004 in. (0.013 and 0.10 mm). Also obtained were curves relating ultrasonic system output voltage to crack depths up to 0.030 in. (0.76 mm) for three materials. These curves were used to demonstrate the capability of the device for *monitoring crack growth.* Author

N68-35198*# California Inst. of Tech., Pasadena.
BUCKLING OF CONICAL SHELLS UNDER AXIAL COMPRESSION
Johann Arbocz Washington NASA Sep. 1968 60 p refs
(Grant NsG-18-59)
(NASA-CR-1162) CFSTI: HC $3.00/MF $0.65 CSCL 20K

An experimental investigation of the effect of the cone semivertex angle on the buckling load of a conical shell under axial compression was carried out. The effect of a specific type of initial imperfection was also investigated. The imperfection studied was axially symmetric in shape. *The experiments were carried out with* shells fabricated by a copper electroforming process. The shells had no longitudinal seams. Final results showed that the dependence of the buckling load on the semivertex angle is adequately represented by the linearized theory. Also the upper boundary to the experimental results of the cones with known axisymmetric initial imperfections agreed well with previously published analytical values. Author

N68-35199*# California Inst. of Tech., Pasadena.
EXPERIMENTAL INVESTIGATION OF THE EFFECT OF GENERAL IMPERFECTIONS ON THE BUCKLING OF CYLINDRICAL SHELLS
Johann Arbocz and C. D. Babcock, Jr. Washington NASA Sep. 1968 81 p refs
(Grant NsG-18-59)
(NASA-CR-1163) CFSTI: HC $3.00/MF $0.65 CSCL 20K

Results are presented on complete imperfection surveys carried out on cylindrical shells before and during the loading process up to the buckling load. A noncontact probe was used to make these surveys on electroformed copper shells. The data recording process was fully automatized and the data reduction was done on an IBM 7094. Three-dimensional plots were obtained of the measured initial imperfection surfaces and of the growth of these imperfections under increasing axial loading. The modal components of the measured imperfection surfaces were also obtained. Preliminary results indicated that the prebuckling deformation which apparently caused the reduction in buckling load from that of a perfect shell could not be represented by an isolated mode. Author

N68-35496*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
DIVERGENCE OF SOME ALL-MOVABLE CONTROL SURFACES INCLUDING DRAG LOADING
Robert C. Goetz Washington Oct. 1968 33 p refs
(NASA-TN-D-4793) CFSTI: HC $3.00/MF $0.65 CSCL 01A

The aeroelastic divergence characteristics of some rigid all-movable control surfaces supported by a flexible shaft have been studied analytically, and the results have been compared with existing experimental data in the Mach number range from 1.64 to 15.4. The configuration studied was a blunt, double-wedge control surface supported by a long, thin cantilever that was weak in the lift direction and stiff in the drag direction. The results of the study indicate that a new type of divergence instability is inherent to this configuration. Its character is a mode of deflection consisting of lateral bending accompanied by torsional rotation. The analysis and experiments indicate that drag loadings, in addition to lift loadings, are important in this new divergence instability. Estimates obtained from a potential energy analysis using aerodynamic characteristics calculated from simple Newtonian theory were in fair agreement with the experimental results over the entire Mach number range; however, excellent agreement resulted when measured static aerodynamic derivatives were incorporated into the analysis for the Mach 6.8 and 15.4 experiments. Author

N68-35632*# General Dynamics Corp., San Diego, Calif.
DYNAMIC STABILITY OF SPACE VEHICLES. STRUCTURAL DYNAMICS MODEL TESTING
J. W. Wissmann Washington NASA Sep. 1968 48 p refs
(Contract NAS8-11486)
(NASA-CR-1195) CFSTI: HC $3.00/MF $0.65 CSCL 20K

The principles of realistic modeling are outlined in terms of dimensional analysis, and similitude and scaling laws which introduce a physical configuration for the prototype along with the one for the scale model. Mathematical representations for each are given. Scale factors sufficient for most routine model work are calculated, and the requirements for kinematic similitude and dynamic similitude are formulated. The practical advantages of distorted scale models are cited, and the mathematical representations are reformulated to account for the variables. An example is included to demonstrate how the analytical formulation of a problem can be used to advantage to design an experiment, to reduce the number of independent variables, and to account for model distortions. Consideration is also given to ways of treating scale effects which represent a special case of model distortions. Recommended test practices are identified as definition of the problem, justification of the use of models, assessment of the model design parameters, model engineering, test setup, test procedure, and data evaluation and interpretation. M.G.J.

N68-37840*# Lehigh Univ., Bethlehem, Pa.
FATIGUE CRACK PROPAGATION IN CYLINDRICAL SHELLS
W. M. Catanach, Jr and F. Erodogan Washington NASA Oct. 1968 112 p 24 refs
(Grant NGR-39-007-011)
(NASA-CR-1197) CFSTI: HC $3.00/MF $0.65 CSCL 20K

This report presents some of the results of the experimental and theoretical studies on the fatigue crack propagation in cylindrical shells subjected to fluctuating internal pressure. Most of the fatigue tests are performed on 6063-T6 aluminum alloys. In the analysis of the experimental results, the stress intensity factor is used as the correlation parameter. A modified crack propagation model is developed to take into account the effect of bending stresses, which are superimposed on membrane loads around the crack in shells. To evaluate the stress intensity factor, the integral equations obtained by Folias are solved numerically after separating the singularities. Partly to verify the theoretical results, strain measurements were made around the crack tip on the outside of the aluminum and inside and outside of the plexiglas cylinders. The results indicate that over the range of crack propagation data covering 10^{-7} to 10^{-3} in/cycle, the model adopted in this study seems to be highly satisfactory. Author

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THERMODYNAMICS AND COMBUSTION

Includes ablation, cooling, heating, heat transfer, thermal balance, and other thermal effects; and combustion theory. For related information see also: 12 Fluid Mechanics; and 27 Propellants.

N68-10368* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TRANSIENT CHILLDOWN OF A SINGLE THICK-WALLED TUBE BY LIQUID AND GASEOUS HYDROGEN

Francis C. Chenoweth, James J. Watt, and Earl L. Sprague Washington NASA Nov. 1967 55 p refs

(NASA-TN-D-4238) CSCL 20M

The flow and heat transfer characteristics during the startup of a nuclear rocket are of particular interest because of the bootstrap type of startup. An analytical procedure was assembled using state-of-the-art equations to provide a tool for predicting the transient flow and heat transfer characteristics of reactor components during the startup. The results of applying this analytical procedure to a single thick-walled tube, which was selected as typical of a passage in the reflector of a current nuclear reactor, are presented. Experiments were performed on a thick-walled tubular test section to provide experimental data for comparison with predicted results. With the test section at room temperature, either liquid-hydrogen or cold-hydrogen-gas flow was directed through the 3/16-inch (0.476-cm) bore of the 55-inch (139.6-cm) long test section until it was thoroughly chilled. During most of the liquid-hydrogen chilldown, a saturated liquid was assumed to be at the inlet of the test section. During the gas chilldown, the inlet gas temperature varied from 470° to 360°R (261° to 200°K). Inlet pressures ranged from 20 to 50 psia (1.38×10^5 to 3.45×10^5 N/m^2 abs). The initial wall temperatures and the flow rate, the inlet enthalpy, and the inlet pressure as functions of time from the experimental test were used as input for the analytical procedure. Comparison of predicted and experimental material temperatures, pressures, and exit temperatures indicated that, when cold hydrogen gas was used as the chilling medium, excellent agreement was obtained. When liquid hydrogen was used, only the average chilldown rates of the test section agreed. Local predicted material temperature variations were traced to characteristics of the heat transfer correlations used. Pressure and exit temperature variations were related to an extreme sensitivity of predicted values to variations in inlet quality and flow rate. Author

N68-11038*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

THE EFFECTS OF MOLECULAR STRUCTURE ON THE THERMOCHEMICAL PROPERTIES OF PHENOLICS AND RELATED POLYMERS

John A. Parker and Ernest L. Winkler Washington Nov. 1967 40 p refs Presented at the Symp. on Phenolic Chem., Natl. Meeting of Am. Chem. Soc., Miami, Fla., Apr. 1967

(NASA-TR-R-276) CFSTI: HC$3.00/MF$0.65 CSCL 11I

Phenolic resins and related polymers were synthesized by established methods to provide different types of char-forming polymers for pyrolysis studies. Certain features of the molecular structure of these polymers which determine the char yield have been characterized. Pyrolysis studies were carried out under both thermogravimetric conditions and in environments simulating reentry ablation to relate the char yields of these polymers to their molecular structure. It has been possible to account for the char-forming reactions of these phenolic derived resins in terms of a general pyrolysis mechanism for these classes of polymers. An analysis based on this mechanism was developed which predicts from molecular structure the observed thermogravimetric char yields accurately over a range from 11 to 65% yield. This analysis makes it possible to control the primary rates of vapor to char production as required for particular heat-shield applications. Composites from these polymers were developed and tested under one-dimensional pyrolysis simulating reentry ablation. Up to applied heating rates of about 25 cal $cm^{-2}sec^{-1}$, the observed char yields agree quite closely with those obtained in thermogravimetric tests. It is tentatively concluded that the primary char-forming processes with these classes of materials are independent of polymer heating rate over a range of temperature rise rates varying from 2° to 5000°C per minute. With certain composites and at heating rates greater than 25 cal $cm^{-2}sec^{-1}$ an additional amount of char is formed due to secondary pyrolysis of vapor products within the char matrix induced by high char temperatures. These secondary processes seem to depend on surface temperature, impact pressure, and the chemical nature of the vapor products. Author

N68-11144* National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

CHARTS FOR EQUILIBRIUM ISENTROPIC EXPANSION OF AIR BEHIND SHOCKS UP TO 50000 FEET PER SECOND (15.24 KILOMETERS PER SECOND)

Ernest V. Zoby and Wayne D. Erickson Washington Nov. 1967 51 p refs

(NASA-TN-D-4247) CFSTI: $3.00 CSCL 20M

Isentropic state properties (enthalpy, temperature, and density) have been computed for equilibrium air as a function of pressure relative to the respective stagnation-point conditions behind normal shocks for a wide range of velocities and altitudes. The free-stream velocities ranged from 10,000 to 50,000 ft/sec and the altitudes ranged from 50,000 to 300,000 feet. These isentropic properties with the associated normal shock properties of pressure, temperature, and density were correlated with nonreacting perfect-gas isentropic and normal shock expressions. Charts of the correlation parameters are presented as well as a simple procedure for computing the properties. Author

N68-11491*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

WEAK LOCALLY HOMOGENEOUS TURBULENCE AND HEAT TRANSFER WITH COMBINED TWO-DIMENSIONAL SHEAR AND NORMAL STRAIN

Robert G. Deissler Washington Dec. 1967 26 p refs

(NASA-TN-D-4273) CFSTI: HC$3.00/MF$0.65 CSCL 20M

An analysis of the effects of shear and normal strain on weak turbulence and turbulent heat transfer is made using two-point correlation equations obtained from the Navier–Stokes and energy equations. The correlation equations are converted to spectral form by taking their Fourier transforms. The resulting first-order partial differential equations are then reduced to an equivalent set of ordinary differential equations. The normal strain is taken as two-dimensional, uniform, and incompressible, with a contraction occurring in the same transverse direction as the uniform shear and temperature gradients. The turbulence is assumed to be initially isotropic but becomes anisotropic in the presence of the shear and normal strain. Author

N68-11636* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MIST-FLOW HEAT TRANSFER USING SINGLE-PHASE VARIABLE-PROPERTY APPROACH

Yih-yun Hsu, Glenn R. Cowgill, and Robert C. Hendricks Washington Dec. 1967 81 p refs

(NASA-TN-D-4149) CFSTI: $3.00 CSCL 20M

Film-boiling mist flow is treated as a single-phase flow with properties being synthesized from those of liquid and vapor phases weighted according to their respective volume fraction. Such a synthesizing approach renders it possible to apply the technique for single-phase turbulent flow to the two-pase flow. Computational results for film-boiling hydrogen at low pressure predicts the experimental data within 25 percent; the deviation between the analytical and experimental results increases gradually with increasing pressure. Further analysis showed that the deviation was due to the assumptions of a thermodynamic equilibrium and homogeneous distribution of void. A simplified design method is proposed so that the heat-transfer coefficient can be calculated from the Dittus–Boelter equation by specifying a reference temperature and a reference void fraction for computation of properties. The coefficient for determining such a reference temperature and void is primarily a function of the bulk void fraction. Author

N68-11642*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HYDROGEN–OXYGEN CHEMICAL REACTION KINETICS IN ROCKET ENGINE COMBUSTION

Martin Hersch Washington Dec. 1967 20 p refs

(NASA-TN-D-4250) CFSTI: HC $3.00/MF $0.65 CSCL 07D

Hydrogen–oxygen reaction times and concentration histories of chemical species during reaction were calculated for rocket combustor conditions. Calculations were made for oxidant-fuel weight ratios of 1 and 10 and initial reactant temperatures of 1200° to 2500°K at a chamber pressure of 20 atmospheres (2.0×10^6 N/sq m). The reaction time varied from about 0.01 second at 1200°K to a few microseconds at 2500°K. Calculations were made by using a numerical integration program and an analytical solution. The reaction mechanism used included five chain branching reactions and three recombination-type reactions. Author

N68-11721*# Israel Program for Scientific Translations, Ltd., Jerusalem.

HEAT AND MASS TRANSFER. VOLUME 1: CONVECTIVE HEAT EXCHANGE IN A HOMOGENEOUS MEDIUM [TEPLO- I MASSOPERENOS. KONVEKTIVNYI TEPLOOBMEN V ODNORODNOI SREDE]

A. V. Lykov, ed., and B. M. Smol'skii, ed. 1967 313 p refs Transl. into ENGLISH from Nauka i Tekhnika (Minsk), 1965 Published for NASA and NSF

(NASA-TT-F-431; TT-67-51367) CFSTI: $3.00 CSCL 20M

Heat transfer and friction resistance in homogeneous media, convective processes, hydrodynamics, boundary layer flow, and unsteady state conditions are covered in a series of papers dealing with experiments in fluid and gas dynamics. For individual titles see N68-11722 to N68-11753. M.W.R.

N68-11811*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

COMPARISON OF CONVECTIVE STAGNATION HEAT TRANSFER IN AIR, CO_2–N_2, AND CO_2–Ar_2 GAS MIXTURES

Clifford M. Akin and Joseph G. Marvin Washington Nov. 1967 15 p refs

(NASA-TN-D-4255) CFSTI: HC $3.00/MF $0.65 CSCL 20M

Convective stagnation-point heat transfer was measured on hemispherical models in air, in 50% CO_2, 50% N_2, and in 65% CO_2, 35% Ar (by volume). The measurements were made in combustion-driven shock tubes over a total enthalpy range from 9.3×10^6 to 48×10^6 J/kg with corresponding stagnation-point pressures from 15 to 160 atmospheres. At the same stagnation enthalpy and pressure, no significant difference was found between the heat transfer measured in air and in the gas mixtures. This observation agrees with theory. The data were adequately predicted by theories which took into account the stagnation-point stagnation–point pressures of the present tests. Author

N68-14042*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYSIS OF TURBULENT LIQUID-METAL HEAT TRANSFER IN CHANNELS WITH HEAT SOURCES IN THE FLUID POWER-LAW VELOCITY PROFILE

Robert M. Inman Washington Jan. 1968 39 p refs

(NASA-TN-D-4336) CFSTI: HC $3.00/MF $0.65 CSCL 20M

An analysis is made to determine the heat-transfer characteristics for turbulent flow of a heat-generating liquid metal between parallel plates with wall heat transfer. The internal heat generation is uniform over the channel cross section and along its length. The wall heat transfer is also uniform along the channel length. The analysis applies in the thermal entrance region of the channel as well as far downstream. The fluid is assumed to have a fully developed, turbulent power-law velocity profile which is unchanging throughout the length of the channel. The idealized eddy diffusivity profile proposed by Poppendiek is used. Numerical results for the wall temperature distribution and Nusselt number variation are presented in graphical form for a 1/7-power-law velocity profile and for values of k ranging from 1 to 5. Results for the fully developed Nusselt numbers for liquid metal flow without internal heat generation are compared with existing calculations (based on the assumption that the eddy diffusivities of heat and momentum are equal) and exhibit good agreement. Author

N68-14052* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

NONLINEAR HEAT TRANSFER AND TEMPERATURE DISTRIBUTION THROUGH FINS AND ELECTRIC FILAMENTS OF ARBITRARY GEOMETRY WITH TEMPERATURE-DEPENDENT PROPERTIES AND HEAT GENERATION

A. R. Shouman Washington Jan. 1968 44 p refs

(NASA-TN-D-4257) CFSTI: $3.00 CSCL 20M

A theoretical analysis was conducted of one-dimensional, steady-state, heat exchange by both convection and radiation between a rod or a fin and their surroundings. The analysis considers both the cases where the heat is being dissipated or received by the fin or rod. Both the infinite and finite length cases are considered. The surroundings equivalent temperature for radiation could be different from that for convection. The fin or rod could have an arbitrary geometry and its physical properties could be temperature dependent as well as displacement dependent. The analysis also considers the effect of heat generation or absorption. The exact solution of the problem for a constant area fin or rod with constant thermal properties is presented. The solution produces two functions of parametric nature. The different parameters are dependent on the boundary conditions. A computer program for evaluating the functions was written. It was shown that the heat generation or absorption cases are reducible to the simple case through a suitable transformation. After this transformation, the tabulated functions can be used for solving problems with internal heat generation or absorption. Author

N68-14240*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CORRELATION OF LOCAL HEAT TRANSFER COEFFICIENTS FOR SINGLE PHASE TURBULENT FLOW OF HYDROGEN IN TUBES WITH TEMPERATURE RATIOS TO 23

Maynard F. Taylor Washington Jan. 1968 22 p refs
(NASA-TN-D-4332) CFSTI: HC$3.00/MF$0.65 CSCL 20M

The existing methods of correlating and predicting single-phase turbulent heat-transfer coefficients with variable properties give coefficients which are sometimes in poor agreement with measured values. Each prediction method can be used only over a limited range of pressure, temperature, ratio of axial position to diameter, and ratio of surface to fluid bulk temperature ratio. Local heat-transfer coefficients for hydrogen from 10 investigations using symmetrically heated straight tubes were used to determine a single equation that will predict heat-transfer coefficients over a wide range of conditions including surface to fluid bulk temperature ratios to 23. Author

N68-14270*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THEORETICAL TEMPERATURES OF THIN-FILM SOLAR CELLS IN EARTH ORBIT
Curt H. Liebert and Robert R. Hibbard Washington Jan. 1968 17 p refs
(NASA-TN-D-4331) CFSTI: HC$3.00/MF$0.65 CSCL 10A

An analysis was made and equations and charts were developed that make it easy to calculate the temperatures of opaque, thin, flat plates in a Sun-planet system. The analysis is general and includes the effects of sunlight, albedo, and Earth radiation at any altitude and for any orientation; it requires that the absorptance and emittance of the plate surfaces be known. This analysis was applied to three thin-film cadmium sulfide solar cells, and it uses experimentally determined optical properties to calculate equilibrium temperatures in various Earth orbits. The calculations consider the effect of painting the inactive side with a black paint or a white, zinc oxide (ZnO) paint and the effect of lowering the solar absorptance of the active side at wavelengths not used in photovoltaic energy conversion. The results show that the temperature of present day cells with the inactive side not painted may vary from 346° K in sunlight to 92°K in the Earth's shadow. It was observed that the temperatures in sunlight may be lowered by painting the inactive side with a ZnO paint. Further temperature reductions may be achieved by lowering the solar absorptance of the active side at wavelengths not used in photovoltaic energy conversion. Author

N68-15330*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL INVESTIGATION OF NUCLEATE BOILING BUBBLE DYNAMICS IN NORMAL AND ZERO GRAVITIES
Thomas H. Cochran, John C. Aydelott, and Charles M. Spuckler Washington Feb. 1968 23 p refs
(NASA-TN-D-4301) CFSTI: HC$3.00/MF$0.65 CSCL 20M

The effects of gravity on the dynamics of bubbles generated on a flat horizontal surface are investigated in the heat-flux range defined as the discrete bubble region over a range of subcoolings, fluid properties, and heat-transfer rates. The zero-gravity data were obtained by allowing the experiment package to free fall in a 2.2-second drop tower, which permitted the attainment of less than 10^{-5} times Earth gravity. Data taken from high-speed motion pictures indicated that boiling was independent of gravity at high subcooling and that the transition from the discrete bubble region occurred at a lower heat flux in zero gravity than in normal gravity. Application of an analysis to the data indicated that a newly defined pressure force was of importance in bringing about bubble separation. Author

N68-15742*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TRANSIENT SOLIDIFICATION OF A FLOWING LIQUID ON A COLD PLATE INCLUDING HEAT CAPACITIES OF FROZEN LAYER AND PLATE
Robert Siegel and Joseph M. Savino Washington Feb. 1968 27 p refs Presented at the ASME Winter Ann. Meeting, Pittsburgh, 17 Nov. 1967 *Its* Paper No. 67-WA/HT-34
(NASA-TN-D-4353) CFSTI: HC$3.00/MF$0.65 CSCL 20M

An analysis is made of solidification within a flowing medium where a convective boundary condition is imposed on the moving interface of the solidifying layer. The configuration is one in which a frozen layer forms in a warm liquid as it is chilled while flowing over a plane wall that is convectively cooled on the opposite side. The analysis includes the heat capacities of both the wall and frozen layer. The solution for frozen layer thickness variation with time is given as a closed-form algebraic equation and in graphical form so that results can be readily evaluated for use in practical applications. Some illustrative examples are given for flowing water in contact with Inconel plates of various thicknesses to demonstrate the effect of the heat capacities and the liquid and cooland temperatures on the growth of the ice layer and the temperature distributions in the ice and wall. Author

N68-15833*# Dynamic Science Corp., Monrovia, Calif.
COMBUSTION INSTABILITY PREDICTION USING A NONLINEAR BIPROPELLANT VAPORIZATION MODEL
R. J. Hoffman, R. O. Wright, and B. P. Breen Washington NASA Jan. 1968 100 p refs
(Contract NAS7-442)
(NASA-CR-920) CFSTI: HC$3.00/MF$0.65 CSCL 20B

An extension of the Priem–Guentert nonlinear annular combustion instability model for liquid rocket engines is presented. additions to the model include: droplet drag effects, propellant spray distributions, and independent heat and mass addition due to a bipropellant system. The addition of droplet drag to the transport equations produces a new dimensionless term, the drag parameter. Computer results show that droplet drag can produce large attenuations in sensitivity to combustion instability. Drop sprays are treated by defining a spray distribution function for both the fuel and oxidizer spray entering an annulus. Results of a parametric study of the influence of mean drop size and of standard deviation are presented. The instability equations were modified to independently calculate mass and heat addition, and these modifications were included in the computer solution. Generally, the independent addition of mass to the flow produced trends similar to the simultaneous addition of heat and mass. For comparison, a complete engine stability map was generated using both the bipropellant model and the monopropellant model. Significant differences are apparent in the predicted sensitivity to instability. Author

N68-15942*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DISPLACEMENT OF DISINTEGRATING LIQUID JETS IN CROSS FLOW
Frederick P. Povinelli Washington Feb. 1968 21 p refs
(NASA-TN-D-4334) CFSTI: HC$3.00/MF$0.65 CSCL 21B

The displacement of three sizes of liquid jets breaking up in a crossflow was measured in a shock tube. Data were obtained for water, oxygen, n-heptane, and three glycerol–water mixtures in gas flows up to 1080 feet per second (329 m/sec). The displacement was approximately proportional to gas velocity squared and inversely proportional to jet diameter. Data were correlated with an empirical parameter. A simple model of jet displacement which includes the rate of mass removal also led to a correlation of the data. Author

N68-16300*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
POTENTIAL USE OF HIGH FREQUENCY INDUCTION HEATING FOR HIGH TEMPERATURE LIQUID METAL HEAT TRANSFER TESTING
John V. Miller Washington Feb. 1968 50 p refs
(NASA-TM-X-1510) CFSTI: HC$3.00/MF$0.65 CSCL 20M

To investigate potential methods of obtaining high temperature liquid metal heat transfer data, several heating devices were examined and the problems of each are discussed. One promising

method is high frequency induction heating. The heating coil is physically separated from the test section, is maintained at a lower temperature than the test section, and therefore, can be constructed of low temperature materials. A thick walled cylinder, internally cooled with liquid metal, was analyzed to evaluate the characteristics of an inductively heated test section. Results indicate that, if the ratio of cylinder radius to current depth is greater than 6, internal heat generation in the cylinder's center is negligible. With a tungsten cylinder; high frequency equipment can obtain the necessary cylinder-radius to current-depth ratio without exceeding allowable thermal stress levels for tungsten. Based on an error analysis of an inductively heated test section, experimental determination of liquid metal heat transfer coefficients at high heat flux levels can be made to an accuracy of ±10% for reasonable tolerances on thermocouple placement and temperature measurements. Author

N68-16324*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYTICAL COMPARISON OF RANKINE CYCLE SPACE RADIATORS CONSTRUCTED OF CENTRAL, DOUBLE, AND BLOCK-VAPOR-CHAMBER FIN-TUBE GEOMETRIES

Henry C. Haller and Seymour Lieblein Washington Feb. 1968 62 p refs

(NASA-TN-D-4411) CFSTI: HC $3.00/MF $0.65 CSCL 13A

An analytical comparison of flat direct-condensing radiators constructed of three different finned tube geometries was made over a wide range of design variables for a 500-day mission, 500-kilowatt output high-temperature Rankine space electric power generating system which used potassium as the cycle working fluid. The fin-tube configurations considered were the central, the double, and the block vapor-chamber geometries. The solid conducting fin geometries (central and double fin) were composed of stainless-steel-clad copper fins. The vapor-chamber fin radiator was evaluated for both stainless-steel-clad and all stainless-steel fins. The vapor-chamber fin-tube radiator consistently showed a significantly lower weight per kilowatt output (specific weight) than the two solid conducting fin radiators. A relatively small reduction in planform area per kilowatt output (specific planform area) at least weight condition was indicated for the vapor-chamber fin-tube radiator compared with the solid conducting fin-tube configurations. In general, the vapor-chamber fin-tube radiator can utilize larger tube diameters and fewer number of tubes than the solid conducting geometries with the least increase in specific weight and planform area. Author

N68-16683*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MINIMUM FILM-BOILING HEAT FLUX IN VERTICAL FLOW OF LIQUID NITROGEN

Frederick F. Simon, S. Stephen Papell, and Robert J. Simoneau Washington Feb. 1968 36 p refs

(NASA-TN-D-4307) CFSTI: HC $3.00/MF $0.65 CSCL 20M

A study was made of the minimum film-boiling heat flux of liquid nitrogen flowing in a vertical, electrically heated tube. Inlet liquid velocities up to 3 meters per second were studied for reduced pressures P/P_c of 0.071, 0.20, and 0.40. An analysis of the wall conduction was used to predict the wall temperatures occurring at the minimum heat flux for an electrically heated system. The predicted wall temperatures were then used in conjunction with a heat-transfer analysis for predicting the minimum heat flux. The analytical results are in good agreement with the experimental data. Author

N68-17566*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

BOILING HEAT TRANSFER COEFFICIENTS, INTERFACE BEHAVIOR, AND VAPOR QUALITY IN ROTATING BOILER OPERATING TO 475 G's

Vernon H. Gray, Paul J. Marto, and Allan W. Joslyn (NASA, Manned Spacecraft Center, Houston, Tex.) Washington Mar. 1968 41 p refs

(NASA-TN-D-4136) CFSTI: HC $3.00/MF $0.65 CSCL 20M

An experimental heated-wall rotating boiler was investigated with continuous through-flow water as the test fluid. Heat-transfer coefficients were obtained with the boiler stationary and at rotative accelerations to 200 g's. Heat fluxes up to 505,000 Btu per hour per square foot were employed in obtaining the coefficients. Photographic and boiler-performance data were obtained to 475 g's. Outlet vapor quality, measured by throttling calorimeters, varied from above 99 percent to several degrees of vapor superheat. High-speed motion pictures revealed that high accelerations nearly eliminated disturbances at the liquid-vapor interface, reduced the number and size of bubbles, and promoted direct evaporation across the interface by the mechanism of convective secondary-flow cells in the rotating fluid annulus. Boiling heat-transfer coefficients at low heat fluxes were increased by increases in acceleration. At high heat fluxes the opposite was true, although the variation in coefficient was small and comparable with that caused by surface conditioning and aging effects. The crossover points for the coefficients occurred at progressively higher heat-flux levels as acceleration was increased. A boiling heat-transfer coefficients as high as 9000 Btu per hour per square foot per °F was measured (at the highest heat-flux value). Boiler-test performance was quite satisfactory and warranted consideration of the rotating boiler concept in Rankine cycle systems for power generation.

Author

N68-18046*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SELF EVACUATED MULTILAYER INSULATION OF LIGHTWEIGHT PREFABRICATED PANELS FOR CRYOGENIC STORAGE TANKS

Porter J. Perkins, Robert P. Dengler, L. R. Niendorf, and G. E. Nies Washington Mar. 1968 25 p refs

(NASA-TN-D-4375) CFSTI: HC $3.00/MF $0.65 CSCL 13D

A new concept for simplifying the application of radiation-shield insulation to cryogenic tanks was developed and tested for both ground and space performance. A vacuum-tight flexible casing of laminated aluminized Mylar encloses the multilayers, forming panels that are bonded to tank walls in an overlapping shingle arrangement. The panels, weighing only 0.34 pound per square foot (1.66 kg/m^2), are filled with carbon dioxide (CO_2) gas which cryopumps to provide required vacuum when the tank is filled with a cryogen. The thermal performance of this insulation was determined in flat-plate and cylindrical calorimeters. Of the many materials tested in the flat-plate calorimeter, polyurethane foam was chosen as the separator between radiation shields because of its small increase in heat flux when compressed to 14.7 psi (10.13 N/cm^2) in panels evacuated in the atmosphere. During ground tests, insulation panels as large as 3 by 6 feet (0.91 by 1.83 m) were mounted on a cylindrical calorimeter of liquid hydrogen and cryopumped to at least 5×10^{-3} torr (6.66×10^{-5} N/cm^2). This procedure resulted in a heat flux of 23 Btu per hour per square foot (261,000 J/(hr) (m^2)) for an external temperature of 70°F (294°K). In simulated space tests, panels evacuated by outside vacuum resulted in a heat flux of 0.86 Btu per hour per square foot (9770 J/ (hr) (m^2)) with outside surfaces at 70°F (294°K). Author

N68-18122*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A THREE-DIMENSIONAL ANALYSIS OF THE EFFECTS OF HEAT GENERATION IN PLATES

Robert R. McWithey Washington Jan. 1968 27 p refs

(NASA-TN-D-4326) CFSTI: HC $3.00/MF $0.65 CSCL 20M

A method for determining three-dimensional steady-state temperature distributions is presented for plates in which heat is generated and conducted throughout the plate material. The solution for the temperature distribution is given in terms of a power series with respect to the plate thickness coordinate. The coefficients of

the power series are dependent upon the temperature distribution over the plate surfaces. Specific attention is given to the determination of temperature distributions and plate deformations resulting from constant heat generation and from the absorption of electromagnetic radiation. Author

N68-18196*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRESSURE-RISE CHARACTERISTICS FOR A LIQUID HYDROGEN DEWAR FOR HOMOGENEOUS, NORMAL GRAVITY QUIESCENT, AND ZERO GRAVITY TESTS

Kaleel L. Abdalla, Thomas C. Frysinger, and Charles R. Andracchio Washington Sep. 1965 35 p refs (Declassified)

(NASA-TM-X-1134) CFSTI: HC$3.00/MF$0.65 CSCL 20M

The pressure-rise characteristics for a liquid-hydrogen Dewar were obtained by utilizing a scientific passenger pod on an Atlas intercontinental ballistic missile during a 21-minute gravity free flight. Results were compared with those from homogeneous and normal-gravity quiescent tests. Residual pod rotation created an undesirable acceleration field on the Dewar of approximately 10^{-3} g throughout the weightless flight time. Temperature instrumentation indicated wall drying during this period. The resultant pressure-rise characteristics were similar to those for the normal-gravity test. Author

N68-19187*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CONSIDERATIONS OF TURBINE COOLING SYSTEMS FOR MACH 3 FLIGHT

Francis S. Stepka Washington Apr. 1968 43 p refs

(NASA-TN-D-4491) CFSTI: HC$3.00/MF$0.65 CSCL 20M

A method is presented for rapidly determining the approximate average midspan metal temperatures and coolant flow requirements of turbine airfoils cooled by compressor exit bleed air. Presented also are the potential reductions in airfoil metal temperatures, coolant flows, or increases in average turbine inlet gas temperatures that are possible by utilization of various airfoil cooling designs, cooling methods, and cooling systems other than the direct use of compressor exit bleed air. These additional cooling systems were direct cooling with engine fuels (Jet A or liquid methane) and the use of heat exchangers to reduce the compressor exit bleed air temperature. The cooling fluids that were used in the heat exchangers were: engine fuel, by-pass air in the fan exit duct of a turbofan engine, and ram air. The analysis was conducted to engines of aircraft cruising at Mach 3 at an altitude of 75,000 feet (22.8 km). Turbine inlet gas temperatures from 2270° to 3170°F (1515° to 2020°K) were investigated. Author

N68-20065*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

APPROXIMATE RELATIONS FOR LAMINAR HEAT-TRANSFER AND SHEAR-STRESS FUNCTIONS IN EQUILIBRIUM DISSOCIATED AIR

Ernest V. Zoby Washington Apr. 1968 21 p refs

(NASA-TN-D-4484) CFSTI: HC$3.00/MF$0.65 CSCL 20M

Simple, approximate equations have been developed for computing the normal derivatives of enthalpy and velocity evaluated at the surface of a flat plate or cone and of a blunt axisymmetric body. These approximate equations were developed by correlating exact similar solutions to the laminar boundary-layer equations for equilibrium dissociated air. The results of these approximate equations represent the exact solutions within ±10 percent. Author

N68-20066*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYSIS OF PRESSURE-DROP FUNCTION IN RANKINE SPACE POWER BOILERS WITH DISCUSSION OF FLOW MALDISTRIBUTION IMPLICATIONS

Andrew A. Schoenberg and Donald R. Packe Washington Apr. 1968 64 p refs

(NASA-TN-D-4498) CFSTI: HC$3.00/MF$0.65 CSCL 13A

The analysis was performed for counterflow liquid-heated single-pass boilers of the type used in Rankine space power systems such as SNAP-8. The analysis takes into account the nonuniform axial distribution of heat flux, variable geometry factors, and the variation of the lengths of the preheat, boiling, and superheat regions. Comparison with data from a single-tube water boiler indicates that the analytical model predicts the pressure drop and its dependence on various boiler-input variables with an average error of less than 10 percent. With the use of results generated from the analytical model, effects on the pressure-drop function caused by variations in some of the geometric and thermodynamic parameters of the boiler were studied. From these studies, the following causes of the multivalued characteristic were established: (1) The magnitude of the multivalued effect is strongly influenced by a boiler-tube insert, but the characteristic could exist even with an open tube. (2) The multivalued characteristic can exist for either a choked nozzle or a constant pressure at boiler discharge. Methods for eliminating the multivalued characteristic and thus the potential for flow maldistribution are evaluated. Author

N68-20331*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RADIANT-INTERCHANGE CONFIGURATION FACTORS FOR SPHERICAL AND CONICAL SURFACES TO SPHERES

James P. Campbell and Dudley G. McConnell Washington Apr. 1968 24 p refs

(NASA-TN-D-4457) CFSTI: HC$3.00/MF$0.65 CSCL 20M

Geometric configuration view factors have been calculated for a sphere and for cones radiating to a sphere. A computer program was set up to give configuration view factors not only for the entire radiating body but, also, for bands of the radiating body which permit the determination of the configuration view factor between any part of the radiating body and the sphere. The range of configurations consisted of equal radii spheres, and right-circular cones of semiapex angles of 15°, 30°, 45°, and 60° radiating to a sphere on the cone axis with radius equal to the cone base radius. Separations for all cases ranged from zero to 10 sphere radii. Curves are presented that give the configuration view factor for any configuration within the limits of the study. Author

N68-20338*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

LOCAL HEAT TRANSFER FOR WATER IN ENTRANCE REGIONS OF TUBES WITH TAPERED FLOW AREAS AND NONUNIFORM HEAT FLUXES

Nick J. Sekas and James R. Stone Washington Apr. 1968 18 p refs

(NASA-TM-X-1554) CFSTI: HC$3.00/MF$0.65 CSCL 20M

Local convective heat-transfer coefficients of water flowing through electrically heated circular tubes with axially varying heat fluxes and flow areas were investigated. Data were obtained in the turbulent flow regime with local Reynolds numbers from 8000 to 50 000 over a Prandtl number range of 1.6 to 4.5. Measurements of mass flow rate, heat flux, water bulk temperatures at tube inlet and outlet, and axial temperature distribution for each run were made and are presented in tabular form. Plots of local to fully developed Nusselt number ratio as a function of heated length-to-diameter ratio are presented. These data are compared with calculated values of the local to fully developed Nusselt number ratios based on a previously reported correlation of entrance effects with tubes of constant flow area and uniform heat flux. The calculated Nusselt number ratios generally approximated the present experimental results. Author

N68-20374*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HEAT-TRANSFER CORRELATION FOR GAS FLOW ACROSS HEATED BANKS OF WIRE MESHES OR TUBES

Byron L. Siegal Washington Apr. 1968 25 p refs

(NASA-TN-D-4514) CFSTI: HC $3.00/MF $0.65 CSCL 20M

The heat-transfer data of this investigation for nitrogen flowing across a bank of electrically heated mesh were compared with the data of other investigators for the flow of hydrogen, nitrogen, helium, and air across single meshes, banks of meshes, and banks of tubes. The data covered the following ranges of variables: (1) Porosities from 0.37 to 0.88, (2) Wire or tube diameters from 0.0076 to 0.375 inch (0.0193 to 0.952 cm), (3) Surface temperatures to 5500°R (3050°K), (4) Outlet gas temperatures to 3160°R (1760°K), and (5) Reynolds numbers from 3 to 30,000. A heat-transfer correlation based on surface-temperature gas property evaluation, wire diameter, and average mesh flow area was found which correlated the data within ±20 percent. Author

N68-21536*# National Aeronautics and Space Administration, Washington, D. C.

DIRECTIONAL DISTRIBUTION IN THE REFLECTION OF HEAT RADIATION AND ITS EFFECT ON HEAT TRANSFER

Benjamin Muench (Ph.D. Thesis—Swiss Tech. Coll., 1955) Apr. 1968 95 p refs Transl. into ENGLISH of the publ. "Die *Richtungsverteilung bei der Reflexion von Waermestrahlung und ihr* Einflus auf die Waermeuebertrangung" Zurich, 1955

(NASA-TT-F-497) CFSTI: HC $3.00/MF $0.65 CSCL 20M

The thermal radiation properties of a surface can be characterized by its emission and reflection coefficients. An experimental apparatus is described for measuring the reflection coefficient as a function of the incident and reflected directions. All directional distributions from the purely specular to the strongly scattering were found by superposition of purely specular and diffuse results. A good approximation was found for the tests on concentric spheres. Author

N68-21680*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL INVESTIGATION OF AN ACOUSTIC LINER WITH VARIABLE CAVITY DEPTH

Bert Phillips Washington Apr. 1968 53 p refs

(NASA-TN-D-4492) CFSTI: HC $3.00/MF $0.65 CSCL 21H

An acoustic liner with individually isolated resonators and variable cavity depths was tested with a nominal 20,000-pound thrust hydrogen-oxygen rocket engine. The liner damping was evaluated by comparing values of hydrogen-inlet temperature at transition into combustion instability. Three concentric tube injectors were studied. Test variables were liner cavity depth, number of liner rows, and axial position of the liner rows. Cavity gas temperature and composition were measured at the screech transition point. A flow-induced frequency shift using a theoretical axial gas velocity profile changed the calculated resonant frequency to a value *matching the pretransition noise frequency. The amplitude of the* pretransition noise oscillations associated with the three injectors affected liner damping. The most effective axial position of the resonators was determined to be closest to the injector. Effectiveness of row combinations of the resonators at some other positions was also determined. There was a much higher concentration of hydrogen and hence higher sonic velocity in the resonator cavities than had been predicted in previous reports. Author

N68-21704*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF FINNED-TUBE ASSEMBLY TECHNIQUES ON THE HEAT-TRANSFER CHARACTERISTICS OF A SPACE RADIATOR

Lawrence A. Mueller Washington Apr. 1968 20 p refs

(NASA-TM-X-1557) CFSTI: HC $3.00/MF $0.65 CSCL 13A

Nine methods of fabricating a finned-tube space radiator were tested. Both mechanical and metallurgical joining of stainless-steel tubes to aluminum meteoroid armor and fins were investigated and compared with an all-aluminum radiator. The mechanically assembled sample had a heat-radiating capacity of 125 to 236 watts per foot of tube length (410 to 774 W/m), and the metallurgically assembled samples radiated 231 to 287 watts per foot (758 to 941 W/m). A brazed assembly had the best heat-transfer characteristics. Measured thermal resistance ranged from 0.07 to 1.5 (°F)(ft)/W (0.011 to 0.258 (°K)(m)/W). Also, the metallurgically joined specimens were not affected by thermal cycling; whereas, all the mechanically assembled specimens, except the bumper finned-tube sample, were affected. Author

N68-21732*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PARTITION FUNCTIONS AND THERMODYNAMIC PROPERTIES TO HIGH TEMPERATURES FOR H_3 AND H_2 IONS

R. W. Patch and Bonnie J. McBride Washington Apr. 1968 77 p refs

(NASA-TN-D-4523) CFSTI: $3.00 CSCL 20M

Tables of partition functions were compiled for H_3^+ and H_2^+ at temperatures from 298.15° to 56,000°K. Tables of thermodynamic properties were compiled at temperatures from 298.15° to 10,000°K. The latter tables give the following thermodynamic functions for ideal gases: heat capacity at constant pressure, sensible enthalpy, entropy at 1 atmosphere, sensible free energy at 1 atmosphere, enthalpy, and free energy at 1 atmosphere. The heats of formation at 298.15°K are also given. Since no band spectra have been observed for either ion, all calculations were based on ab initio potential energy calculations found in or derived from the literature. All results for H_2^+ are reliable up to 15,000°K, but results for H_3^+ are tentative at all temperatures. A digital computer program to calculate Wentzel–Kramers–Brillouin rotational energies from the potential energy of a diatomic molecule or molecular ion is also included. The program is in FORTRAN IV. Author

N68-22118*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EFFECTS OF SHOCK IMPINGEMENT AND OTHER FACTORS ON LEADING-EDGE HEAT TRANSFER

Dennis M. Bushnell Washington Apr. 1968 17 p refs *Presented at the Conf. on Hypersonic Aircraft Technol., Moffett* Field, Calif., 16–18 May 1967 Submitted for publication

(NASA-TN-D-4543; NASA-SP-148) CFSTI: HC $3.00/MF $0.65 CSCL 20M

An investigation was conducted at a Mach number of 8 to determine the effects on stagnation-line heat transfer of shock impingement, chordwise grooves in the leading edge, and end contamination of the leading-edge boundary layer from an adjoining surface. Heat-transfer measurements were made along the leading edge of a 76° swept fin mounted on a flat plate. Tests were made with and without a series of small chordwise grooves cut into the leading edge to simulate construction details. Analysis of the observed heating distribution on the leading edge with the grooves indicates that some fraction of the stagnation-line boundary layer is bled off by the grooves, so that a new viscous sublayer grows downstream of each groove. The general level of heating was about the same as or less than the leading-edge heating data *obtained on the same configurations without the grooves.* Author

N68-22318*# Tennessee Univ., Tullahoma. Space Inst.

RADIATION HEAT TRANSFER IN ABSORBING, SCATTERING, AND EMITTING MEDIUM

F. Shakrokhi and P. Wolf Washington NASA Apr. 1968 22 p refs

(Grant NGR-43-001-021)

(NASA-CR-1023) CFSTI: HC $3.00/MF $0.65 CSCL 20M

Radiative heat flow is computed between plane parallel, plates with anisotropically scattering atmosphere. Results indicate that a usable solution to the problem can be obtained by simple

iteration of the set of equations which result from approximation of the equation of radiation transfer. The iteration worked perfectly, the computer program is simple and short, and the method can accomodate the same, if not more, parameter variations than more analytical treatments. Author

N68-23513*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
ANALYSIS OF THREE-FLUID, CROSSFLOW HEAT EXCHANGERS
Noel C. Willis, Jr. Washington May 1968 114 p refs
(NASA-TR-R-284) CFSTI: HC$3.00/MF$0.65 CSCL 13A

The detailed behavior of three-fluid, crossflow heat exchangers has been investigated. The equations governing the two-dimensional temperature distributions of the three fluids have been derived and nondimensionalized. Performance characteristics have been determined for a wide range of operating parameters for single-pass heat exchangers. The performance of two-pass heat exchangers for both cocurrent and countercurrent flow has been studied for selected operating conditions. Results have been presented graphically in terms of the temperature effectiveness of the two outer fluids as functions of heat-exchanger size for sets of fixed operating conditions. Nondimensional operating parameters have been defined which allow an efficient presentation of the large volume of performance data required to represent a practical range of operating conditions. Sample problems are included to illustrate the use of the performance graphs for design applications. Author

N68-24618*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DETERMINATION OF CONVECTIVE HEAT-TRANSFER COEFFICIENTS ON ADIABATIC WALLS USING A SINUSOIDALLY FORCED FLUID TEMPERATURE
Ronald G. Huff Washington Jun. 1968 34 p refs
(NASA-TM-X-1594) CFSTI: HC$3.00/MF$0.65 CSCL 20M

The response of an insulated wall, over which a heated fluid flows, to a sinusoidally forced fluid temperature was used to calculate the convective heat-transfer coefficients. An exact solution is given which accounts for thermal conductivity and the location of the sensed wall temperature in one-dimensional heat-transfer problems. Charts are included to aid in the calculation. A comparative analysis was made of solutions that do not account for thermal conductivity and the location of the sensed wall temperature and those that do. If the exact solution is not used, errors greater than 23 percent are possible. Author

N68-24965*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MIXING AND REACTION STUDIES OF HYDRAZINE AND NITROGEN TETROXIDE USING PHOTOGRAPHIC AND SPECTRAL TECHNIQUES
Marshall C. Burrows Washington, D. C. Jun. 1968 26 p refs
Film Supplement Number C-258 to this Report is Available on Loan from Lewis Research Center, Cleveland
(NASA-TN-D-4467) CFSTI: HC$3.00/MF$0.65 CSCL 21B

Distances required to atomize, mix, and react N_2H_4 and N_2O_4 were experimentally determined for a quadlet injector element. Atomization occurred in less than 1 inch (2.5 cm), and vaporizing NO_2 extended downstream for 4 inches (10.2 cm) or less. Hottest gases were in the oxidant-rich zones; fuel-rich gases appeared to be influenced by the decomposition reaction of hydrazine. Concentration profiles of H_2O determined from total radiation and gas temperature compared favorably with H_2O concentrations calculated for combustion profiles limited by either fuel or oxidant vaporization. Author

N68-25102*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL VERIFICATION OF A DOUBLE DEAD TIME MODEL DESCRIBING CHUGGING IN LIQUID BIPROPELLANT ROCKET ENGINES
John R. Szuch and Leon M. Wenzel Washington May 1968 38 p refs
(NASA-TN-D-4564) CFSTI: HC$3.00/MF$0.65 CSCL 21B

Stability limits were determined, experimentally, for a 2-inch (5.08 cm) diameter rocket engine. Liquid oxygen and gaseous hydrogen were the propellants. Chamber pressures of 650 and 300 psia (4.48×10^6 and 2.07×10^6 N/m^2) were run with an oxidant-fuel ratio of 5.0 and a characteristic length of 95 inches (2.41). For comparison with experimental data, boundaries were generated on the analog computer using the chugging model proposed by the authors and calculated values of delay. Results agreed with regard to observed frequencies and boundary shape. Discrepancies in boundary location (required pressure drops) were attributed to a high combustion noise level. Author

N68-25122*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
VAPOR PRESSURE OF POTASSIUM TO 2170°K
Kenneth J. Bowles Washington May 1968 12 p refs
(NASA-TN-D-4535) CFSTI: HC$3.00/MF$0.65 CSCL 20M

A static capsule method was used to measure the vapor pressure of potassium from 945° to 2170°K. The resulting Kirchhoff-type vapor-pressure equation is given. The standard deviation in pressure is ±1.23 percent. Data calculated from this equation were pooled with data calculated from potassium-vapor-pressure equations determined previously in four independent studies. The pooled equation is used as a standard curve against which all data are compared. Author

N68-25244*# Itek Corp., Palo Alto, Calif. Vidya Div.
AN ANALYSIS OF THE COUPLED CHEMICALLY REACTING BOUNDARY LAYER AND CHARRING ABLATOR, PART 1 Summary Report
Robert M. Kendall, Eugene P. Bartlett, Roald A. Rindal, and Carl B. Moyer Washington, D. C. NASA Jun. 1968 111 p refs
(Contract NAS9-4599)
(NASA-CR-1060; Rept.-66-7, Pt. 1) CFSTI: HC $3.00/MF $0.65 CSCL 20M

This report summarizes analyses and computational procedures for predicting the transient in-depth response of charring ablation materials, either coupled to a nonsimilar, laminar, multicomponent, chemically-reacting boundary-layer computational procedure or partially decoupled through the use of convective transfer coefficients. The computational procedure for charring ablators is an implicit finite difference procedure for an ablating surface material with several nonablating backup materials. It considers one-dimensional heat and mass transfer along thermal streamtubes of arbitrary cross-sectional area and permits a multiple-reaction model for gas decomposition and a general thermochemical surface boundary condition. The boundary-layer procedure utilizes a newly developed integral matrix solution procedure. It applies for general chemical systems, allowing rate-controlled surface reactions, and incorporates approximate formulations for mixture transport properties, including unequal diffusion and thermal diffusion coefficients for all species. Analyses are also presented for extending the boundary-layer computational procedure to include mixed equilibrium–nonequilibrium, homogeneous or heterogeneous general chemical systems and to include radiation absorption and emission, and for extending the charring ablation procedure to include char-density buildup due to coking reactions in depth. Author

N68-25312*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYTICAL INVESTIGATION OF ELECTRICALLY HEATED WIRE MESH FOR FLOWING GAS HEATERS
William F. Mattson and William L. Maag Washington June 1968 42 p refs
(NASA-TN-D-4595) CSCL 13A

By specifying the gas, the flow rate, the system pressure, the desired inlet and outlet gas temperatures, and the power supply characteristics, a compatible wire mesh heater element design

can be determined. The calculations involve solving simultaneous equations for the heat generation rate, the convective heat transfer from the mesh to the gas, and the change in enthalpy of the gas at every axial position along the heater length. The method also enables the determination of the operating conditions of an existing mesh heater when used at some off design condition or with another gas. Author

N68-25917*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
STATIC-TEMPERATURE DISTRIBUTION IN A FLAT PLATE COMPRESSIBLE TURBULENT BOUNDARY LAYER WITH HEAT TRANSFER
S. Z. Pinckney Washington Jun. 1968 45 p refs
(NASA-TN-D-4611) CFSTI: HC $3.00/MF $0.65 CSCL 20M

An expression based on the differential equations for the local energy transfer and shear is derived for the relationship between the static temperature and the velocity in a zero-pressure-gradient turbulent boundary layer. The boundary conditions imposed by these governing equations showed the temperature-velocity relation to be at least a fourth degree polynomial which differs considerably from the second degree polynomial obtained by previous investigators. These governing equations are integrated by using as boundary conditions the value of a particular total-energy-deficiency parameter of the boundary layer at the station under consideration, the slope of the laminar-sublayer temperature-velocity profile at the wall (as determined from a modified Reynolds analogy), and the local free-stream and wall conditions. Results obtained by this method are compared with experimental temperature-velocity profile data and are found to correlate well with the experimental profiles. Author

N68-26641*# Itek Corp., Palo Alto, Calif. Vidya Div.
AN ANALYSIS OF THE COUPLED CHEMICALLY REACTING BOUNDARY LAYER AND CHARRING ABLATOR. PART 3: NONSIMILAR SOLUTION OF THE MULTICOMPONENT LAMINAR BOUNDARY LAYER BY AN INTEGRAL MATRIX METHOD
Eugene P. Bartlett and Robert M. Kendall (Aerotherm Corp.) Washington NASA Jun. 1968 138 p refs Prepared jointly with Aerotherm Corp., Palo Alto, Calif.
(Contract NAS9-4599)
(NASA-CR-1062; Rept.-66-7, Pt. 3) CFSTI: HC $3.00/MF $0.65 CSCL 20M

A laminar nonsimilar boundary-layer procedure is described which yields accurate solutions for a broad range of problems. In its current formulation, solutions can be obtained for any equilibrium chemical environment with specified rate-controlled reactions at the surface. It has been used to treat a variety of ablating and nonablating surface boundary conditions including coupled energy and mass balances. The formulation considers unequal diffusion and thermal diffusion coefficients for all species in a particularly convenient manner through a bifurcation approximation for binary diffusion coefficients. The multicomponent viscosity and thermal conductivity of the mixture are determined by use of Sutherland–Wassiljewa type approximations. The procedure is readily applicable to inclusion of one-dimensional radiation emission and absorption and a general nonequilibrium chemical model. The procedure combines features of the general integral relations approach with those of matrix solution techniques. Following the former, smooth functions (in particular, cubic spline functions) are chosen to relate the principal dependent variables to their derivatives. Author

N68-26650*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BODY ROTATION EFFECTS ON MELTING ABLATION
Thomas H. Cochran and Simon Ostrach (Case Inst. of Tech.) Washington Jun. 1968 40 p refs
(NASA-TN-D-4614) CFSTI: HC $3.00/MF $0.65 CSCL 20M

The effects of rotation on the ablation of an axisymmetric body composed of a highly viscous material and subject to deceleration in an airstream were studied analytically and experimentally. The tests were conducted so that a parameter representing the importance of rotation effects and which was obtained from a nondimensionalization of the governing equations was varied from 0 to 4.2. The results indicate that, although rotation had no effect on the ablation process in the vicinity of the stagnation point of the body, significant changes in the character of the generated waves and in the flange were caused by rotation. Liquid was thrown from the body in the vicinity of the flange when the spin parameter was 0.88 or greater. Author

N68-26692*# Itek Corp., Palo Alto, Calif. Vidya Div.
AN ANALYSIS OF THE COUPLED CHEMICALLY REACTING BOUNDARY LAYER AND CHARRING ABLATOR. PART 2: FINITE DIFFERENCE SOLUTION FOR THE IN-DEPTH RESPONSE OF CHARRING MATERIALS CONSIDERING SURFACE CHEMICAL AND ENERGY BALANCES
Carl B. Moyer and Roald A. Rindal Washington NASA Jun. 1968 142 p refs Prepared jointly with Aerotherm Corp., Palo Alto, Calif.
(Contract NAS9-4599)
(NASA-CR-1061; Rept.-66-7, Pt. 2) CFSTI: HC $3.00/MF $0.65 CSCL 20M

An analysis of the in-depth response of materials exposed to a high temperature environment was presented, and a computer program based upon the analysis was described. The differential equations for the in-depth response are formulated and then cast into a finite difference form implicit in temperature. Three pyrolyzing constituents are allowed, with an accurate model of observed pyrolysis kinetics. Heat flow in-depth is one-dimensional, but cross-section area may vary with depth. The program for in-depth response computation may be coupled to a variety of boundary conditions. One of the possible boundary conditions is a complete boundary layer solution described in other reports of this series. Another version of the program may be coupled to a general film coefficient model of the boundary layer; this boundary condition is described in some detail in the present report. Author

N68-26759*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BOUNDARY CONDITIONS FOR THE DIFFUSION SOLUTION OF COUPLED CONDUCTION-RADIATION PROBLEMS
Marvin Goldstein and John R. Howell Washington Jun. 1968 42 p refs
(NASA-TN-D-4618) CFSTI: HC $3.00/MF $0.65 CSCL 20M

The boundary condition for use with the diffusion solution for coupled radiation and conduction energy transfer is derived. An effective slip coefficient is presented as a function of the conduction–radiation parameter. Comparison to exact numerical solutions is good for the geometry of infinite parallel black plates. In the course of the analysis, a uniformly valid asymptotic expansion for the combined conduction and radiation problem in a nongray medium in the optically thick regime, and an exact analytical solution to the radiation-conduction transport equation in the boundary regime are obtained. Author

N68-26815*# Itek Corp., Palo Alto, Calif. Vidya Div.
AN ANALYSIS OF THE COUPLED CHEMICALLY REACTING BOUNDARY LAYER AND CHARRING ABLATOR. PART 4: A UNIFIED APPROXIMATION FOR MIXTURE TRANSPORT PROPERTIES FOR MULTICOMPONENT BOUNDARY-LAYER APPLICATIONS

Eugene P. Bartlett, Robert M. Kendall, and Roald A. Rindal Washington NASA Jun. 1968 57 p refs
(Contract NAS9-4599)
(NASA-CR-1063; Rept.-66-7, Pt. 4) CFSTI: HC $3.00/MF $0.65 CSCL 20M

Self-consistent approximations for binary diffusion coefficients, multicomponent thermal diffusion coefficients and mixture viscosity and thermal conductivity are presented which greatly simplify the solution of multicomponent laminar boundary-layer problems. The basic premise of the approach is a bifurcation of binary diffusion coefficients, $D_{ij} = \bar{D}/F_iF_j$, where $\bar{D}$ is a reference diffusion coefficient and F_i is a diffusion factor for species i. The primary utility of the bifurcation approximation in multicomponent boundary-layer applications is that it enables explicit solution of the Stefan–Maxwell relations for the diffusive mass fluxes, j_i. The approximation for multicomponent thermal diffusion coefficients is based upon generalization of a semi-empirical equation for correlating binary thermal diffusion data. Approximate relations for mixture viscosity and thermal conductivity of the Sutherland–Wassilijewa type are simplified by use of the bifurcation approximation for binary diffusion coefficients. Author

N68-26816*# Itek Corp., Palo Alto, Calif. Vidya Div.
AN ANALYSIS OF THE COUPLED CHEMICALLY REACTING BOUNDARY LAYER AND CHARRING ABLATOR. PART 5: A GENERAL APPROACH TO THE THERMOCHEMICAL SOLUTION OF MIXED EQUILIBRIUM–NONEQUILIBRIUM, HOMOGENEOUS OR HETEROGENEOUS SYSTEMS
Robert M. Kendall Washington NASA Jun. 1968 45 p refs
(Contract NAS9-4599)
(NASA-CR-1064; Rept.-66-7, Pt. 5) CFSTI: HC $3.00/MF $0.65 CSCL 20M

A general equilibrium and nonequilibrium chemical state procedure is developed and applied mathematically to a number of open and closed thermodynamic systems. The conventional equilibrium relations are developed in terms of a set of base species. The base species concept is then extended in order to treat mixed equilibrium and nonequilibrium systems in a general fashion. The specification of controlling reactions is used to create non-redundant equation sets as equilibrium is approached. The treatment of open system mass balances within the basic framework of the state solution permits direct surface state calculations considering boundary-layer transfer relations and surface-condensed phase removal relations. The computer program which performs the equilibrium state solutions according to the methods presented, the Aerotherm Chemical Equilibrium (ACE) program is described briefly. The program which contains some of the nonequilibrium features of the analysis, the ACE/KINET program is also introduced. Author

N68-26817*# Itek Corp., Palo Alto, Calif. Vidya Div.
AN ANALYSIS OF THE COUPLED CHEMICALLY REACTING BOUNDARY LAYER AND CHARRING ABLATOR. PART 6: AN APPROACH FOR CHARACTERIZING CHARRING ABLATOR RESPONSE WITH IN-DEPTH COKING REACTIONS
Roald A. Rindal Washington NASA Jun. 1968 48 p refs
(Contract NAS9-4599)
(NASA-CR-1065; Rept.-66-7, Pt. 6) CFSTI: HC $3.00/MF $0.65 CSCL 20M

The analysis of a charring ablation material which may undergo subsurface coking of the pyrolysis gas is considered. Coking reactions considered include thermal cracking of gaseous hydrocarbons resulting in precipitation of carbon onto the char layer and, at higher temperatures, the subsequent internal chemical erosion of the char structure by the gaseous pyrolysis products. A generalized type of ablation material is defined which consists of inert, carbon, and reactive constituents. Three types of subsurface reactions are considered, 1) decomposition of up to three organic constituents to form initial char and pyrolysis gas products, 2) kinetically controlled decomposition of the pyrolysis gas resulting in carbon precipitation and char desification, and 3) at high temperature, chemical erosion of the subsurface char matrix by the pyrolysis products according to the dictates of chemical equilibrium. A model is considered for evaluating the pressure distribution through the char layer of variable permeability. Differential equations are developed to represent the transfer of mass, energy, and momentun within the framework of the postulated phenomenological model. Author

N68-28100*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
AN EXPERIMENTAL STUDY OF FLAME PROPAGATION IN SUPERSONIC PREMIXED FLOWS OF HYDROGEN AND AIR
Griffin Y. Anderson and Allen R. Vick Washington Jun. 1968 34 p refs
(NASA-TN-D-4631) CFSTI: HC $3.00/MF $0.65 CSCL 20M

The results of an experimental study of a Mach 1.5 free jet of hydrogen-air mixture ignited by a coaxial, hot gas, pilot jet are presented. This configuration produces an approximately conical average flame surface propagating from the pilot jet into the unburned, supersonic mixture. Flash schlieren, direct, and time schlieren photographic observations of the flame and flow field are discussed for mixtures up to 1.3 times stoichiometric with stagnation temperatures of 300°K and 450°K. Flame cone half-angle measured from time schlieren photographs is found to increase rapidly with equivalence ratio to a maximum at 0.8 times stoichiometric and remain approximately constant thereafter. The maximum flame angle is approximately 9.2° for mixture stagnation temperature of 300°K and decreases to about 7.4° with an increase in temperature to 450°K. Unlike maximum flame angle, the computed velocity normal to the average flame surface or flame-propagation velocity increases with increasing stagnation temperature. Relative values of flame-propagation velocity computed from flame angles measured in supersonic mixtures for hydrogen, methane, ethane, and ethylene were found to be similar to relative laminar burning velocity data for these fuels. Author

N68-28156*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CENTAUR/SURVEYOR NOSE FAIRING AERODYNAMIC HEATING INVESTIGATION
C. W. Eastwood, Jr. Washington Jul. 1968 20 p refs
(NASA-TM-X-1605) CFSTI: HC $3.00/MF $0.65 CSCL 20M

An experimental investigation was conducted to verify the structural integrity of the Centaur/Surveyor fiberglas nose fairing at the thermal and pressure environment predicted for the fourth Atlas/Centaur flight. Specimens of the fairing, including two coated with a protective subliming material, were exposed to the simulated aerodynamic heating and decreasing atmospheric pressure associated with the flight trajectory. Nose fairing specimen skin temperatures,, bondline temperatures, and core pressures in the simulated environment are presented. Core pressure required to delaminate the skin-core assembly is given. Fairing skin temperatures from two subsequent Atlas/Centaur flights are compared with the experimental results. Author

N68-28371*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FLOW AND WALL-TEMPERATURE SENSITIVITY IN PARALLEL PASSAGES FOR LARGE INLET TO EXIT DENSITY RATIOS IN SUBSONIC FLOW
Meyer Reshotko Washington Jul. 1968 31 p refs
(NASA-TN-D-4649) CFSTI: HC $3.00/MF $0.65 CSCL 20M

There is a large gas density decrease from reactor inlet to exit in a nuclear rocket. Under certain reactor operating conditions, the momentum pressure drop can be a large portion of the overall pressure drop. As a result, deviations in flow rate or passage diameter can cause the reactor walls to overheat. A simplified analytical investigation was made to find the sensitivity of the flow and wall temperature in heated passages as a function of Mach number for (1) a change in heat addition, and (2) nonuniform passage diameter. The Mach number range is from 0.2 to 0.9. Author

N68-28530*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THERMAL RADIATION HEAT TRANSFER. VOLUME I: THE BLACKBODY, ELECTROMAGNETIC THEORY, AND MATERIAL PROPERTIES

Robert Siegel and John R. Howell Washington 1968 194 p refs

(NASA-SP-164) GPO: HC$1.00; CFSTI: MF$0.65 CSCL 20M

The importance of thermal radiation data to aerospace design is discussed, with attention focused on the inherent differences and complexities of radiation problems as compared with convection and conduction. The radiative behavior of the black body, or ideal radiating surface, is examined to serve as a standard for comparing the performance of real radiating bodies. Both unaveraged and averaged emissive, absorptive, and reflective properties are defined, and blackbody emission is given as a function of wavelength and temperature. Nomenclature is introduced for defining radiative properties, and these definitions are used for assessing the restrictions on the various forms of Kirchhoff's law relating emissivity to absorptivity. The reciprocal relations for reflectivities are derived. Equations for predicting the radiative properties of materials by classical electromagnetic theory are formulated. The radiative performance of real materials is discussed in terms of property variations with wavelength and temperature. Conversion factors are tabulated. Numerical examples are presented to delineate the use of the analytical relations and to bridge the gap between theory and practical application. F.S.

N68-30041# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

EFFECT OF CARBON DIOXIDE AND WATER VAPOR ON THE INDUCTION PERIOD OF THE HYDROGEN–OXYGEN REACTION

Casimir J. Jachimowski and William M. Houghton Washington Aug. 1968 15 p refs

(NASA-TN-D-4685) CFSTI: HC $3.00/MF$0.65 CSCL 21B

The effect of carbon dioxide and water vapor on the induction period kinetics of the hydrogen–oxygen reaction was studied in a shock tube at temperatures between 1000° and 1500°K. The results show that carbon dioxide does not produce any noticeable effect, whereas water vapor appears to accelerate the hydrogen–oxygen reaction. The analysis of experimental data indicates that the accelerating influence of water vapor is due to two processes. One process is dominant at the higher temperatures, the chain branching reaction $O + H_2O \rightarrow 2OH$, and the other, an unidentified process, is dominant at the lower temperatures. Author

N68-30518*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF CHAMBER PRESSURE, FLOW PER ELEMENT, AND CONTRACTION RATIO ON ACOUSTIC-MODE INSTABILITY IN HYDROGEN-OXYGEN ROCKETS

John P. Wanhainen, Charles E. Feiler, and C. Joe Morgan Washington Aug. 1968 35 p refs

(NASA-TN-D-4733) CFSTI: HC$3.00/MF$0.65 CSCL 21H

An experimental investigation of a 20,000-lb. (89-kN) thrust engine with a single coaxial-type injector was conducted to determine the effect of variations in chamber pressure, weight flow per element, and contraction ratio, by changing nozzle throat diameter, on tangential-acoustic-mode stability characteristics of hydrogen-oxygen rocket engines. These characteristics were evaluated by determining the hydrogen-injection temperature below which combustion was unstable. A correlation of the stability limits was obtained as a function of the variables investigated. The roles of various parameters were also interpreted according to the mechanism assumed in the response-factor model of this propellant combination. Author

N68-30747*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

FLIGHT TEST ANALYSIS OF APOLLO HEAT SHIELD MATERIAL USING THE PACEMAKER VEHICLE SYSTEM

Randolph A. Graves, Jr. and William G. Witte Washington Aug. 1968 34 p refs

(NASA-TN-D-4713) CFSTI: HC $3.00/MF $0.65 CSCL 22B

The Apollo heat-shield material was flight tested on the hemispherically blunted nose cap of a Pacemaker vehicle. Ablation and temperature data were obtained at the stagnation point and at the 22.5°, 45°, and 67.5° stations. Maximum pressures at these locations were 8.4, 6.7, 4.1, and 1.7, atmospheres, respectively. (1 atm = 101 325 N/m^2.) Recession rates at the 22.5°, 45°, and 67.5° stations were greater than predicted, and this result is attributed to the high levels of turbulent aerodynamic shear, which exceeded the threshold shear sensitivity of this material. Unequal absorption of the surface sealer into the porous heat-shield material modified its behavior and introduced uncentainties in the analysis during the early portions of the data period. Author

N68-31498*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL MEASUREMENTS OF THERMAL RADIATION PROPERTIES BY CYCLIC INCIDENT RADIATION

Ernie W. Spisz and John R. Jack Washington Aug. 1968 15 p refs

(NASA-TM-X-1618) CFSTI: HC$3.00/MF$0.65 CSCL 20M

A new experimental technique is developed to determine simultaneously the total hemispherical emittance, solar absorptance, and absorptance-emittance ratio for metals at cryogenic temperatures. The method compares the temperature response of thin metal samples to a sinusoidal perturbation of an imposed radiant intensity. Emittance data are presented for aluminum, copper, and 304 stainless steel over the temperature range of 150 to 500 K. From the data, the applicability of the cyclic radiant intensity method is evaluated, and the problems associated with extending the method to temperatures below 150K are discussed. Author

N68-31959*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

A SIMPLIFIED METHOD FOR CALCULATING LAMINAR HEAT TRANSFER OVER BODIES AT AN ANGLE OF ATTACK

Fred R. De Jarnette and Ruby M. Davis Washington Aug. 1968 21 p refs

(NASA-TN-D-4720) CFSTI: HC$3.00/MF$0.65 CSCL 20M

A simplified method is developed for calculating the ratio of the local to stagnation-point heat-transfer rate for bodies at an angle of attack with only the free-stream Mach number and the ratio of specific heats required as inputs. The viscous problem is simplified by using the axisymmetric analog for three-dimensional boundary layers (small cross flow in boundary layer) in conjunction with Lees' laminar heating rate for axisymmetric bodies. An approximate technique for determining the geometry of the inviscid surface streamline is presented. In this technique the direction of a streamline at a given point on the body is taken as the direction of the resultant of the free-stream velocity vector minus its normal component. For determining the inviscid surface properties, the modified Newtonian pressure distribution is used with isentropic flow along the surface. The heat transfer over spherically blunted cones with 15° and 30° semiapex angles at angles of attack of 0°, 10°, and 20° and a free-stream Mach number of 10.6 was computed. The values obtained agreed well with experimental data. Author

N68-32073*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CONFORMAL MAPPING FOR STEADY TWO-DIMENSIONAL SOLIDIFICATION ON A COLD SURFACE IN FLOWING LIQUID

Robert Siegel Washington Aug. 1968 22 p refs
(NASA-TN-D-4771) CFSTI: HC$3.00/MF$0.65 CSCL 20M

Conformal mapping has been applied to determine the shape of two-dimensional solidified layers formed on a cold surface immersed in a flowing warm liquid. The frozen region is represented by a rectangle in a potential plane, and the rectangle is mapped into the physical plane to determine the frozen boundary configuration. The method is demonstrated for solidification on a cold plate of finite width that is insulated along its edges. Author.

N68-32099*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TESTS OF A SINGLE TUBE-IN-SHELL WATER-BOILING HEAT EXCHANGER WITH A HELICAL-WIRE INSERT AND SEVERAL INLET FLOW-STABILIZING DEVICES
James R. Stone and Nick J. Sekas Washington Aug. 1968 60 p refs
(NASA-TN-D-4767) CFSTI: HC$3.00/MF$0.65 CSCL 13A

Experimental data were obtained on a vertical-upflow, single tube-in-shell, 0.436-in.-(1.11-cm) inside diameter by 60.5-in.-(1.54-m) long, water-boiling heat exchanger with a helical-wire insert (wire-pitch-to-inside-diameter ratio 1.90). Entrance-region plugs, inlet orifices, and a venturi-type inlet were tested at boiling-fluid flow rates from 60 to 100 lb_m/hr (0.0075 to 0.0125 kg/sec) and exit pressure ≈ 17 psia (≈ 115 kN/m^2). Results are compared with those on a boiler with the same dimensions, but with no insert. Vapor superheat with heat-balance exit quality >1.0 was obtained. With no inlet device, with or without plugs the tendency for back-slugging instabilities was present. Orifices eliminated back-slugging, but exit quality of 1.0 was not obtained, although vapor superheat was indicated. The venturi eliminated back slugging and gave a heat-balance quality as high as 1.02; however, the flow range was limited. Author

N68-32988*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPARISON OF EXPERIMENTAL AND PREDICTED HEAT TRANSFER CHARACTERISTICS FOR A CYLINDRICAL EJECTOR
Francis C. Chenoweth and Fred W. Steffen Washington Aug. 1968 25 p refs
(NASA-TM-X-1641) CFSTI: HC$3.00/MF$0.65 CSCL 20M

The heat transfer characteristics of a cylindrical ejector for a small afterburning turbojet engine operating at static sea level conditions were compared with film-cooling correlations based on an insulated wall. Since the ejector in this tests was not insulated, a correction for radiation and free-convection losses was derived and applied to the wall temperatures calculated using one of the correlations. Good agreement was obtained between the experimental and predicted wall temperatures. Author

N68-33167*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYTICAL INVESTIGATION OF THERMAL DEGRADATION OF HIGH-PERFORMANCE MULTILAYER INSULATION IN THE VICINITY OF A PENETRATION
William R. Johnson and Earl L. Sprague Washington Sep. 1968 60 p refs
(NASA-TN-D-4778) CFSTI: HC$3.00/MF$0.65 CSCL 20M

An analytical investigation was conducted to determine the thermal degradation of high-performance multilayer insulation on a liquid hydrogen tank in the vicinity of a penetration. Results were obtained with and without the use of a thermal buffer zone between the shields and the pentration, for various values of thermal contact resistance. Input variables to the program included radiation source temperature, penetration diameter, number of shields, shield emissivity, shield thermal conductivity, shield spacing, buffer zone dimensions, and buffer zone thermal conductivity. The results of the program are presented in graphical form, as well as in equations representing curve fits of the analytical data. Author

N68-33203*# Pratt and Whitney Aircraft, East Hartford, Conn.
VAPOR CHAMBER FIN STUDIES. OPERATING CHARACTERISTICS OF FIN MODELS
H. R. Kunz, S. S. Wyde, G. H. Nashick, and J. F. Barnes Washington NASA Aug. 1968 95 p refs
(Contract NAS3-7622)
(NASA-CR-1139; PWA-3154) CFSTI: HC $3.00/MF $0.65 CSCL 13A

This report presents the test results from experiments on two vapor-chamber fin (heat pipe) geometries and compares these results with a theory developed and presented in a prior report. Typical temperature distributions were obtained for heat pipe operation plus limiting heat flux data which was compared to the theory. This comparison indicated that the theory showed the correct trends at low levels of heat flux. An effect of working fluid inventory was found which was not included in the present theory. Tests with a noncondensable gas present in the chamber were found to result in complete mixing of this gas with the working fluid vapor. Author

N68-33208*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
SINGLE-THERMOCOUPLE METHOD FOR DETERMINING HEAT FLUX TO A THERMALLY THICK WALL
Floyd G. Howard Washington Sep. 1968 51 p refs
(NASA-TN-D-4737) CFSTI: HC$3.00/MF$0.65 CSCL 20M

A method that accounts for variable thermal properties has been developed for determining heat flux from a single temperature-time history within a thermally thick wall. The accuracy depends on the thermal depth of the measurement point, and ranges from good to excellent for a number of practical cases, with best results occurring nearest the heated surface in conjunction with a small computing interval. The method is believed to be as accurate, if not more so, than other methods utilizing multiple thermocouples. If measurement is near the heated surface and accurate, the method can detect sudden changes in slope of heat flux such as are experienced when boundary layer flow becomes transitional or when heating rate history fluctuates as a result of body motions in flight. Author

N68-34088*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYSIS OF BOILING ON A FIN
Y. Y. Hsu Washington Sep. 1968 23 p refs
(NASA-TN-D-4797) CFSTI: HC$3.00/MF$0.65 CSCL 20M

A simplified method of calculation is proposed to determine the performance of a fin exposed to various modes of boiling. The heat-transfer coefficients of boiling were approximated by segments of simple n^{th} power functions of superheat. These functions provide the analytical solution of the temperature gradient in the fin as a function of temperature. Results compare favorably with those obtained from a small-increment numerical solution. Three examples are given to illustrate the application of fin concept to boiling heat-transfer processes. Author

N68-35116*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
FLIGHT INVESTIGATION OF THE EFFECTS OF APOLLO HEAT-SHIELD SINGULARITIES ON ABLATOR PERFORMANCE
Thomas E. Walton, Jr., William G. Witte, and Brian J. O'Hare Washington Sep. 1968 62 p refs
(NASA-TN-D-4791) CFSTI: HC$3.00/MF$0.65 CSCL 20M

A flight investigation was conducted to evaluate the performance of the Apollo ablative heat-shield material under perturbed heating conditions caused by several simulated Apollo heat-shield singularities. The recovered spacecraft, which contained simulations of the Apollo singularities, experienced an

order-of-magnitude less recession in the unperturbed areas than had been predicted. A recalculation of the surface recession utilizing revised rate-controlled oxidation constants obtained from arc-jet tests produced results compatible with the measured surface recession. With the exception of the upstream lip of both simulated umbilical fairings, no appreciable increase in surface recession attributable to the singularities was noted. The effects of simulated Apollo singularities on ablator performance were minor, as evidenced from the recovered spacecraft. Author

N68-35248*# Douglas Aircraft Co., Inc., Santa Monica, Calif.
RADIATIVE AND CONVECTIVE HEATING DURING ATMOSPHERIC ENTRY
W. S. Rigdon, R. B. Dirling, Jr., and M. Thomas Washington NASA Sep. 1968 52 p refs
(Contract NAS1-7757)
(NASA-CR-1170) CFSTI: HC$3.00/MF$0.65 CSCL 20M

The first solutions for radiation-convection coupled stagnation point heat transfer retaining complete spectral detail of the radiative transfer have been generated for a single entry condition both with and without mass injection. The problems associated with obtaining massive blowing solutions with radiation have been generated for a single entry condition both with and without mass injection with radiation have been identified and solution procedures developed. The effect of radiative boundary conditions at the wall has been investigated by obtaining solutions for transparent, black, and totally reflecting walls. The detailed spectral solutions reveal that the originally proposed approximate relation for the divergence of the radiative flux is not suitable for accurate real-gas radiative convective coupling analyses. Therefore, the radiative transfer processes have been investigated and the theoretical basis for a new approximate formulation for the divergence of the radiative flux has been established such as to account for the dominant real-gas radiative transfer effects. Author

N68-35468*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
EMPIRICAL STAGNATION-POINT HEAT-TRANSFER RELATION IN SEVERAL GAS MIXTURES AT HIGH ENTHALPY LEVELS
Ernest V. Zoby Washington Oct. 1968 21 p refs
(NASA-TN-D-4799) CFSTI: HC$3.00/MF$0.65 CSCL 20M

A simple empirical method was developed for computing stagnation point heating rates in arbitrary gas mixtures. The method was shown to be in good agreement with stagnation point heating results in air, argon, carbon dioxide, hydrogen, nitrogen, and mixtures of argon, carbon dioxide, and nitrogen for enthalpy potentials up to 50,000 Btu/lbm (1.17×10^5 joule/g). One useful application of the method is for parametric stagnation point–heat transfer studies. The method is in good agrement with the existing prediction methods and is in fair agreement with the existing experimental data. Author

N68-36072*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
A STUDY OF THE REACTION-PLANE APPROXIMATION IN ABLATION ANALYSES
C. W. Stroud Washington Oct. 1968 21 p refs
(NASA-TN-D-4817) CFSTI: HC$3.00/MF$0.65 CSCL 20M

Equations which describe the reactive zone in charring ablators during steady state ablation are derived. Average reaction zone temperatures and reaction zone thicknesses are studied for half-order, and second-order reactions. This study was made for each of these reaction orders over a wide range of frequency factors and heats of pyrolysis. One technique used to simplify ablation analyses is to idealize the degradation process and assume that it occurs in a plane. The purpose of this paper is to investigate the validity of this technique as a good engineering approximation. Empirical relations are developed between the frequency factors and the average reaction zone temperature for the three reaction orders. These relations are used to locate the reaction zone in a reaction plane analysis. The resulting temperature profile is shown to be in substantial agreement with the profile obtained from a reaction in depth analysis. Author

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GENERAL

Includes reports of a broad nature related to industrial applications and technology, and to basic research; defense aspects; law and related legal matters; and legislative hearings and documents.

N68-11307*# National Aeronautics and Space Administration, Washington, D. C.
NASA THESAURUS: SUBJECT TERMS FOR INDEXING SCIENTIFIC AND TECHNICAL INFORMATION. VOLUME 1: ALPHABETICAL LISTING A–L
Dec. 1967 441 p
(NASA-SP-7030) CFSTI: HC $3.00/MF $0.65 CSCL 05B

The NASA Thesaurus is an alphabetical listing of terms by which the documents in the NASA scientific and technical information system are indexed and retrieved. The first two volumes of the three-volume publication contain the subject terms and the complete cross-reference structure that comprise the Thesaurus proper; the final volume consists of four appendixes which arrange the Thesaurus elements in other ways for purposes of further explication and utility. The four appendixes are: Hierarchical Display (Appendix A); Category Term Listing (Appendix B); Permuted Index (Appendix C); and Postable Terms (Appendix D). Author

N68-11308*# National Aeronautics and Space Administration, Washington, D. C.
NASA THESAURUS: SUBJECT TERMS FOR INDEXING SCIENTIFIC AND TECHNICAL INFORMATION. VOLUME 2: ALPHABETICAL LISTING M–Z
Dec. 1967 428 p For abstract see N68-11307
(NASA-SP-7030) CFSTI: HC $3.00/MF $0.65 CSCL 05B

N68-11309*# National Aeronautics and Space Administration, Washington, D. C.
NASA THESAURUS: SUBJECT TERMS FOR INDEXING SCIENTIFIC AND TECHNICAL INFORMATION. VOLUME 3: APPENDIXES
Dec. 1967 651 p For abstract see N68-11307
(NASA-SP-7030) CFSTI: HC $3.00/MF $0.65 CSCL 05B

N68-21828*# National Aeronautics and Space Administration, Washington, D. C.
MANAGEMENT. A CONTINUING LITERATURE SURVEY WITH INDEXES, 1962–1967
Mar. 1968 29 p refs
(NASA-SP-7500) CFSTI: HC $3.00/MF $0.65 CSCL 05A

A compilation of references to unclassified reports and periodicals on the subject of management that may be found in the NASA scientific and technical information system is reported. The publication assembles groups of citations formerly announced in separate journals, Scientific and Technical Aerospace Reports (STAR) and International Aerospace Abstracts (IAA), to provide management with a convenient information tool. Contents include material generated or sponsored by NASA during the period 1962 through 1967. Abstracts in the survey are grouped under the following categories: program management, contract management, research and development, management tools and techniques; personnel management; urban management; management policy and philosophy; economics; and general which includes conference proceedings, reviews, patent information, speeches, and bibliographies. S.C.W.

N68-24567*# National Aeronautics and Space Administration, Washington, D. C.
MANAGEMENT: A CONTINUING LITERATURE SURVEY, WITH INDEXES, 1962–1967
May 1968 87 p refs
(NASA-SP-7500(02)) CFSTI: HC $3.00/MF $0.65 CSCL 05A

A bibliography of annotated references to unclassified reports and journals articles on various aspects of management was taken from entries to the NASA information system between 1962 and 1967. Abstracts as well as subject matter, author, and corporate source indexes are presented. References are given under the general categories of program management, contract management, research and development, management tools and techniques, personnel management, urban management, management policy and philosophy, and economics. A category designated general includes conference proceedings, reviews, patent information, speeches, and other bibliographies. M.W.R.

N68-25221*# National Aeronautics and Space Administration, Washington, D. C.
CUMULATIVE INDEX TO NASA TECH BRIEFS, 1963–1967
Apr. 1968 376 p refs
(NASA-SP-5021(06)) CFSTI: HC $3.00/MF $0.65 CSCL 05B

This cumulative index to NASA Tech Brief lists single page descriptions of individual innovations, devices, methods, or concepts published from 1963 through 1967. A subject index, as well as indices relating Tech Brief number with originating source and number are provided. Subject categories covered are: electrical (electronic); physical sciences (energy sources); materials (chemistry); life sciences; mechanical; and computer programs. G.G.

N68-26813*# Boeing Co., Seattle, Wash.
STUDIES OF COST EFFECTIVE STRUCTURES DESIGN FOR FUTURE SPACE SYSTEMS—SUMMARY Final Report, 17 Oct. 1966–17 Oct. 1967
Bruce Allesina and E. F. Styer Washington NASA Jun. 1968 158 p refs
(Contract NAS7-525)
(NASA-CR-1068; D2-114116-1) CFSTI: HC $3.00/MF $0.65 CSCL 14A

The application of economics to aerospace design problems is discussed. The three major goals were: to define promising directions for structural research by applying the concept of minimum cost rather than maximum performance to structural design; to understand the relationship of the structure to the economics of the total system; and to identify and apply the interactions of the various aspects of program costs to point out the potential cost savings they imply. All goals were satisfied and some of the conclusions reached were: (1) Cost considerations should be employed early in a program. (2) A concerted program of cost data collection, economic methods development, and industry education in use of cost as a design criteria is required. (3) Proper balance should be established between costs and weights for design candidates at the part, subsystem, and systems level. (4) Sophistication in low earth orbit payloads should be de-emphasized, with more emphasis placed on use of larger launch vehicles. (5) Space program testing philosophy should be defined on a cost effective basis, measured against mission risk. A.L.

N68-29039*# National Aeronautics and Space Administration, Washington, D. C.
NASA SCIENTIFIC AND TECHNICAL REPORTS FOR 1967. A SELECTED LISTING
May 1968 424 p refs
(NASA-SP-7029) GPO: HC$2.50; CFSTI: MF$0.65 CSCL 05B

Bibliographic citations and abstracts arranged by subject categories are presented, selected from NASA reports that appeared in STAR. These documents listed were issued as part of the following NASA report series: *Special Publications* (NASA SP-), *Technical Reports* (NASA TR-), *Technical Notes* (NASA TN D-), *Technical Memorandums* (NASA TM X-), *Technical Translations* (NASA TT F-), and *Contractor Reports* (NASA CR-). Indexes are included on subject, personal author, corporate source, report/accession number, and accession/report number. M.G.J.

N68-32769*# National Aeronautics and Space Administration, Washington, D. C.
BIBLIOGRAPHIES ON AEROSPACE SCIENCE A Continuing Bibliography With Indexes
Jul. 1968 134 p refs
(NASA-SP-7006(03)) CFSTI: HC$3.00/MF$0.65 CSCL 05B

An annotated bibliography is presented which provides references to bibliographies, literature searches, abstract compilations, literature reviews and surveys, and report listings pertaining to aerospace subjects. Technical reports containing comprehensive reference listings are included along with a subject index. B.S.D.

N68-33682*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE ROLE OF THE EXPERIMETER ASSOCIATED WITH MULTI-EXPERIMENT SCIENTIFIC SATELLITES
George H. Ludwig Washington Sep. 1968 14 p Presented at the AIAA Space Program Issues of the 70's Meeting, Seattle, 28 Aug. 1967
(NASA-TN-D-4731) CFSTI: HC$3.00/MF$0.65 CSCL 22B

The primary objective of the scientific investigators concerned with scientific spacecraft is to obtain interpretable measurements from their sensors. An additional primary objective of university investigators is to train students in the space sciences and research techniques. To achieve these objectives, the investigators must help define mission requirements; participate in mission planning, instrument development, integration and testing, prelaunch activities, and operations; and be prepared to analyze the data upon receipt. Prelaunch preparations must be kept as short as possible commensurate with reasonable success probabilities, provide a reasonable balance between system capability and simplicity, and provide flight data as rapidly as possible. Improvements to present flight programs can be made in several areas. The experiment life cycle needs shortening, and greater simplification of the experiment/spacecraft interfaces is desirable. Technical and management coordination should be simplified and made more direct. Experimenters need better financial management, improved ability to meet schedules, better quality control, and better preparation for data reduction after launch. Author

N68-35564*# National Aeronautics and Space Administration, Washington, D. C.
A STUDY OF NASA UNIVERSITY PROGRAMS
1968 85 p refs
(NASA-SP-185) CFSTI: HC$3.00/MF$0.65 CSCL 05I

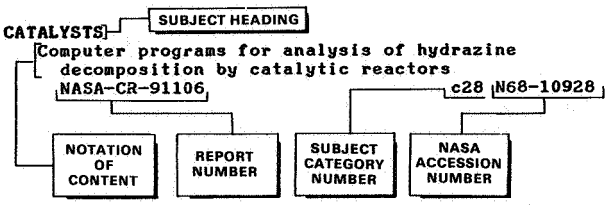
Selected samplings of NASA-university interactions were made by interviews, university visits, and in-depth studies to assess the overall NASA university program, which has the dual goal of accomplishing the aeronautics and space mission and strengthening the universities involved. Scope of the NASA university program is considered in terms of relations to the total amount of federal university support, university community involvement, and individual programs; and a general summary is included of the research grants and contracts in various areas, flight experiments, and university research centers and laboratories. Sustaining university programs are reviewed, including grants for traineeships, research programs, and facilities; and mention is made of personnel development programs in connection with the overall effort. M.W.R.

N68-37216*# Little (Arthur D.), Inc., Cambridge, Mass.
SPACE TECHNOLOGY TRANSFER AND DEVELOPING NATIONS
Peter E. Glaser, Robert M. Jolkovski, Claudio Margueron, and Walter M. Noel Washington NASA Oct. 1968 158 p refs
(Contract NASw-1649)
(NASA-CR-1222) CFSTI: HC$3.00/MF$0.65 CSCL 05A

The potential for transferring space technology advances to aid developing nations was assessed using Brazil as a model. The NASA technical information file was searched to retrieve document abstracts relevant to Brazilian developmental needs in agriculture, public health, exploration and utilization of natural resources, industrialization, housing, education and training, communications, and transportation. More than 40 matches of need with technology were obtained. Included in the findings are: (1) Technology oriented searches (refrigeration and electric power, for example) provided a broader range of relevant abstracts than problem oriented searches for example, forest clearing and road construction. (2) Because all abstracts are in English, transfer to technology to developing nations would be impeded. (3) Abstracts containing information on principles, development status, application results, costs, and feasibility had the highest potential for matching. (4) Information search printouts in the form of document titles and key words only are inadequate for technology transfer matching. E.C.

SUBJECT INDEX

Typical Subject Index Listing



The subject heading is a key to the subject content of the document. The Notation of Content (NOC), rather than the title of the document, is used to provide a more exact description of the subject matter. The report number helps to indicate the type of document cited (e.g., NASA report, translation, NASA contractor report). The subject category number indicates the subject category in the abstract section in which the citation is located. The NASA accession number denotes the number by which the citation is identified within the subject category. The NOC's are arranged under each subject heading in ascending accession number order.

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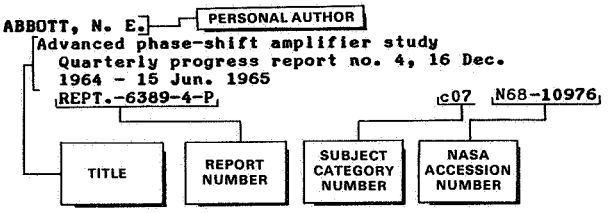
PERSONAL AUTHOR INDEX

Typical Personal Author Index Listing



Listings in this index are arranged alphabetically by personal author. The title of the document provides the user with a brief description of the subject matter. The report number helps to indicate the type of document cited (e.g., NASA report, NASA contractor report). The subject category number indicates the subject category in the abstract section in which the citation is located. The NASA accession number denotes the number by which the citation is identified within the subject category. The titles are arranged under each personal author in ascending accession number order.

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ABBOTT, A. S.
Guidance, flight mechanics and trajectory optimization. Volume 1 - Coordinate systems and time measure
NASA-CR-1000 c30 N68-16103
Guidance, flight mechanics and trajectory optimization. Volume 2 - Observation theory and sensors
NASA-CR-1001 c30 N68-19676
Guidance, flight mechanics and trajectory optimization. Volume 8 - Boost guidance equations
NASA-CR-1007 c30 N68-20449
Guidance, flight mechanics and trajectory optimization. Volume 10 - Dynamic programming
NASA-CR-1009 c30 N68-21077
Guidance, flight mechanics and trajectory optimization. Volume 15 - Application of optimization techniques
NASA-CR-1014 c30 N68-21231
Guidance, flight mechanics and trajectory optimization. Volume 5 - State determination and/or estimation
NASA-CR-1004 c30 N68-21685

ABDALLA, K. L.
Pressure-rise characteristics for a liquid hydrogen dewar for homogeneous, normal gravity quiescent, and zero gravity tests
NASA-TM-X-1134 c33 N68-18196
An experimental investigation of the effect of gravity on a forced circulation pattern in spherical tanks
NASA-TN-D-4409 c12 N68-20352
An experimental study of liquid flow into a baffled spherical tank during weightlessness
NASA-TM-X-1526 c12 N68-21365
Liquid inflow to initially empty, hemispherical ended cylinders during weightlessness
NASA-TN-D-4628 c12 N68-25866
Liquid vapor interface configurations in toroidal tanks during weightlessness
NASA-TN-D-4819 c12 N68-35823

ACKEN, R. A.
Navigator performance studies for space navigation using the NASA CV-990 research aircraft
NASA-TN-D-4449 c21 N68-21123

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Sound measurements on a full-scale jet-engine inlet-noise-suppressor cowling
NASA-TN-D-4639 c02 N68-29887

ADAMS, D. W.
Study of vibration induced stresses in design of fuel-element support assembly for tungsten water-moderated nuclear reactor
NASA-TM-X-1608 c32 N68-28330

ADAMS, E. W.
Theory of the investigation of the atmosphere of binary stars by analogy between gas dynamics and shallow-water flows
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AHTYE, W. F.
A critical evaluation of the use of ultrasonic absorption for determing high-temperature gas properties
NASA-TN-D-4433 c24 N68-18949

AIKIN, A. C.
Temporal variations of mesospheric oxygen and ozone during auroral events
NASA-TN-D-3993 c13 N68-10369

AILMAN, C. M.
Narrow band cross-correlation analysis of fluctuating pressures beneath a turbulent boundary layer
NASA-CR-1066 c12 N68-23482

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Plasma boundary interactions - 2
NASA-CR-1072 c25 N68-25821

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Comparison of convective stagnation heat transfer in air, CO2-N2, and CO2-Ar gas mixtures
NASA-TN-D-4255 c33 N68-11811

ALBRITTON, D. W.
A study of sensitization in types 301 and 304L stainless steels using Moessbauer spectroscopy
NASA-CR-1077 c17 N68-25318

ALEXANDER, R. L.
Ages of D/d,n/He sup 3 and T/d,n/He sup 4 neutrons in water and tungsten-water mixtures
NASA-TN-D-4581 c22 N68-25058

ALFANO, D. L.
Analysis of performance characteristics in ground effect of a large scale V/STOL multi-fan-in-wing transport model
NASA-CR-1180 c28 N68-35594

ALFARO-BOU, E.
Ballistic limit of aluminum plates determined by an exploding foil gun technique
NASA-TN-D-4259 c32 N68-11355

ALFRIEND, K. T.
Time-optimal rendezvous for elliptic orbits
NASA-CR-1036 c30 N68-22202

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External aerodynamics of the magnetosphere
NASA-TN-D-4482 c29 N68-25181

ALLEN, G.
An efficient method for computation of character tables of finite groups
NASA-TN-D-4763 c19 N68-31961

ALLEN, H. J.
A method for computing luminous efficiencies from meteor data
NASA-TN-D-4808 c30 N68-33055

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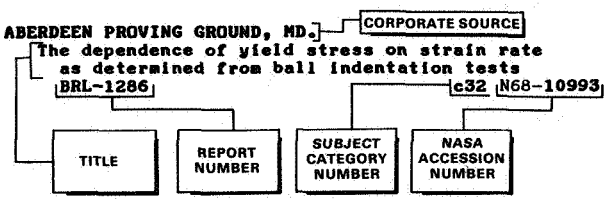
CORPORATE SOURCE INDEX

Typical Corporate Source Index Listing



Listings in this index are arranged alphabetically by corporate source. The title of the document provides the user with a brief description of the subject matter. The report number helps to indicate the type of document cited (e.g., NASA report, translation, NASA contractor report). The subject category number indicates the subject category in the abstract section in which the citation is located. The NASA accession number denotes the number by which the citation is identified within the subject category. The titles are arranged under each personal author in ascending accession number order.

A

AEROSPACE PRODUCTS RESEARCH CORP., SANTA MONICA, CALIF.
Computer driven electroluminescent vertical scale indicator
NASA-CR-919 c05 N68-10648

AEROTHERM CORP., PALO ALTO, CALIF.
An analysis of the coupled chemically reacting boundary layer and charring ablator. Part 3 - Nonsimilar solution of the multicomponent laminar boundary layer by an integral matrix method
NASA-CR-1062 c33 N68-26641
An analysis of the coupled chemically reacting boundary layer and charring ablator. Part 2 - Finite difference solution for the in-depth response of charring materials considering surface chemical and energy balances
NASA-CR-1061 c33 N68-26692

AIR VEHICLE CORP., LA JOLLA, CALIF.
Nonlinear lift and pressure distribution of slender conical bodies with strakes at low speeds
NASA-CR-1202 c01 N68-37255

AIRESEARCH MFG. CO., LOS ANGELES, CALIF.
Recuperator for solar Brayton cycle system
NASA-CR-1150 c03 N68-33062

ALLIED RESEARCH ASSOCIATES, INC., CONCORD, MASS.
Structural design synthesis approach to filamentary composites
NASA-CR-964 c32 N68-11191
Minimum weight design aspects of stiffened cylinders under compression
NASA-CR-963 c32 N68-11282

ANDREW CORP., CHICAGO, ILL.
The dielectric clad axial slot antenna
NASA-CR-1057 c07 N68-26621

APPLIED PHYSICS LAB., JOHNS HOPKINS UNIV., SILVER SPRING, MD.
Extended duration, recoverable primate satellite
NASA-CR-926 c05 N68-15306

ARINC RESEARCH CORP., ANNAPOLIS, MD.
Microelectronic device data handbook. Volume 1 - Text
NASA-CR-1110 c09 N68-29525
Microelectronic device data handbook. Volume 2 - Manufacturer and specific device information
NASA-CR-1111 c09 N68-29526

ARIZONA UNIV., TUCSON.
Multisegmented optimal trajectories
NASA-CR-1103 c30 N68-25895
Chronological catalog of reported lunar events
NASA-TR-R-277 c30 N68-28192

ASTRO RESEARCH CORP., SANTA BARBARA, CALIF.
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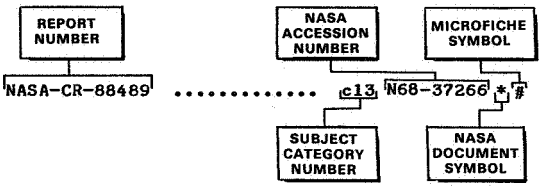

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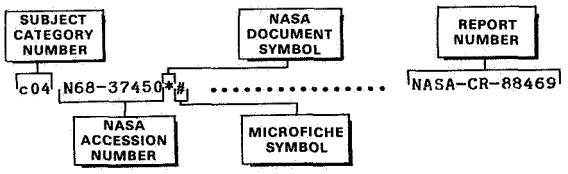

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