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(NASA-TM-79162) BIBLIOGRAPHY OF LEWIS RESEARCH CENTER TECHNICAL PUBLICATIONS ANNOUNCED IN 1978 (NASA) 367 p
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BIBLIOGRAPHY OF LEWIS RESEARCH CENTER TECHNICAL PUBLICATIONS ANNOUNCED IN 1978

Lewis Research Center
Cleveland, Ohio 44135

May 1979

NASA

PREFACE

In 1978, the Lewis publications output was 213 research reports and 243 journal articles and conference presentations. The number of conference presentations (199) that were given at seminars and society symposiums was the highest in the Center's history. The production of 267 contractor reports increased 16 percent over that of 1977. In addition, 50 patent applications were filed and 35 patents issued.

In 1977, the Lewis Director initiated the Annual Award for Best Lewis Publication. The purpose of the award is to encourage and reward outstanding research and technology contributions by Lewis staff members. The criteria for selection are quality and innovativeness, potential impact on the research and technology field, and the excellence of the presentation. The publication date must be between July 1 of the preceding year and June 30 of the award year. The winning publication is selected by the Lewis Research Advisory Board. The award is a framed certificate and $1000.

In 1977, the first year of the award, the Best Lewis Publication was "Isothermal Elastohydrodynamic Lubrication Point Contacts, Parts III and IV" by Bernard J. Hamrock and Duncan Dowson (TN's D-8317 and D-8318). They are described in Abstracts N77-11400 (p. 111) and N76-35509 (p. 89) of the "Bibliography of Lewis Research Center Publications Announced in 1977" and the "Bibliography of Lewis Research Center Publications Announced in 1976," respectively.

In 1978, the Annual Award for Best Lewis Publication was presented for the following two papers: "Unsteady Flow in a Supersonic Cascade with Strong In-Passage Shocks" by Marvin E. Goldstein, Willis Braun, and J. J. Adamczyk, which is described in Abstract A78-17270 (p. 6) and "Models for Some Aspects of Atmospheric Vortices" by Robert G. Deissler, which is described in Abstract A78-14581 (p. 150).

All the publications in this collection were announced in the 1978 issues of STAR (Scientific and Technical Aerospace Reports) and/or IAA (International Aerospace Abstracts).

The arrangement of the material is by NASA subject category, as noted in the Contents. The Lewis-authored items are listed first, followed by the contractor items. Within each of these groups is listed report literature, in N-number sequence, followed by the journal and conference presentations, in A-number sequence.

The various indexes will help locate specific publications by subject, author, contractor organization, contract number, and report number.

CONTENTS

01 AERONAUTICS (GENERAL)

N78-25049*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

INTERACTION OF A TURBULENT-JET NOISE SOURCE WITH TRANSVERSE MODES IN A RECTANGULAR DUCT

George P. Succi (MIT, Cambridge, Mass.), Kenneth J. Baumeister, and K. Uno Ingard (MIT, Cambridge, Mass.) Jun. 1978 42 p refs

(NASA-TP-1248; E-9462) Avail: NTIS HC A03/MF A01 CSCL 20A

A turbulent jet was used to excite transverse acoustic modes in a rectangular duct. The pressure spectrum showed asymmetric singularities (pressure spikes) at the resonant frequencies of the duct modes. This validates previously published theoretical results. These pressure spikes occurred over a range of jet velocities, orientations, and inlet turbulence levels. At the frequency of the spike, the measured transverse pressure shape matched the resonant mode shape. Author

N78-27048*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

ACEE PROPULSION OVERVIEW c07

Donald L. Nored *In* NASA. Langley Res. Center CTOL Transport Technol., 1978 Jun. 1978 p 9-23 refs (For primary document see N78-27046 18-01)

Avail: NTIS HC A22/MF A01 CSCL 21E

Technology for fuel-efficient subsonic CTOL transport aircraft is discussed. The engine component improvement project, the energy efficient engine project, and the advanced turboprop project are included. The overall goals and objectives of each project are reviewed and the approach and schedule for accomplishing these project goals and objectives are given. J.M.S.

N78-27055*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

STATUS OF ADVANCED TURBOPROP TECHNOLOGY c07

J. F. Dugan, B. A. Miller, and D. A. Sagerser *In* NASA. Langley Res. Center CTOL Transport Technol., 1978 Jun. 1978 p 139-166 refs (For primary document see N78-27046 18-01)

Avail: NTIS HC A22/MF A01 CSCL 21E

Research is reviewed in the following areas: turboprop powered transport aircraft, wind tunnel aerodynamic and acoustics tests of model propellers, turboprop maintenance, and wind tunnel tests on airframe-turboprop interactions. Continued development of the technology for advanced turboprop transport was emphasized. J.M.S.

N78-27056*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio

PROPULSION SYSTEMS NOISE TECHNOLOGY c07

C. E. Feiler *In* NASA. Langley Res. Center CTOL Transport Technol., 1978 Jun. 1978 p 167-185 refs (For primary document see N78-27046 18-01)

Avail: NTIS HC A22/MF A01 CSCL 21E

Turbofan engine noise research relevant to conventional aircraft is discussed. In the area of fan noise, static to flight noise differences were discussed and data were presented for two different ways of simulating flight behavior. Experimental results from a swept rotor fan design are presented which show that this concept has potential for reducing the multiple-pure-tone or buzz saw noise related to the shock waves on a fan operating at supersonic tip speeds. Acoustic suppressor research objectives centered around the effect of the wave system generated by the fan stage that is the input to the treatment. A simplifying and unifying parameter, mode cutoff ratio was described. Results are presented which show that suppressor performance can be improved if the input wave is more precisely described. In jet noise, calculated results showing the potential noise reduction from the use of internal mixer nozzles rather than separate flow nozzles are presented. J.M.S.

N78-27057*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

ADVANCED MATERIALS RESEARCH FOR LONG-HAUL AIRCRAFT TURBINE ENGINES c07

R. A. Signorelli and C. P. Blankenship *In* NASA. Langley Res. Center CTOL Transport Technol., 1978 Jun. 1978 p 187-204 refs (For primary document see N78-27046 18-01)

Avail: NTIS HC A22/MF A01 CSCL 21E

The status of research efforts to apply low to intermediate temperature composite materials and advanced high temperature materials to engine components is reviewed. Emerging materials technologies and their potential benefits to aircraft gas turbines were emphasized. The problems were identified, and the general state of the technology for near term use was assessed. J.M.S.

N78-27058*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

GAS TURBINE ENGINE EMISSION REDUCTION TECHNOLOGY PROGRAM c07

Donald A. Petrash and Larry A. Diehl *In* NASA. Langley Res. Center CTOL Transport Technol., 1978 Jun. 1978 p 205-216 (For primary document see N78-27046 18-01)

Avail: NTIS HC A22/MF A01 CSCL 21E

Progress in the development of combustor technology to meet the standards for the allowable pollutant emission levels of aircraft gas turbine engines is reported. The high-bypass-ratio turbofan engines which power the large commercial aircraft were emphasized along with efforts to reduce emission for near term applications. Recommendations for continuing research to reduce emissions to meet far term needs are given. J.M.S.

N78-15987*# Nielsen Engineering and Research, Inc., Mountain View, Calif.

PERTURBATION SOLUTIONS FOR TRANSONIC FLOW ON THE BLADE-TO-BLADE SURFACE OF COMPRESSOR BLADE ROWS Final Report

Stephen S. Stahara, Denny S. Chaussee, and John R. Spreiter Jan. 1978 71 p refs

(Contract NAS3-19738)

(NASA-CR-2941; NEAR-TR-136) Avail: NTIS HC A04/MF A01 CSCL 21E

A preliminary investigation was conducted to establish the theoretical basis of perturbation techniques with the objective of minimizing computational requirements associated with parametric studies of transonic flows in turbomachines. The theoretical analysis involved the development of perturbation methods for determining first order changes in the flow solution due to variations of one or more geometrical or flow parameters. The formulation is primarily directed toward transonic flows on the blade to blade surface of a single blade row compressor. Two different perturbation approaches were identified and studied. Applications and results of these methods for various perturbations are presented for selected two dimensional transonic cascade flows to illustrate the advantages and disadvantages of each technique. Additionally, it was found that, for flows with shock waves, proper account of shock displacement was crucial. Author

N78-15988*# Pratt and Whitney Aircraft, East Hartford, Conn.
AERO-ACOUSTIC TESTS OF DUCT-BURNING TURBOFAN EXHAUST NOZZLES. COMPREHENSIVE DATA REPORT. VOLUME 1: MODEL SCALE ACOUSTIC DATA Final Report
Hilary Kozlowski and Allan B Packman Feb 1977 440 p 3 Vol
(Contract NAS3-17866)
(NASA-CR-134910; PWA-5336) Avail: NTIS HC A19/MF A01 CSCL 02A

A compilation of all the detailed acoustic and aerodynamic data covering static aero-acoustic tests of duct-burning turbofan exhaust nozzles is presented. The basic model scale acoustic data and acoustic data scaled to full size is tabulated. In addition, perceived noise levels are shown at various sideline distances. A graphical presentation of the data is also given. Author

N78-15989*# Pratt and Whitney Aircraft, East Hartford, Conn.
AERO-ACOUSTIC TESTS OF DUCT-BURNING TURBOFAN EXHAUST NOZZLES. COMPREHENSIVE DATA REPORT. VOLUME 2: ACOUSTIC AND AERODYNAMIC DATA Final Report
Hilary Kozlowski and Allan B. Packman Feb. 1977 570 p 3 Vol
(Contract NAS3-17866)
(NASA-CR-134910; PWA-5336) Avail: NTIS HC A24/MF A01 CSCL 02A

For abstract, see N78-15988.

N78-15990*# Pratt and Whitney Aircraft, East Hartford, Conn.
AERO-ACOUSTIC TESTS OF DUCT-BURNING TURBOFAN EXHAUST NOZZLES. COMPREHENSIVE DATA REPORT. VOLUME 3: ACOUSTIC AND AERODYNAMIC DATA CURVES Final Report
Hilary Kozlowski and Allan B Packman Feb. 1977 427 p 3 Vol
(Contract NAS3-17866)
(NASA-CR-134910; PWA-5336) Avail: NTIS HC A19/MF A01 CSCL 02A

For abstract, see N78-15988

N78-21044*# General Electric Co., Cincinnati, Ohio
WIND TUNNEL PERFORMANCE TESTS OF COANNULAR PLUG NOZZLES Final Report
Paul S Staid Washington NASA Apr 1978 116 p refs
(Contract NAS3-19777)
(NASA-CR-2990; Rept-77AEG596) Avail: NTIS HC A06/MF A01 CSCL 02A

Wind tunnel performance test results and data analyses are presented for dual-flow plug nozzles applicable to supersonic cruise aircraft during takeoff and low-speed flight operation. Outer exhaust stream pressure ratios from 1.5 to 3.5 were tested, inner exhaust stream conditions were varied from very low, or bleed flow rates, up to a pressure ratio of 3.5. Mach numbers tested ranged from zero to 0.45. Measured thrust coefficients for the eight model configurations, operating at an external Mach number of 0.36 and an outer flow pressure ratio of 2.5 varied from 0.95 to 0.974 for high inner flow rates. At low inner flow the performance ranged from 0.88 to 0.97 for the same operating conditions. The primary design variables influencing the performance levels were the annular height of the inner and outer nozzle throats (denoted by radius ratio - the ratio of inner-to-outer flowpath diameter at the nozzle throat), the plug geometry and the inner stream flow rate. Author

N78-28043*# General Electric Co., Cincinnati, Ohio Aircraft Engine Group.
ACOUSTIC TESTS OF DUCT-BURNING TURBOFAN JET NOISE SIMULATION Final Report
P. R. Knott, E. J. Stringas, J. F. Brausch, P. S. Staid, P. H. Heck, and D. Latham Jul. 1978 345 p refs
(Contract NAS3-18008)
(NASA-CR-2966; DOC-R77AEG524) Avail: NTIS HC A15/MF A01 CSCL 20A

The results of a static acoustic and aerodynamic performance, model-scale test program on coannular unsuppressed and multielement fan suppressed nozzle configurations are summarized. The results of the static acoustic tests show a very beneficial interaction effect. When the measured noise levels were compared with the predicted noise levels of two independent but equivalent conical nozzle flow streams, noise reductions for the unsuppressed coannular nozzles were of the order of 10 PNdB; high levels of suppression (8 PNdB) were still maintained even when only a small amount of core stream flow was used. The multielement fan suppressed coannular nozzle tests showed 15 PNdB noise reductions and up to 18 PNdB noise reductions when a treated ejector was added. The static aerodynamic performance tests showed that the unsuppressed coannular plug nozzles obtained gross thrust coefficients of 0.972, with 1.2 to 1.7 percent lower levels for the multielement fan-suppressed coannular flow nozzles. For the first time anywhere, laser velocimeter velocity profile measurements were made on these types of nozzle configurations and with supersonic heated flow conditions. Measurements showed that a very rapid decay in the mean velocity occurs for the nozzle tested. J.M.S.

02 AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

For related information see also *34 Fluid Mechanics and Heat Transfer.*

N78-10026*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ATMOSPHERIC EFFECTS ON INLETS FOR SUPERSONIC CRUISE AIRCRAFT
Gary L. Cole. 1977. 14 p. refs. Presented at 13th Prop. Conf., Orlando, Fla., 11-13 Jul. 1977; sponsored by AIAA and Soc. of Automotive Engr.
(NASA-TM-X-73647; E-9154) Avail: NTIS HC A02/MF A01 CSCL 01A

Mixed-compression inlet dynamic behavior in the vicinity of unstart was simulated and analyzed to investigate time response of an inlet's normal shock to independent disturbances in ambient temperature and pressure and relative velocity (longitudinal gust), with and without inlet controls active. The results indicate that atmospheric disturbances may be more important than internal disturbances in setting inlet controls requirements because they are usually not anticipated and because normal shock response to rapid atmospheric disturbances is not attenuated by the inlet, as it is for engine induced disturbances. However, before inlet control requirements can be fully assessed, more statistics on extreme atmospheric disturbances are needed. Author

N78-11002*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL PERFORMANCE OF A 13.65-CENTIMETER-TIP-DIAMETER TANDEM-BLADED SWEPT-BACK CENTRIFUGAL COMPRESSOR DESIGNED FOR A PRESSURE RATIO OF 8
Hugh A. Klassen, Jerry R. Wood (Army Air Mobility Res. and Develop. Lab., Cleveland), and Lawrence F. Schumann (Army Air Mobility Res. and Develop. Lab., Cleveland). Nov. 1977. 27 p. refs.
(NASA-TP-1091) Avail: NTIS HC A03/MF A01 CSCL 01A

A 13.65 cm tip diameter backswept centrifugal impeller having a tandem inducer and a design mass flow rate of 0.907 kg/sec was experimentally investigated to establish stage and impeller characteristics. Tests were conducted with both a cascade diffuser and a vaneless diffuser. A pressure ratio of 5.9 was obtained near surge for the smallest clearance tested. Flow range at design speed was 6.3 percent for the smallest clearance test. Impeller exit to shroud axial clearance at design speed was varied to determine the effect on stage and impeller performance. Author

N78-11008*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF COOLANT FLOW EJECTION ON AERODYNAMIC PERFORMANCE OF LOW-ASPECT-RATIO VANES. 2: PERFORMANCE WITH COOLANT FLOW EJECTION AT TEMPERATURE RATIOS UP TO 2
Jeffrey E. Hass (Army Air Mobility Res. and Develop. Lab., Cleveland) and Milton G. Kofskey. Oct. 1977. 34 p. refs.
(NASA-TP-1057, E-9213) Avail: NTIS HC A03/MF A01 CSCL 21E

The aerodynamic performance of a 0.5 aspect ratio turbine vane configuration with coolant flow ejection was experimentally determined in a full annular cascade. The vanes were tested at a nominal mean section ideal critical velocity ratio of 0.890 over a range of primary to coolant total temperature ratio from 1.0 to 2.08 and a range of coolant to primary total pressure ratio from 1.0 to 1.4 which corresponded to coolant flows from 3.0 to 10.7 percent of the primary flow. The variations in primary and thermodynamic efficiency and exit flow conditions with circumferential and radial position were obtained. Author

N78-14998*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COLD-AIR PERFORMANCE OF A TIP TURBINE DESIGNED TO DRIVE A LIFT FAN
Jeffrey E. Haas, Milton G. Kofskey, and Glen M. Hotz. Jan. 1978. 23 p. refs.
(NASA-TP-1126, E-9293) Avail: NTIS HC A02/MF A01 CSCL 20E

Performance was obtained over a range of speeds and pressure ratios for a 0.4 linear scale version of the LF460 lift fan turbine with the rotor radial tip clearance reduced to about 2.5 percent of the rotor blade height. These tests covered a range of speeds from 60 to 140 percent of design equivalent speed and a range of scroll inlet total to diffuser exit static pressure ratios from 2.6 to 4.2. Results are presented in terms of equivalent mass flow, equivalent torque, equivalent specific work, and efficiency. Author

N78-16001*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COLD-AIR PERFORMANCE OF A TIP TURBINE DESIGNED TO DRIVE A LIFT FAN. 3: EFFECT OF SIMULATED FAN LEAKAGE ON TURBINE PERFORMANCE
Jeffrey E. Haas (Army R and T Labs.), Milton G. Kofskey, Glen M. Hotz, and Samuel M. Futral, Jr. Jan. 1978. 28 p. refs.
(NASA-TP-1109; E-9331) Avail: NTIS HC A03/MF A01 CSCL 01A

Performance data were obtained experimentally for a 0.4 linear scale version of the LF460 lift fan turbine for a range of scroll inlet total to diffuser exit static pressure ratios at design equivalent speed with simulated fan leakage air. Tests were conducted for full and partial admission operation with three separate combinations of rotor inlet and rotor exit leakage air. Data were compared to the results obtained from previous investigations in which no leakage air was present. Results are presented in terms of mass flow, torque, and efficiency. Author

N78-17001*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SYNTHESIS OF BLADE FLUTTER VIBRATORY PATTERNS USING STATIONARY TRANSDUCERS
A. Kurkov and J. Dicus. Mar. 1977. 26 p. refs. Proposed for presentation at Gas Turbine Conf., London, Engl., 9-13 Apr. 1978; sponsored by Am. Soc. of Mechan. Engineers.
(NASA-TM-73821; E-9410) Avail: NTIS HC A03/MF A01 CSCL 01A

Flutter frequency was determined and rotor vibratory amplitude and phase distributions during flutter were reconstructed from stationary aerodynamic type measurements. A previously reported optical method for measuring blade-tip displacement during flutter was extended by means of digital analysis. Displacement amplitudes and phase angles were determined based on this method. For selected blades, spectral results were also obtained from strain gage measurements. The results from these three types of measurement were compared and critically evaluated. Author

N78-17998*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF DESIGN CHANGES ON AERODYNAMIC AND ACOUSTIC PERFORMANCE OF TRANSLATING-CENTERBODY SONIC INLETS
Brent A. Miller. Feb. 1978. 49 p. refs.
(NASA-TP-1132; E-9283) Avail: NTIS HC A03/MF A01 CSCL 01A

An experimental investigation was conducted to determine the effect of design changes on the aerodynamic and acoustic performance of translating centerbody sonic inlets. Scale model inlets were tested in the Lewis Research Center's V/STOL wind tunnel. The effects of centerbody position, entry lip contraction ratio, diffuser length, and diffuser area ratio on inlet total pressure recovery, distortion, and noise suppression were investigated at static conditions and at forward velocity and angle of attack. With the centerbody in the takeoff position (retracted), good aerodynamic and acoustic performance was attained at static

conditions and at forward velocity. At 0 deg incidence angle with a sound pressure level reduction of 20 dB, the total pressure recovery was 0.986. Pressure recovery at 50 deg was 0.981. With the centerbody in the approach position (extended), diffuser flow separation occurred at an incidence angle of approximately 20 deg. However, good performance was attained at lower angles. With the centerbody in the takeoff position the ability of the inlet to tolerate high incidence angles was improved by increasing the lip contraction ratio. However, at static conditions with the centerbody in the approach position, an optimum lip contraction ratio appears to exist, with both thinner and thicker lips yielding reduced performance. Author

N78-19067*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE CHARACTERISTICS OF TWO ANNULAR DUMP DIFFUSERS USING SUCTION-STABILIZED VORTEX FLOW CONTROL

A. J. Juhasz and J. M. Smith 1978 14 p refs In ENGLISH; FRENCH summary Proposed for Presentation at the Joint Symp. on Design and Operation of Fluid Machinery, Fort Collins, Colo., 12-14 Jun. 1978

(NASA-TM-73857) Avail: NTIS HC A02/MF A01 CSCL 01A

Test results are described for two abrupt area change annular diffusers with provisions for maintaining suction stabilized toroidal vortices at the area discontinuity. Both diffusers had an overall area ratio of 4.0 with the prediffuser area ratio being 1.18 for diffuser A and 1.4 for diffuser B. Performance was evaluated at near atmospheric pressure and temperature for a range of inlet Mach numbers from 0.18 to 0.41 and suction rates from 0 to 18%. Static pressure recovery improved significantly as the suction rate was increased to approximately 11%. Results obtained with diffuser A were superior to that obtained with diffuser B. Flat radial profiles of exit velocity were not obtained since the flow showed preferential hub or tip attachment at moderate suction rates. At high suction rates the diffuser exit flow became circumferentially nonuniform and unstable. Author

N78-20060*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF COOLING-HOLE GEOMETRY ON AERODYNAMIC PERFORMANCE OF A FILM-COOLED TURBINE VANE TESTED WITH COLD AIR IN A TWO-DIMENSIONAL CASCADE

John F. Kline, Roy G. Stabe, and Thomas P. Moffitt Mar. 1978 49 p refs

(NASA-TP-1136; E-9174) Avail: NTIS HC A03/MF A01 CSCL 01A

The effect of the orientation and cooling-hole size on turbine-vane aerodynamic losses was evaluated. The contribution of individual vane regions to the overall effect was also investigated. Test configurations were based upon a representative configuration having 45 spanwise rows of holes spaced about the entire vane profile. Nominal hole diameters of 0.0254 and 0.0356 cm and nominal hole orientations of 35 deg, 45 deg, and 55 deg from the local vane surface and 0 deg, 45 deg, and 90 deg from the main-stream flow direction were investigated. Flow conditions and aerodynamic losses were determined by vane-exit surveys of total pressure, static pressure, and flow angle. Author

N78-24058*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECTS OF NOZZLE DESIGN AND POWER ON CRUISE DRAG FOR UPPER-SURFACE-BLOWING AIRCRAFT

Edward T. Meleason *In* NASA. Langley Res. Center Powered-Lift Aerodyn. and Acoustics 1976 p 183-196 refs (For availability see N78-24046 15-02)

Avail: NTIS HC A22/MF A01 CSCL 01A

A high speed wind tunnel investigation was conducted on a series of upper surface blowing nozzles with D-shaped exits installed on a representative short haul aircraft model. Both two and four engine configurations were investigated. Powered engine simulators were used to properly represent nacelle flows. Large differences in cruise drag penalties associated with the various nozzle designs were seen. Some geometric parameters influencing nozzle cruise drag are identified. Author

N78-24063*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ANALYTICAL MODELING OF UNDER-THE-WING EXTERNALLY BLOWN FLAP POWERED-LIFT NOISE

Daniel J. McKinzie, Jr. *In* NASA. Langley Res. Center Powered-Lift Aerodyn. and Acoustics 1976 p 263-282 refs (For availability see N78-24046 15-02)

Avail: NTIS HC A22/MF A01 CSCL 01A

The sound field produced by the interaction of a subsonic jet with a large-scale model of the under the wing externally blown flap in an approach attitude was analyzed. The analysis was performed to obtain a better understanding of the dominant noise sources and the mechanisms governing the peak sound pressure level frequencies of the broadband spectra. An analytical expression is derived which incorporates two available theories and experimental data; the expression predicts the sound field along a circular arc of approximately 120 deg measured from the upstream jet axis in the fly-over plane. The analysis compares favorably with test results obtained from two large-scale models, one using cold air from a conical nozzle and the other using hot gas from a TF-34 turbofan engine having a conical exhaust nozzle with a 12 lobe internal forced mixer. The frequency at which the peak sound pressure level occurs appears to be governed by a phenomenon which produces periodic formation and shedding of large-scale turbulence structures from the nozzle lip. Author

N78-24066*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OVERVIEW OF THE QCSEE PROGRAM

Carl C. Ciepluch *In* NASA. Langley Res. Center Powered-Lift Aerodyn. and Acoustics 1976 p 325-333 refs (For availability see N78-24046 15-02)

Avail: NTIS HC A22/MF A01 CSCL 01A

Externally blown flap and upper surface blown flap powered lift concepts were investigated in the Quiet Clean Short-Haul Experimental Engine Program and briefly discussed along with propulsion system requirements. Noise limits, emission standards, thrust requirements, and thrust-to-weight ratios are among the factors considered. J.M.S.

N78-24067*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ACOUSTIC DESIGN OF THE QCSEE PROPULSION SYSTEMS

Irvin J. Loeffler, Edward B. Smith (GE Co., Fairfield, Conn.), and Harry D. Sowers (GE Co., Fairfield, Conn.) *In* NASA. Langley Res. Center Powered-Lift Aerodyn. and Acoustics 1976 p 335-356 refs (For availability see N78-24046 15-02)

Avail: NTIS HC A22/MF A01 CSCL 01A

Acoustic design features and techniques employed in the Quiet Clean Short-Haul Experimental Engine (QCSEE) Program are described. The role of jet/flap noise in selecting the engine fan pressure ratio for powered lift propulsion systems is discussed. The QCSEE acoustic design features include a hybrid inlet (near-sonic throat velocity with acoustic treatment); low fan and core pressure ratios; low fan tip speeds; gear-driven fans; high and low frequency stacked core noise treatment; multiple-thickness treatment; bulk absorber treatment; and treatment on the stator vanes. The QCSEE designs represent and anticipated acoustic technology improvement of 12 to 16 PNdb relative to the noise levels of the low-noise engines used on current wide-body commercial jet transport aircraft. Author

N78-24069*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INLET TECHNOLOGY FOR POWERED-LIFT AIRCRAFT

Roger W. Luidens *In* NASA Langley Res. Center Powered-Lift Aerodyn. and Acoustics 1976 p 369-385 refs (For availability see N78-24046 15-02)

Avail: NTIS HC A22/MF A01 CSCL 01A

The concepts, analytical tools, and experimental data available for designing inlets for powered lift aircraft are discussed. It is shown that inlets can be designed to meet noise, distortion, and cruise drag requirements at the flight and engine operating conditions of a powered lift aircraft. The penalty in pressure recovery for achieving the required noise suppression was 0.3 percent. Author

N78-24070*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

REVERSE-THRUST TECHNOLOGY FOR VARIABLE-PITCH FAN PROPULSION SYSTEMS

David A. Sagerser, John W. Schaefer, and Donald A. Dietrich *In* NASA Langley Res. Center Powered-Lift Aerodyn. and Acoustics 1976 p 387-402 refs (For availability see N78-24046 15-02)

Avail: NTIS HC A22/MF A01 CSCL 01A

Tests conducted to develop the technology necessary to meet the unique reverse-thrust performance requirements of a variable pitch fan propulsion system are discussed. The losses and distortion associated with the air entering the fan and core compressor from the rear of the engine, the direction of fan blade pitch rotation for best reverse-thrust aeroacoustic performance, and engine response and operating characteristics during forward- to reverse-thrust transients are among the factors studied. The test results of several scale fan models as well as a full-size variable pitch fan engine are summarized. Results show the following: a flared exhaust nozzle makes a good reverse-thrust inlet, acceptable core inlet duct recovery and distortion levels in reverse flow were demonstrated; adequate thrust levels were achieved; forward- to reverse-thrust response time achieved was better than the goal; thrust and noise levels strongly favor reverse through feather pitch; and finally, flight-type inlets make the establishment of reverse flow more difficult. Author

N78-26098*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COLD-AIR PERFORMANCE OF THE COMPRESSOR-DRIVE TURBINE OF THE DEPARTMENT OF ENERGY BASELINE AUTOMOBILE GAS-TURBINE ENGINE ***Final Report***

Richard J. Roelke and Kerry L. McLallin Jul. 1978 24 p refs (Contract EC-77-A-31-1011)

(NASA-TM-78894; E-9480; DOE/NASA/1011-78/25) Avail: NTIS HC A02/MF A01 CSCL 01A

The aerodynamic performance of the compressor-drive turbine of the DOE baseline gas-turbine engine was determined over a range of pressure ratios and speeds. In addition, static pressures were measured in the diffusing transition duct located immediately downstream of the turbine. Results are presented in terms of mass flow, torque, specific work, and efficiency for the turbine and in terms of pressure recovery and effectiveness for the transition duct. Author

N78-26099*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

VSTOL TILT NACELLE AERODYNAMICS AND ITS RELATION TO FAN BLADE STRESSES

Robert J. Shaw, Robert C. Williams, and Joseph L. Koncsek (Boeing Mil. Airplane Develop.) Jul. 1978 15 p refs Proposed for presentation at the 14th Joint Propulsion Conf., Las Vegas, Nev., 25-27 Jul. 1978; sponsored by the AIAA and the Soc. of Automotive Engr.

(NASA-TM-78899; E-9635) Avail: NTIS HC A02/MF A01 CSCL 10A

A scale model of a VSTOL tilt nacelle with a 0.508 m single stage fan was tested in a low speed wind tunnel to ascertain inlet aerodynamic and fan aeromechanical performance over the low speed flight envelope. Fan blade stress maxima occurred at discrete rotational speeds corresponding to integral engine order vibrations of the first flatwise bending mode. Increased fan blade stress levels coincided with internal boundary layer separation but became severe only when the separation location had progressed to the entry lip region of the inlet. G.G.

N78-26100*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A VISCOUS-INVISCID INTERACTIVE COMPRESSOR CALCULATIONS

William Johnston (Case Western Reserve Univ.) and Peter M. Sockol Jul. 1978 14 p refs Presented at 11th Fluid and Plasma Dynamics Conf., Seattle, Washington, 10-12 Jul. 1978; sponsored by AIAA

(NASA-TM-78920; E-9658) Avail: NTIS HC A02/MF A01 CSCL 01A

A viscous-inviscid interactive procedure for subsonic flow is developed and applied to an axial compressor stage. Calculations are carried out on a two-dimensional blade-to-blade region of constant radius assumed to occupy a mid-span location. Hub and tip effects are neglected. The Euler equations are solved by MacCormack's method, a viscous marching procedure is used in the boundary layers and wake, and an iterative interaction scheme is constructed that matches them in a way that incorporates information related to momentum and enthalpy thicknesses as well as the displacement thickness. The calculations are quasi-three-dimensional in the sense that the boundary layer and wake solutions allow for the presence of spanwise (radial) velocities. Author

N78-27083*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPUTER PROGRAMS FOR CALCULATING TWO-DIMENSIONAL POTENTIAL FLOW IN AND ABOUT PROPULSION SYSTEM INLETS

J. Dennis Hawk, Norbert O. Stockman, and Charles A. Farrell, Jr. Jun. 1978 366 p refs

(NASA-TM-78930; E-0671) Avail: NTIS HC A16/MF A01 CSCL 01A

Incompressible potential flow calculations are presented that were corrected for compressibility in two-dimensional inlets at arbitrary operating conditions. Included are a statement of the problem to be solved, a description of each of the computer programs, and sufficient documentation, including a test case, to enable a user to run the program. G.G.

N78-30057*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE WITH AND WITHOUT INLET RADIAL DISTORTION OF A TRANSONIC FAN STAGE DESIGNED FOR REDUCED LOADING IN THE TIP REGION

James F. Schmidt and Robert S. Ruggeri Aug. 1978 84 p refs

(NASA-TP-1294; E-9246) Avail: NTIS HC A05/MF A01 CSCL 01A

A transonic compressor stage designed for a reduced loading in the tip region of the rotor blades was tested with and without inlet radial distortion. The rotor was 50 cm in diameter and designed for an operating tip speed of 420 m/sec. Although the rotor blade loading in the tip region was reduced to provide

additional operating range, analysis of the data indicates that the flow around the damper appears to be critical and limited the stable operating range of this stage. For all levels of tip and hub radial distortion, there was a large reduction in the rotor stall margin. Author

N78-32062*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

WIND TUNNEL EVALUATION OF YF-12 INLET RESPONSE TO INTERNAL AIRFLOW DISTURBANCES WITH AND WITHOUT CONTROL

Gary L. Cole, George H. Neiner, and Miles O. Dustin *In* NASA. Dryden Flight Res. Center YF-12 Experiments Symp., Vol. 1 Aug. 1978 p 157-192 *refs* (For primary document see N78-32055 23-02)

Avail: NTIS HC A13/MF A01 CSCL 01A

The response of terminal-shock position and static pressures in the subsonic duct of a YF-12 aircraft flight-hardware inlet to perturbations in simulated engine corrected airflow were obtained with and without inlet control. Frequency response data, obtained with inlet controls inactive, indicated the general nature of the inherent inlet dynamics, assisted in the design of controls, and provided a baseline reference for responses with active controls. All the control laws were implemented by means of a digital computer that could be programmed to behave like the flight inlet's existing analog control. The experimental controls were designed using an analytical optimization technique. The capabilities of the controls were limited primarily by the actuation hardware. The experimental controls provided somewhat better attenuation of terminal shock excursions than did the YF-13 inlet control. Controls using both the forward and aft bypass systems also provided somewhat better attenuation than those using just the forward bypass. The main advantage of using both bypasses is in the greater control flexibility that is achieved. A.R.H.

A78-12289 * **Calculation of 3-dimensional choking mass flow in turbomachinery with 2-dimensional flow models.** T. Katsanis (NASA, Lewis Research Center, Cleveland, Ohio). In: Transonic flow problems in turbomachinery; Proceedings of the Workshop, Monterey, Calif., February 11, 12, 1976. (A78-12286 02-02) Washington, D.C., Hemisphere Publishing Corp., 1977, p. 60-67; Discussion, p. 67-69.

An approach is considered for obtaining an approximate flow solution in the case of a cross-sectional flow surface within a guided channel, taking into account a pair of typical turbine blades with three-dimensional orthogonal surfaces across the flow passage, the calculation of the mass flow across the throat in the case of a 2-D passage with curved walls, and the determination of the choking mass flow. It is pointed out that the choking solution for a three-dimenstional guided passage in a blade row can be obtained in a very similar manner by satisfying momentum equations for the blade-to-blade and the hub-to-tip direction. A considered example involves the calculation of the choking mass flow for a centrifugal compressor impeller in an automotive application. G.R.

A78-12312 * **Review of experimental work on transonic flow in turbomachinery.** W. D. McNally (NASA, Lewis Research Center, Cleveland, Ohio). In: Transonic flow problems in turbomachinery; Proceedings of the Workshop, Monterey, Calif., February 11, 12, 1976. (A78-12286 02-02) Washington, D.C., Hemisphere Publishing Corp., 1977, p. 457-484; Discussion, p. 484. 51 refs.

The review is primarily concerned with modern experimental techniques of high response and laser supported instrumentation. The considered techniques make it possible to obtain detailed data of steady and unsteady processes occurring inside transonic blade rows and in the vicinity of the rows. Such data are needed for the verification of computer codes used for the study of the operational characteristics of turbomachinery. Attention is given to high response transducers, hot wire probes, hot film gages, laser Doppler velocimeter systems, laser fluorescence, and laser holography. G.R.

A78-17270 * **Unsteady flow in a supersonic cascade with strong in-passage shocks.** M. E. Goldstein, W. Braun, and J. J. Adamczyk (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Fluid Mechanics*, vol. 83, Dec. 5, 1977, p. 569-604. 21 refs.

Linearized theory is used to study the unsteady flow in a supersonic cascade with in-passage shock waves. We use the Wiener-Hopf technique to obtain a closed-form analytical solution for the supersonic region. To obtain a solution for the rotational flow in the subsonic region we must solve an infinite set of linear algebraic equations. The analysis shows that it is possible to correlate quantitatively the oscillatory shock motion with the Kutta condition at the trailing edges of the blades. This feature allows us to account for the effect of shock motion on the stability of the cascade. Unlike the theory for a completely supersonic flow, the present study predicts the occurrence of supersonic bending flutter. It therefore provides a possible explanation for the bending flutter that has recently been detected in aircraft-engine compressors at higher blade loadings. (Author)

A78-20701 * # **Development and test of an inlet and duct to provide airflow for a wing boundary layer control system.** D. W. Gunnarson (Boeing Commercial Airplane Co., Seattle, Wash.) and J. C. McArdle (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 16th, Huntsville, Ala., Jan. 16-18, 1978, Paper 78-141.* 9 p. NASA-sponsored research.

The boundary layer control (BLC) system of the quiet short-haul research airplane (QSRA) requires significant amounts of pressurized airflow for successful operation. An inlet and duct were successfully developed which removed airflow from the engine fan duct for the BLC system at or above the required total pressure of 99% of the average fan duct total pressure. The design was constrained by the tight space limitations of the QSRA nacelle. Potential flow with boundary layer analysis techniques were used as an aid to select the inlet and duct geometries. Airflow and total pressure profile data were obtained during development tests. (Author)

A78-20702 * # **A combined potential and viscous flow solution for V/STOL engine inlets.** A. H. Ybarra, W. W. Rhoades (Vought Corp., Dallas, Tex.), and N. O. Stockman (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 16th, Huntsville, Ala., Jan. 16-18, 1978, Paper 78-142.* 8 p. 5 refs.

A potential flow routine and a viscous boundary layer routine have been combined into a single routine for estimating the flow in and around subsonic inlets. In this combined routine, the viscous flow solution about the inlet body is obtained by adding the viscous displacement thickness to the inlet geometry. Combination of the two flow solutions has resulted in cost savings, both in preparation time and in computer time. This routine is a useful tool in optimizing lip shapes for V/STOL inlets. The method of combining the routine, comparison with NASA test data and utilization of the routine for V/STOL inlet design are presented. (Author)

A78-41843 * # **A viscous-inviscid interactive compressor calculation.** W. A. Johnston (Case Western Reserve University, Cleveland, Ohio) and P. M. Sockol (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 11th, Seattle, Wash., July 10-12, 1978, Paper 78-1140.* 10 p. 24 refs. NASA-supported research.

A viscous-inviscid interactive procedure for subsonic flow is developed and applied to an axial compressor stage. Calculations are carried out on a two-dimensional blade-to-blade region of constant radius assumed to occupy a mid-span location. Hub and tip effects are neglected. The Euler Equations are solved by MacCormack's method. A viscous marching procedure is used in the boundary layers and wake, and an iterative interaction scheme is constructed that

matches them in a way that incorporates information related to momentum and enthalpy thicknesses as well as the displacement thickness. The calculations are quasi-three-dimensional in the sense that the boundary layer and wake solutions allow for the presence of spanwise (radial) velocities. (Author)

A78-43520 * # **VSTOL tilt nacelle aerodynamics and its relation to fan blade stresses.** R. J. Shaw, R. C. Williams (NASA, Lewis Research Center, Cleveland, Ohio), and J. L. Koncsek (Boeing Aerospace Co., Boeing Military Airplane Development, Seattle, Wash.). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Joint Propulsion Conference, 14th, Las Vegas, Nev., July 25-27, 1978, AIAA Paper 78-958.* 11 p. 9 refs.

A scale model of a VSTOL tilt nacelle with a 0.508 m single stage fan was tested in the NASA Lewis 9x15 Low Speed Wind Tunnel to ascertain inlet aerodynamic and fan aeromechanical performance over the low speed flight envelope. Fan blade stress maxima occurred at discrete rotational speeds corresponding to integral engine order vibrations of the first flatwise bending mode. Increased fan blade stress levels coincided with internal boundary layer separation occurring but became severe only when the separation location had progressed to the entry lip region of the inlet. The inlet/fan system could operate within the low speed flight envelope without incurring fan blade stress limits although boundary layer separation did occur for certain operating conditions. (Author)

A78-45096 * # **Inlet-engine matching for SCAR including application of a bicone variable geometry inlet.** J. F. Wasserbauer and W. H. Gerstenmaier (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Joint Propulsion Conference, 14th, Las Vegas, Nev., July 25-27, 1978, AIAA Paper 78-961.* 22 p. 15 refs.

Airflow characteristics of variable cycle engines (VCE) designed for Mach 2.32 can have transonic airflow requirements as high as 1.6 times the cruise airflow. This is a formidable requirement for conventional, high performance axisymmetric, translating centerbody mixed compression inlets. An alternate inlet is defined where the second cone of a two cone centerbody collapses to the initial cone angle to provide a large off-design airflow capability, and incorporates modest centerbody translation to minimize spillage drag. Estimates of transonic spillage drag are competitive with those of conventional translating centerbody inlets. The inlet's cruise performance exhibits very low bleed requirements with good recovery and high angle of attack capability. (Author)

A78-45133 * # **End-wall boundary layer prediction for axial compressors.** P. M. Sockol (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 11th, Seattle, Wash., July 10-12, 1978, Paper 78-1139.* 19 p. 15 refs.

An integral boundary layer procedure has been developed for the computation of viscous and secondary flows along the annulus walls of an axial compressor. The procedure is an outgrowth and extension of the pitch-averaged methods of Mellor and Horlock. In the present work secondary flow theory is used to develop approximations for the velocity profiles inside a rotating blade row and for the blade force deficit terms in the momentum integral equations. The computer code based on this procedure has been iteratively coupled to a quasi-one-dimensional model for the external inviscid flow. Computed results are compared with measurements in a compressor cascade. (Author)

A78-46537 * # **Methods for calculating the transonic boundary layer separation for V/STOL inlets at high incidence angles.** D. C. Chou, H. C. Lee (Iowa, University, Iowa City, Iowa), R. W. Luidens, and N. O. Stockman (NASA, Lewis Research Center, Cleveland, Ohio). In: Atmospheric Flight Mechanics Conference, Palo Alto, Calif., August 7-9, 1978, Technical Papers. (A78-46526 20-08) New York, American Institute of Aeronautics and Astronautics, Inc., 1978, p. 100-106. 10 refs. Grant No. NsG-3117. (AIAA 78-1340)

A semi-empirical scheme for the prediction of transonic pressure distribution on the surface of V/STOL inlets at high incidence angles has been developed. The investigation is intended to improve the boundary layer calculation and separation prediction by including the effects of shock wave-boundary layer interaction into the Lewis Inlet Viscous Computer Program. Wind-tunnel results and theoretical pressure calculation for critical cases are used in constructing the transonic pressure distribution. The program, which describes the development of the boundary layer and predicts the possible flow separation, can handle the cases of inlets at high incidence angles where local supersonic region may occur in the flow. (Author)

N78-12034*# Advanced Technology Labs., Inc., Westbury, N. Y.

COMPUTATION OF UNSTEADY TRANSONIC FLOWS THROUGH ROTATING AND STATIONARY CASCADES. 2: USER'S GUIDE TO FORTRAN PROGRAM B2DATL Final Report

Edgar Alzner and Paul P. Kalben Nov. 1977 81 p refs
(Contract NAS3-16807)
(NASA-CR-2901; ATL-TR-205-Vol-2) Avail: NTIS
HC A03/MF A01 CSCL 01A

Documentation for the FORTRAN program B2DATL is provided. The program input, output, and operational procedures are described; a dictionary of the principal FORTRAN variables is provided; the function of all subroutines; is outlined and flow charts of the principal subroutines and the main program are presented. Author

N78-12035*# Advanced Technology Labs., Inc., Westbury, N. Y.

COMPUTATION OF UNSTEADY TRANSONIC FLOWS THROUGH ROTATING AND STATIONARY CASCADES. 3: ACOUSTIC FAR-FIELD ANALYSIS Final Report

Simon Slutsky, Dietrich Fischer, and John I. Erdos Nov. 1977 56 p refs
(Contract NAS3-16807)
(NASA-CR-2902; ATL-TR-205-Vol-3) Avail: NTIS
HC A04/MF A01 CSCL 01A

A small perturbation type analysis has been developed for the acoustic far field in an infinite duct extending upstream and downstream of an axial turbomachinery stage. The analysis is designed to interface with a numerical solution of the near field of the blade rows and, thereby, to provide the necessary closure condition to complete the statement of infinite duct boundary conditions for the subject problem. The present analysis differs from conventional inlet duct analyses in that a simple harmonic time dependence was not assumed, since a transient signal is generated by the numerical near-field solution and periodicity is attained only asymptotically. A description of the computer code developed to carry out the necessary convolutions numerically is included, as well as the results of a sample application using an impulsively initiated harmonic signal. Author

N78-17991*# Pratt and Whitney Aircraft, East Hartford, Conn. Commercial Products Div

MEAN VELOCITY, TURBULENCE INTENSITY AND TURBULENCE CONVECTION VELOCITY MEASUREMENTS FOR A CONVERGENT NOZZLE IN A FREE JET WIND TUNNEL. COMPREHENSIVE DATA REPORT

C. J. McColgan and R. S. Larson Apr. 1977 262 p
(Contract NAS3-17866)
(NASA-CR-135238; PWA-5516) Avail: NTIS
HC A12/MF A01 CSCL 01A

The effect of flight on the mean flow and turbulence properties of a 0.056m circular jet were determined in a free jet wind tunnel. The nozzle exit velocity was 122 m/sec, and the wind tunnel velocity was set at 0, 12, 37, and 61 m/sec Measurements of flow properties including mean velocity, turbulence intensity and spectra, and eddy convection velocity were carried out using two linearized hot wire anemometers. This report contains the raw data and graphical presentations. The final technical report includes a description of the test facilities, test hardware, along with significant test results and conclusions. Author

N78-20082*# Advanced Technology Labs., Inc., Westbury, N. Y.
COMPUTATION OF UNSTEADY TRANSONIC FLOWS THROUGH ROTATING AND STATIONARY CASCADES. 1: METHOD OF ANALYSIS Final Report
John I. Erdos and Edgar Alzner Dec. 1977 131 p refs
(Contract NAS3-16807)
(NASA-CR-2900; ATL-TR-205-Vol-1) Avail: NTIS HC A07/MF A01 CSCL 01A

A numerical method of solution of the inviscid, compressible, two-dimensional unsteady flow on a blade-to-blade stream surface through a stage (rotor and stator) or a single blade row of an axial flow compressor or fan is described. A cyclic procedure has been developed for representation of adjacent blade-to-blade passages which asymptotically achieves the correct phase between all passages of a stage. A shock-capturing finite difference method is employed in the interior of the passage, and a method of characteristics technique is used at the boundaries. The blade slipstreams form two of the passage boundaries and are treated as moving contact surfaces capable of supporting jumps in entropy and tangential velocity. The Kutta condition is imposed by requiring the slipstreams to originate at the trailing edges, which are assumed to be sharp. Results are presented for several transonic fan rotors and compared with available experimental data, consisting of holographic observations of shock structure and pressure contour maps. A subcritical stator solution is also compared with results from a relaxation method. Finally, a periodic solution for a stage consisting of 44 rotor blades and 46 stator blades is discussed. Author

N78-21068*# Pratt and Whitney Aircraft Group, East Hartford, Conn.
MEAN VELOCITY, TURBULENCE INTENSITY AND TURBULENCE CONVECTION VELOCITY MEASUREMENTS FOR A CONVERGENT NOZZLE IN A FREE JET WIND TUNNEL Final Report
C. J. McColgan and R. S. Larson Apr. 1978 31 p refs
(Contract NAS3-17866)
(NASA-CR-2949; PWA-5506) Avail: NTIS HC A03/MF A01 CSCL 01A

The effect of flight on the mean flow and turbulence properties of a 0.056 m circular jet were determined in a free jet wind tunnel. The nozzle exit velocity was 122 m/sec, and the wind tunnel velocity was set at 0, 12, 37, and 61 m/sec. Measurements of flow properties including mean velocity, turbulence intensity and spectra, and eddy convection velocity were carried out using two linearized hot wire anemometers. Normalization factors were determined for the mean velocity and turbulence convection velocity. Author

N78-32066*# Hamilton Standard, Windsor Locks, Conn.
AERODYNAMIC DESIGN AND PERFORMANCE TESTING OF AN ADVANCED 30 DEG SWEPT, EIGHT BLADED PROPELLER AT MACH NUMBERS FROM 0.2 TO 0.85 Final Report
D. M. Black, R. W. Menthe, and H. S. Wainauski Sep. 1978 119 p refs
(Contract NAS3-20219)
(NASA-CR-3047) Avail: NTIS HC A06/MF A01 CSCL 01A

The increased emphasis on fuel conservation in the world has stimulated a series of studies of both conventional and unconventional propulsion systems for commercial aircraft. Preliminary results from these studies indicate that a fuel saving of from 15 to 28 percent may be realized by the use of an advanced high speed turboprop. The turboprop must be capable of high efficiency at Mach 0.8 above 10.68 km (35,000 ft) altitude if it is to compete with turbofan powered commercial aircraft. An advanced turboprop concept was wind tunnel tested. The model included such concepts as an aerodynamically integrated propeller/nacelle, blade sweep and power (disk) loadings approximately three times higher than conventional propeller designs. The aerodynamic design for the model is discussed. Test results are presented which indicate propeller net efficiencies near 80 percent were obtained at high disk loadings at Mach 0.8. B.B.

N78-33044*# United Technologies Research Center, East Hartford, Conn.
DERIVATION AND EVALUATION OF AN APPROXIMATE ANALYSIS FOR THREE-DIMENSIONAL VISCOUS SUBSONIC FLOW WITH LARGE SECONDARY VELOCITIES Final Report
O. L. Anderson, W. R. Briley, and H. McDonald Oct. 1978 84 p refs
(Contract NAS3-19752)
(NASA-CR-159430; UTRC78-106) Avail: NTIS HC A05/MF A01 CSCL 01A

An approximate analysis is presented for calculating three-dimensional, low Mach number, laminar viscous flows in curved passages with large secondary flows and corner boundary layers. The analysis is based on the decomposition of the overall velocity field into inviscid and viscous components with the overall velocity being determined from superposition. An incompressible vorticity transport equation is used to estimate inviscid secondary flow velocities to be used as corrections to the potential flow velocity field. A parabolized streamwise momentum equation coupled to an adiabatic energy equation and global continuity equation is used to obtain an approximate viscous correction to the pressure and longitudinal velocity fields. A collateral flow assumption is invoked to estimate the viscous correction to the transverse velocity fields. The approximate analysis is solved numerically using an implicit ADI solution for the viscous pressure and velocity fields. An iterative ADI procedure is used to solve for the inviscid secondary vorticity and velocity fields. This method was applied to computing the flow within a turbine vane passage with inlet flow conditions of M = 0.1 and M = 0.25, Re = 1000 and adiabatic walls, and for a constant radius curved rectangular duct with R/D = 12 and 14 and with inlet flow conditions of M = 0.1, Re = 1000, and adiabatic walls. A.R.H.

A78-12307* **Perturbation solutions for blade-to-blade surfaces of a transonic compressor.** S. S. Stahara, D. S. Chaussee (Nielsen Engineering and Research, Inc., Mountain View, Calif.), and J. R. Spreiter (Stanford, University, Stanford, Calif.). In: Transonic flow problems in turbomachinery; Proceedings of the Workshop, Monterey, Calif., February 11, 12, 1976. (A78-12286 02-02) Washington, D.C., Hemisphere Publishing Corp., 1977, p. 359-366; Discussion, p. 366-368. Contract No. NAS3-19738.

The paper describes a perturbation method for turbomachinery calculations, particularly where it is necessary to carry out a number of calculations for closely-related flows such as are needed in a parametric study. The method is applied for solving a model problem involving blade-to-blade surfaces of a transonic compressor. Basically, the method makes use of a previously calculated base solution to determine first-order changes in the flow field due to variations in one or more of a variety of geometrical or flow field parameters. The fundamental assumption associated with the perturbation solution is that the magnitude of the deviations from the base solution lies within the range of a linear perturbation analysis. Comparisons are made for results obtained, by varying the thickness ratio of an unstaggered nonlifting cascade composed of biconvex profiles in a flow with an oncoming freestream Mach number of 0.60. S.D.

03 AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

For related information see also *16 Space Transportation* and *85 Urban Technology and Transportation.*

N78-31061*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

SIMULTANEOUS MEASUREMENTS OF OZONE OUTSIDE AND INSIDE CABINS OF TWO B-747 AIRLINERS AND A GATES LEARJET BUSINESS JET

Porter J. Perkins and Daniel Briel 1978 11 p refs Proposed for presentation at the Conf. on Atmospheric Environ. of Aerospace Systems and Appl. Meteorology, New York, 13-16 Nov. 1978; sponsored by the Am. Meteorol. Soc. and the AIAA

(NASA-TM-78983; E-9760) Avail: NTIS HC A02/MF A01 CSCL 06T

The average amount of ozone measured in the cabins of two B-747 airliners varied from 40 percent to 80 percent of the atmospheric concentrations without special ozone destruction systems. A charcoal filter in the cabin air inlet system of one B-747 reduced the ozone to about 5 percent of the atmospheric concentration. A Learjet 23 was also instrumented with monitors to measure simultaneously the atmospheric and ozone concentrations. Results indicate that a significant portion of the atmospheric ozone is not destroyed in the pressurization system and remains in the aircraft cabin of the Learjet. For the two cabin configurations tested, the ozone retentions were 63 and 41 percent of the atmospheric ozone concentrations. Ozone concentrations measured in the cabin near the conditioned-air outlets were reduced only slightly from atmospheric ozone concentrations. It is concluded that a constant difference between ozone concentrations inside and outside the cabin does not exist. G.G.

N78-11024*# General Electric Co., Pittsfield, Mass.

LIGHTNING PROTECTION OF AIRCRAFT

Franklin A. Fisher and J. Anderson Plumer Oct. 1977 530 p refs

(Contract NAS3-19080)

(NASA-RP-1008) Avail: NTIS HC A23/MF A01 CSCL 01C

The current knowledge concerning potential lightning effects on aircraft and the means that are available to designers and operators to protect against these effects are summarized. The increased use of nonmetallic materials in the structure of aircraft and the constant trend toward using electronic equipment to handle flight critical control and navigation functions have served as impetus for this study. For individual titles, see N78-11025 through N78-11041.

05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

For related information see also *18 Spacecraft Design, Testing and Performance* and *39 Structural Mechanics*.

N78-17041*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRELIMINARY STUDY OF PROPULSION SYSTEMS AND AIRPLANE WING PARAMETERS FOR A US NAVY SUBSONIC V/STOL AIRCRAFT

C. L. Zola, L. H. Fishbach, and J. L. Allen. Feb. 1978. 42 p. refs

(NASA-TM-73652; E-9519) Avail: NTIS HC A03/MF A01 CSCL 01C

Two V/STOL propulsion concepts were evaluated in a common aircraft configuration. One propulsion system consists of cross coupled turboshaft engines driving variable pitch fans. The other system is a gas coupled combination of turbojet gas generators and tip turbine fixed pitch fans. Evaluations were made of endurance at low altitude, low speed loiter with equal takeoff fuel loads. Effects of propulsion system sizing, bypass ratio, and aircraft wing planform parameters were investigated and compared. Shaft driven propulsion systems appear to result in better overall performance, although at higher installed weight, than gas systems. Author

N78-25080*# Sikorsky Aircraft, Stratford, Conn.

OIL-AIR MIST LUBRICATION FOR HELICOPTER GEARING Final Report

F. McGregan. Dec. 1976. 52 p. refs

(Contract NAS3-18538)

(NASA-CR-135031; SER-50959) Avail: NTIS HC A04/MF A01 CSCL 01C

The applicability of a once-through oil mist system to the lubrication of helicopter spur gears was investigated and compared to conventional jet spray lubrication. In the mist lubrication mode, cooling air was supplied at 366K (200 F) to the out of mesh location of the gear sets. The mist air was also supplied at 366K (200 F) to the radial position mist nozzle at a constant rate of 0.0632 mol/s (3 SCFM) per nozzle. The lubricant contained in the mist air varied between 32 - 44 cc/hour. In the recirculating jet spray mode, the flow rate was varied between 1893 - 2650 cc/hour. Visual inspection revealed the jet spray mode produced a superior surface finish on the gear teeth but a thermal energy survey showed a 15 - 20% increase in heat generated. The gear tooth condition in the mist lubrication mode system could be improved if the cooling air and lubricant/air flow ratio were increased. The test gearbox and the procedure used are described. Author

06 AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

For related information see also *19 Spacecraft Instrumentation* and *35 Instrumentation and Photography*.

N78-17052*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INSTRUMENTATION FOR PROPULSION SYSTEMS DEVELOPMENT

Isidore Warshawsky 1978 24 p refs Presented at the Soc. of Automotive Engr. Congr. (Meeting 1M21), Detroit, 27 Feb. - 3 Mar. 1978

(NASA-TM-73840) Avail: NTIS HC A02/MF A01 CSCL 01D

Apparatus and techniques developed or used by NASA-Lewis to make steady state or dynamic measurements of gas temperature, pressure, and velocity and of the temperature, tip clearance, and vibration of the blades of high-speed fans or turbines are described. The advantages and limitations of each instrument and technique are discussed and the possibility of modifying them for use in developing various propulsion systems is suggested. Author

N78-24137*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ON THE USE OF RELATIVE VELOCITY EXPONENTS FOR JET ENGINE EXHAUST NOISE

James R Stone 1978 17 p refs Presented at 95th Meeting of Acoust. Soc. of Am., Providence, R. I., 16-19 May 1978

(NASA-TM-78873, E-9605) Avail: NTIS HC A02/MF A01 CSCL 20A

The effect of flight on jet engine exhaust noise has often been presented in terms of a relative velocity exponent, n, as a function of radiation angle. The value of n is given by the OASPL reduction due to relative velocity divided by 10 times the logarithm of the ratio of relative jet velocity to absolute jet velocity. In such terms, classical subsonic jet noise theory would result in a value of n being approximately 7 at 90 degree angle to the jet axis with n decreasing, but remaining positive, as the inlet axis is approached and increasing as the jet axis is approached. However, flight tests have shown a wide range of results, including negative values of n in some cases. In this paper it is shown that the exponent n is positive for pure subsonic jet mixing noise and varies in a systematic manner, as a function of flight conditions and jet velocity. Author

N78-24138*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESIGN AND PRELIMINARY RESULTS OF A SEMITRANSPIRATION COOLED (LAMILLOY) LINER FOR A HIGH-PRESSURE HIGH-TEMPERATURE COMBUSTOR

Jerrold D. Wear, Arthur M. Trout, John M. Smith, and Robert E. Jones 1978 13 p refs To be presented at the 14th Propulsion Conf., Las Vegas, Nev., 25-27 Jul. 1978, sponsored by AIAA and SAE

(NASA-TM-78874; E-9607) Avail: NTIS HC A02/MF A01 CSCL 21E

A Lamilloy combustor liner was designed, fabricated and tested in a combustor at pressures up to 8 atmospheres. The liner was fabricated of a three layer Lamilloy structure and designed to replace a conventional step louver liner. The liner is to be used in a combustor that provides hot gases to a turbine cooling test facility at pressures up to 40 atmospheres. The Lamilloy liner was tested extensively at lower pressures and demonstrated lower metal temperatures than the conventional liner, while at the same time requiring about 40 percent less cooling air flow. Tests conducted at combustor exit temperatures in excess of 2200 K have not indicated any cooling or durability problems with the Lamilloy liner. Author

N78-24139*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

GENERAL AVIATION INTERNAL-COMBUSTION ENGINE RESEARCH PROGRAMS AT NASA-LEWIS RESEARCH CENTER

Edward A. Willis 1978 23 p refs Proposed for presentation at 14th Propulsion Conf., Las Vegas, Nev., 25-27 Jul. 1978; cosponsored by AIAA and SAE

(NASA-TM-78891; E-9628) Avail: NTIS HC A02/MF A01 CSCL 21A

An update is presented of non-turbine general aviation engine programs. The program encompasses conventional, lightweight diesel and rotary engines. It's three major thrusts are: (1) reduced SFC's; (2) improved fuels tolerance; and (3) reduced emissions. Current and planned future programs in such areas as lean operation, improved fuel management, advanced cooling techniques and advanced engine concepts, are described. These are expected to lay the technology base, by the mid to latter 1980's, for engines whose life cycle fuel costs are 30 to 50% lower than today's conventional engines. Author

07 AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

For related information see also *20 Spacecraft Propulsion and Power, 28 Propellants and Fuels,* and *44 Energy Production and Conversion.*

N78-10066*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
CONCEPTS FOR THE DEVELOPMENT OF LIGHT-WEIGHT COMPOSITE STRUCTURES FOR ROTOR BURST CONTAINMENT
Arthur G. Holms *In* MIT An Assessment of Technol for Turbojet Engine Rotor Failures Mar. 1977 p 295-330 refs (For availability see N78-10068 01-07)
Avail: NTIS HC A18/MF A01 CSCL 21E

Published results on rotor burst containment with single materials, and on body armor using composite materials were used to establish a set of hypotheses about what variables might control the design of a weight-efficient protective device. Based on modern concepts for the design and analysis of small optimum sealing experiments, a particular experiment for evaluating the hypotheses and materials was designed. The design and methods for the analysis of results are described. The consequence of such hypotheses is that the device should consist of as many as four concentric rings, each to consist of a material uniquely chosen for its position in the penetration sequence. Author

N78-10068*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
APPLICATION OF A FLIGHT-LINE DISK CRACK DETECTOR TO A SMALL ENGINE
John R. Barranger *In* MIT An Assessment of Technol. for Turbojet Engine Rotor Failures Mar. 1977 383-388 (For availability see N78-10068 01-07)
Avail: NTIS HC A18/MF A01 CSCL 21E

A disk crack detector was developed and applied to a small military engine for use as a flight-line turbine crack monitor. The system consists of an eddy current type sensor and its cables within the engine, external connecting cables, and a remotely located electrical capacitance-conductance bridge and signal analyzer. As the turbine spins, the rotor is monitored by the sensor for radial surface cracks emanating from the interblade region of the rotor. Author

N78-10069*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
TURBINE DISKS FOR IMPROVED RELIABILITY
Albert Kaufman *In* MIT An Assessment of Technol for Turbojet Engine Rotor Failures Mar. 1977 p 389-411 (For availability see N78-10068 01-07)
Avail: NTIS HC A18/MF A01 CSCL 21E

Advanced disk structural concepts were employed to improve the cyclic lives and reliability of turbine disks. Analytical studies were conducted to evaluate bore-entry disks as potential replacements for the existing first stage turbine disks in the CF6-50 and JT8D-17 engines. Results of low cycle fatigue, burst, fracture mechanics, and fragment energy analyses are summarized for the advanced disk designs and the existing disk designs with both conventional and advanced disk materials. Other disk concepts such as composite laminated link, multibore, multidisk, and spline disks were also evaluated for the CF6-50 engine. Author

N78-10087*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
EVALUATION OF AN F100 MULTIVARIABLE CONTROL USING A REAL-TIME ENGINE SIMULATION
John R. Szuch, Charles Skira (AFSC), and James F. Soeder 1977 17 p refs Presented at 13th Propulsion Conf., Orlando, Fla., 11-13 Jul. 1977; sponsored by AIAA and Soc. of Automotive Engr.
(NASA-TM-X-73648; E-9155) Avail: NTIS HC A02/MF A01 CSCL 21E

A multivariable control design for the F100 turbofan engine was evaluated, as part of the F100 multivariable control synthesis (MVCS) program. The evaluation utilized a real-time, hybrid computer simulation of the engine and a digital computer implementation of the control. Significant results of the evaluation are presented and recommendations concerning future engine testing of the control are made. Author

N78-10088*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THE PROMISE OF EUTECTICS FOR AIRCRAFT TURBINES
Hugh R. Gray 1977 21 p refs Presented at Mater. Show and Conf., Chicago, 25-27 Oct. 1977, sponsored by ASM
(NASA-TM-73714; E-9258) Avail: NTIS HC A02/MF A01 CSCL 21E

The current status of the first generation eutectics, gamma/gamma transition - delta and NiTaC-13, is described in detail. Several second generation systems, such as gamma/gamma transition - alpha and NiTaC 3-116A, gamma - beta, and COTAC 74 are also reviewed with particular emphasis on their critical physical and mechanical properties, future research directions, and potential applications. Results of recent cost-benefit analyses of eutectic turbine blades are discussed. Author

N78-11063*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
AIRCRAFT ENGINE EMISSIONS
Oct. 1977 452 p Conf. held in Cleveland, 18-19 May 1977
(NASA-CP-2021; E-9262) Avail: NTIS HC A20/MF A01 CSCL 21E

A conference on aircraft engine emissions was held to present the results of recent and current work. Such diverse areas as components, controls, energy efficient engine designs, and noise and pollution reduction are discussed. For individual titles, see N78-11064 through N78-11080.

N78-11065*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EMISSIONS REDUCTION TECHNOLOGY PROGRAM
Robert E. Jones *In its* Aircraft Eng. Emissions Oct. 1977 p 19-58 (For availability see N78-11063 02-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Combustor concepts having the potential for significantly lower emissions levels were investigated. The combustor emissions reduction was measured in an engine test. Emission characteristics common to all engine classes are shown. Multiple-burning zone combustors, specifically the double annular and swirl-can combustors were studied. Airblast and air assist fuel injection techniques were evaluated for emissions control potential. The combustor screening and refining phases are summarized. Author

N78-11067*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
POLLUTION REDUCTION TECHNOLOGY PROGRAM FOR CLASS T4(JT8D) ENGINES
R. Roberts (Pratt and Whitney Aircraft Group, East Hartford, Conn.), A. J. Fiorentino (Pratt and Whitney Aircraft Group, East Hartford, Conn.), and L. A. Diehl *In its* Aircraft Eng. Emissions Oct. 1977 p 29-89 refs (For availability see N78-11063 02-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

The technology required to develop commercial gas turbine engines with reduced exhaust emissions was demonstrated. Can-annular combustor systems for the JT8D engine family (EPA class T4) were investigated. The JT8D turbofan engine is an axial-flow, dual-spool, moderate-bypass-ratio design. It has a two-stage fan, a four-stage low-pressure compressor driven by a three-stage low-pressure turbine, and a seven-stage high-pressure compressor driven by a single-stage high-pressure turbine. A cross section of the JT8D-17 showing the mechanical configuration is given. Key specifications for this engine are listed. Author

N78-11071*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUMMARY OF EMISSIONS REDUCTION TECHNOLOGY PROGRAMS
Richard W. Niedzwiecki *In its* Aircraft Eng. Emissions Oct. 1977 p 181-202 (For availability see N78-11063 02-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

The NASA emissions reduction contract programs for EPA aircraft engine classes P2 (turboshaft engines), T1 (jet engines with thrust under 8000 lb), T4 (JT8D) engines), and T2 (jet engines with thrust over 8000 lb) are discussed. The most important aspects of these programs, the commonality of approaches used, the test results, and assessments regarding applications of the derived technology are summarized. Author

N78-11072*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
EMISSIONS CONTROL FOR GROUND POWER GAS TURBINES
Richard A. Rudney, Richard J. Prem, Albert J. Juhasz, David N. Anderson, Theddeus S. Mroz, and Edward J. Mularz *In its* Aircraft Eng. Emissions Oct. 1977 p 203-242 refs (For availability see N78-11063 02-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

The similarities and differences of emissions reduction technology for aircraft and ground power gas turbines is described. The capability of this technology to reduce ground power emissions to meet existing and proposed emissions standards is presented and discussed. Those areas where the developing aircraft gas turbine technology may have direct application to ground power and those areas where the needed technology may be unique to the ground power mission are pointed out. Emissions reduction technology varying from simple combustor modifications to the use of advanced combustor concepts, such as catalysis is described and discussed. Author

N78-11073*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
GENERAL AVIATION PISTON-ENGINE EXHAUST EMISSION REDUCTION
Erwin E. Kempke, Jr., William H. Houtman (EPA, Washington, D. C.), William T. Westfield (FAA, Washington, D. C.), Larry C. Duke (AVCO Lycoming, Williamsport, Pa.), and Bernard J. Rezy (Teledyne Continental Motors, Los Angeles) *In its* Aircraft Eng. Emissions Oct. 1977 p 243-275 refs (For availability see N78-11063 02-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

To support the promulgation of aircraft regulations, two airports were examined, Van Nuys and Tamiami. It was determined that the carbon monoxide (CO) emissions from piston engine aircraft have a significant influence on the CO levels in the ambient air in and around airports where workers and travelers would be exposed. Emissions standards were set up for control of emissions from aircraft piston engines manufactured after December 31, 1979. The standards selected were based on a technologically feasible and economically reasonable control of carbon monoxide. It was concluded that substantial CO reductions could be realized if the range of typical fuel-air ratios could be narrowed. Thus, improvements in fuel management were determined as reasonable controls. Author

N78-11074*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ALTERNATIVE FUELS
Jack S. Grobman, Helmut F. Butze, Robert Friedman, Albert C. Antoine, and Thane W. Reynolds *In its* Aircraft Eng. Emissions Oct. 1977 p 277-308 refs (For availability see N78-11063 02-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Potential problems related to the use of alternative aviation turbine fuels are discussed and both ongoing and required research into these fuels is described. This discussion is limited to aviation turbine fuels composed of liquid hydrocarbons. The advantages and disadvantages of the various solutions to the problems are summarized. The first solution is to continue to develop the necessary technology at the refinery to produce specification jet fuels regardless of the crude source. The second solution is to minimize energy consumption at the refinery and keep fuel costs down by relaxing specifications. Author

N78-11076*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
GLOBAL ATMOSPHERIC SAMPLING PROGRAM
Erwin A. Lezberg, Porter J. Perkins, David R. Englund, Daniel J. Gauntner, and James D. Holdeman *In its* Aircraft Eng. Emissions Oct. 1977 p 323-355 refs (For availability see N78-11063 02-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

Automated instruments were installed on a commercial B-747 aircraft, during the program, to obtain baseline data and to monitor key atmospheric constituents associated with emissions of aircraft engines in order to determine if aircraft are contributing to pollution of the upper atmosphere. Data thus acquired on a global basis over the commercial air routes for 5 to 10 years will be analyzed. Ozone measurements in the 29,000 to 45,000 foot altitude were expanded over what has been available from ozonesondes. Limited aerosol composition measurements from filter samples show low levels of sulfates and nitrates in the upper troposphere. Recently installed instruments for measurement of carbon monoxide and condensation nuclei are beginning to return data. Author

N78-11077*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
STRATOSPHERIC CRUISE EMISSION REDUCTION PROGRAM
Larry A. Diehl, Gregory M. Reck, Cecil J. Marek, and Andrew J. Staniszlo *In its* Aircraft Eng. Emissions Oct. 1977 p 357-391 (For availability see N78-11063 02-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

A recently implemented NASA effort specifically aimed at reducing cruise oxides of nitrogen from high-altitude aircraft is discussed. The desired emission levels and the combustor technology required to achieve them are discussed. A brief overview of the SCERP operating plan is given. Lean premixed-prevaporized combustion and some of the potential difficulties that are associated with applying this technique to gas turbine combustors are examined. Base technology was developed in several key areas. These fundamental studies are viewed as a requirement for successful implementation of the lean premixed combustion technique. Author

N78-11078*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ADVANCED LOW-NO(x) COMBUSTORS FOR SUPERSONIC HIGH-ALTITUDE GAS TURBINES
Peter B. Roberts (International Harvester, Chicago) *In its* Aircraft Eng. Emissions Oct. 1977 p 393-415 ref (For availability see N78-11063 02-07)
Avail: NTIS HC A20/MF A01 CSCL 21E

The impact of gas-turbine-engine-powered aircraft on worldwide pollution was defined within two major areas of contribution. First, the contribution of aircraft to the local air pollution of metropolitan areas and, second, the long-term effects on the chemical balance of the stratosphere of pollutants emitted from future generations of high-altitude, supersonic commercial and military aircraft. Preliminary findings indicate that stratospheric oxides of nitrogen (NOx) emissions may have to be limited to very low levels if, for example, ozone depletion with concomitant increases in sea-level radiation, are to be avoided. Theoretical considerations suggest that (NOx) levels as low as 10 gram per kilogram of fuel and less should be attainable from an idealized premixed type of combustor. Experimental rig studies were intended to explore new combustor concepts designed to minimize the formation of (NOx) in aircraft gas turbines and to define their major operational problems and limitations. Author

N78-11098* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
EFFECT OF ENDWALL COOLING ON SECONDARY FLOWS IN TURBINE STATOR VANES
Louis J. Goldman and Kerry L. McLallin *In* AGARD Secondary Flows in Turbomachines Sep. 1977 29 p refs (For availability see N78-11083 02-07)
Avail: NTIS HC A14/MF A01 CSCL 21E

An experimental investigation was performed to determine the effect of endwall cooling on the secondary flow behavior and the aerodynamic performance of a coreturbine stator vane. The investigation was conducted in a cold-air, full-annular cascade, where three-dimensional effects could be obtained. Two endwall cooling configurations were tested. In the first configuration, the cooling holes were oriented so that the coolant was injected in line with the inviscid streamline direction. In the second configuration, the coolant was injected at an angle of 15 deg to the inviscid streamline direction and oriented toward the vane pressure surface. In both cases the stator vanes were solid and uncooled so that the effect of endwall cooling could be obtained directly. Total-pressure surveys were taken downstream of the stator vanes over a range of cooling flows at the design, mean-radius, critical velocity ratio of 0.778. Changes in the total-pressure contours downstream of the vanes were used to obtain the effect of endwall cooling on the secondary flows in the stator. Comparisons were made between the two cooled-endwall configurations and with the results obtained previously for solid endwalls. Author

N78-11106*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
ALTITUDE TEST OF SEVERAL AFTERBURNER CONFIGURATIONS ON A TURBOFAN ENGINE WITH A HYDROGEN HEATER TO SIMULATE AN ELEVATED TURBINE DISCHARGE TEMPERATURE
Roy L. Johnsen and Richard P. Cullom Nov. 1977 57 p refs (NASA-TP-1068, E-9207) Avail: NTIS HC A04/MF A01 CSCL 21E

A performance test of several experimental afterburner configurations was conducted with a mixed flow turbofan engine in an altitude facility. The simulated flight conditions were for Mach 1.4 at two altitudes, 12,190 and 14,630 meters. Turbine discharge temperatures of 889 and 1056 K were used. A production afterburner was tested for comparison. The research afterburners included partial forced mixers with V-gutter flameholders, a carbureted V-gutter flameholder, and a triple-ring V-gutter flameholder with four swirl-can fuel mixers. Fuel injection variations were included. Performance data shown include augmented thrust ratio, thrust specific fuel consumption, combustion efficiency, and total pressure drop across the afterburner. Author

N78-13066*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF FUEL PROPERTIES ON PERFORMANCE OF SINGLE AIRCRAFT TURBOJET COMBUSTOR AT SIMULATED IDLE, CRUISE, AND TAKEOFF CONDITIONS
Helmut F. Butze and Arthur L. Smith Sep. 1977 21 p refs (NASA-TM-73780; E-9336) Avail: NTIS HC A02/MF A01 CSCL 21E

The performance of a single-can JT8D combustor was investigated with a number of fuels exhibiting wide variations in chemical composition and volatility. Performance parameters investigated were combustion efficiency, emissions of CO, unburned hydrocarbons and nitrogen oxides, as well as liner temperatures and smoke. The most pronounced effects of changes in fuel composition were observed at simulated cruise and takeoff conditions where smoke and liner temperatures increased significantly as the hydrogen content of the fuel decreased. At the simulated idle condition, emissions of CO and unburned hydrocarbons increased slightly and, accordingly, combustion efficiencies decreased slightly as the hydrogen content of the fuels decreased. Author

N78-13080*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FLIGHT-EFFECTS ON PREDICTED FAN FLY-BY NOISE
Marcus F. Heidmann and Bruce J. Clark 1977 24 p refs Presented at 94th Meeting of the Acoustical Soc. of Am., Miami, Fla., 13-16 Dec. 1977
(NASA-TM-73798) Avail: NTIS HC A02/MF A01 CSCL 20A

The impact on PNLT (Perceived Noise Level, Tone corrected) and Fly-by EPNL (Effective Perceived Noise Level) when forward motion reduces the noise generated by the bypass fan of an aircraft engine was studied. Calculated noise spectra for a typical subsonic tip speed fan designed for blade passage frequency (BPF) tone cutoff were translated in frequency by systematically varying the BPF from 0.5 to 8 kHz. Two cases of predicted flight-effects on fan source noises were considered, reduced BPF tone level of 8 db and reduced broadband noise level of about 2 db in addition to reduced tone level. The maximum reduction in PNLT of the noise as emitted from the fan occurred when the BPF was at 4 kHz where the reductions were 7.4 and 10.0 db. The maximum reduction in EPNL of the noise as received during a 500-foot altitude fly-by occurred when the BPF was at 2.5 kHz where the reductions were 5.0 and 7.8 db. Author

N78-13081*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
AN EMPIRICAL MODEL FOR INVERTED-VELOCITY-PROFILE JET NOISE PREDICTION
James R. Stone 1977 30 p refs Presented at 94th Meeting of the Acoustical Soc. of Am., Miami, Fla., 13-16 Dec. 1977 (NASA-TM-73838, E-9425) Avail: NTIS HC A03/MF A01 CSCL 20A

An empirical model for predicting the noise from inverted-velocity-profile coaxial or coannular jets is presented and compared with small-scale static and simulated flight data. The model considered the combined contributions of as many as four uncorrelated constituent sources: the premerged-jet/ambient mixing region, the merged-jet/ambient mixing region, outer-stream shock/turbulence interaction, and inner-stream shock/turbulence interaction. The noise from the merged region occurs at relatively low frequency and is modeled as the contribution of a circular jet at merged conditions and total exhaust area, with the high frequencies attenuated. The noise from the premerged region occurs at high frequency and is modeled as the contribution of an equivalent plug nozzle at outer stream conditions, with the low frequencies attenuated. Author

N78-13082*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
AN OVERVIEW OF AEROSPACE GAS TURBINE TECHNOLOGY OF RELEVANCE TO THE DEVELOPMENT OF THE AUTOMOTIVE GAS TURBINE ENGINE
D. G. Evans and T. J. Miller 1978 52 p refs Presented at Ann. Meeting of the Soc. of Automotive Engineers, Detroit, Mich.,

27 Feb. - 3 Mar. 1978

(NASA-TM-73849) Avail: NTIS HC A04/MF A01 CSCL 21E

Technology areas related to gas turbine propulsion systems with potential for application to the automotive gas turbine engine are discussed. Areas included are: system steady-state and transient performance prediction techniques, compressor and turbine design and performance prediction programs and effects of geometry, combustor technology and advanced concepts, and ceramic coatings and materials technology. Author

N78-13063*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MECHANICAL CHARACTERISTICS OF STABILITY-BLEED VALVES FOR A SUPERSONIC INLET

George H. Neiner, Miles O. Dustin, and Gary L. Cole Washington Dec. 1977 39 p refs

(NASA-TM-X-3483; E-8852) Avail: NTIS HC A03/MF A01 CSCL 21E

Mechanical characteristics of a set of direct-operated relief valves used in a throat-bypass stability-bleed system designed for the YF-12 aircraft inlet are described. A comparison of data taken before and after the windtunnel tests (at room temperature) showed that both the effective spring rate and the piston friction had decreased during the wind tunnel tests. In neither the effective spring rate nor the piston friction was the magnitude of change great enough to cause significant impairment of overall system effectiveness. No major valve mechanical problems were encountered in any of the tests. During high temperature bench tests, piston frictional drag increased. The friction returned to its initial room temperature value when the stability-bleed valve was disassembled and reassembled. The problem might be solved by using a different material for the piston sleeve bearing and the piston rings. Author

N78-13064*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INFLUENCE OF OIL SQUEEZE-FILM DAMPING ON STEADY-STATE RESPONSE OF FLEXIBLE ROTOR OPERATING TO SUPERCRITICAL SPEEDS

Robert E. Cunningham Dec. 1977 44 p refs

(NASA-TP-1094; E-9091) Avail: NTIS HC A03/MF A01 CSCL 21E

Experimental data were obtained for the unbalance response of a flexible rotor to speeds above the third lateral bending critical. Squeeze-film damping coefficients calculated from measured data showed good agreement with short-journal-bearing approximations over a frequency range from 5000 to 31,000 cpm. Response of a rotor to varying amounts of unbalance was investigated. A very lightly damped rotor was compared with one where oil-squeeze dampers were applied. Author

N78-15042*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRELIMINARY QCSEE PROGRAM TEST RESULTS

Carl C. Ciepluch 1977 22 p refs Presented at 1977 Aerospace Meeting, Los Angeles, 14-17 Nov. 1977; sponsored by SAE

(NASA-TM-73732) Avail: NTIS HC A02/MF A01 CSCL 21E

The QCSEE (Quiet, Clean, Short-Haul Experimental Engine) program has entered the engine test phase. Overall design and advanced technology incorporated into the two engines in the program were described. In addition, preliminary engine test results are presented and compared to the technical requirements the engines were designed to meet. Author

N78-15043*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPUTER PROGRAMS FOR CALCULATION OF A GAS TEMPERATURE PROFILE BY INFRARED EMISSION: ABSORPTION SPECTROSCOPY

Donald R. Buchele Dec. 1977 85 p refs

(NASA-TM-73848; E-9436) Avail: NTIS HC A05/MF A01 CSCL 21E

A computer program to calculate the temperature profile of a flame or hot gas was presented in detail. Emphasis was on profiles found in jet engine or rocket engine exhaust streams containing H2O or CO2 radiating gases. The temperature profile was assumed axisymmetric with an assumed functional form controlled by two variable parameters. The parameters were calculated using measurements of gas radiation at two wavelengths in the infrared. The program also gave some information on the pressure profile. A method of selection of wavelengths was given that is likely to lead to an accurate determination of the parameters. The program is written in FORTRAN 4 language and runs in less than 60 seconds on a Univac 1100 computer. Author

N78-15044*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TEMPERATURE DISTRIBUTIONS AND THERMAL STRESSES IN A GRADED ZIRCONIA/METAL GAS PATH SEAL SYSTEM FOR AIRCRAFT GAS TURBINE ENGINES

Christopher M. Taylor (Leeds Univ.) and Robert C. Bill (Army R and T Labs., Cleveland) 1978 19 p refs Presented at the Conf. on Air-Breathing Propulsion Systems, Huntsville, Ala., 16-18 Jan. 1978; sponsored by AIAA

(NASA-TM-73818) Avail: NTIS HC A02/MF A01 CSCL 21E

A ceramic/metallic aircraft gas turbine outer gas path seal designed for improved engine performance was studied. Transient temperature and stress profiles in a test seal geometry were determined by numerical analysis. During a simulated engine deceleration cycle from sea-level takeoff to idle conditions, the maximum seal temperature occurred below the seal surface, therefore the top layer of the seal was probably subjected to tensile stresses exceeding the modulus of rupture. In the stress analysis both two- and three-dimensional finite element computer programs were used. Predicted trends of the simpler and more easily usable two-dimensional element programs were borne out by the three-dimensional finite element program results. Author

N78-15045*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A COMPUTER PROGRAM FOR THE TRANSIENT THERMAL ANALYSIS OF AN IMPINGEMENT COOLED TURBINE BLADE

Raymond E. Gaugler 1978 10 p refs Presented at Aerospace Sci. Meeting, Huntsville, Ala., 16-18 Jan. 1978; sponsored by AIAA

(NASA-TM-73819) Avail: NTIS HC A02/MF A01 CSCL 21E

A computer program to calculate transient and steady state temperatures, pressures, and coolant flows in a cooled turbine blade or vane with an impingement insert is described. Input to the program includes a description of the blade geometry, coolant supply conditions, outside thermal boundary conditions and wheel speed. Coolant-side heat transfer coefficients are calculated internally in the program, with the user specifying the mode of heat transfer at each internal flow station. Program output includes the temperature at each node, the coolant pressures and flow rates, and the inside heat transfer coefficients. A sample problem is discussed. Author

N78-16063*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COLD-AIR PERFORMANCE OF FREE-POWER TURBINE DESIGNED FOR 112-KILOWATT AUTOMOTIVE GAS-TURBINE ENGINE. 1: DESIGN STATOR-VANE-CHORD SETTING ANGLE OF 35 DEG

Milton G. Kofskey and William J. Nusbaum Jan. 1978 23 p refs

(NASA-TP-1007 CONS/1011-12, E-8964) Avail: NTIS HC A02/MF A01 CSCL 21E

A cold air experimental investigation of a free power turbine designed for a 112-kW automotive gas turbine was made over a range of speeds from 0 to 130 percent of design equivalent speeds and over a range of pressure ratio from 1.11 to 2.45. Results are presented in terms of equivalent power, torque, mass flow, and efficiency for the design power point setting of the variable stator. Author

N78-18065*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
A REVIEW OF NASA'S PROPULSION PROGRAMS FOR AVIATION
Warner L. Stewart, Harry W. Johnson, and Richard J. Weber 1978 21 p refs Presented at the 16th Aerospace Sci. Meeting, Huntsville, Ala., 16-18 Jan., sponsored by AIAA
(NASA-TM-73831) Avail: NTIS HC A02/MF A01 CSCL 21A

A review of five NASA engine-oriented propulsion programs of major importance to civil aviation are presented and discussed. Included are programs directed at exploring propulsion system concepts for (1) energy conservation subsonic aircraft (improved current turbofans, advanced turbofans, and advanced turboprops); (2) supersonic cruise aircraft (variable cycle engines); (3) general aviation aircraft (improved reciprocating engines and small gas turbines); (4) powered lift aircraft (advanced turbofans); and (5) advanced rotorcraft. Author

N78-17066* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
VARIABLE THRUST NOZZLE FOR QUIET TURBOFAN ENGINE AND METHOD OF OPERATING SAME Patent
Arthur P. Adamson, inventor (to NASA) (GE, Cincinnati, Ohio) Issued 17 Jan. 1978 7 p Filed 29 May 1975 Sponsored by NASA
(NASA-Case-LEW-12317-1; US-Patent-4,068,469; US-Patent-Appl-SN-581750; US-Patent-Class-60-204; US-Patent-Class-60-226R; US-Patent-Class-60-271) Avail: US Patent Office CSCL 21E

An improved method of operating a gas turbine engine is presented wherein engine-generated noise is maintained at a reduced level during reduced thrust operation. Fan speed was maintained at a constant level while fan nozzle area was increased. This maintained high inlet Mach numbers for reduced forward noise propagation and also permited reduced nozzle exhaust velocity for reduced shear noise. In another embodiment, airflow was increased by means of a fan blade pitch change or speed increase while the fan nozzle area was increased, yielding both a net reduction in engine thrust and noise.
Official Gazette of the U.S. Patent Office

N78-17068* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
GAS TURBINE ENGINE WITH CONVERTIBLE ACCESSORIES Patent
Donald F. Sargisson (GE, Cincinnati, Ohio) and Arthur P. Adamson, inventors (to NASA) Issued 17 Jan. 1978 6 p Filed 8 Nov. 1974 Sponsored by NASA
(NASA-Case-LEW-12390-1; US-Patent-4,068,470; US-Patent-Appl-SN-522109; US-Patent-Class-60-226R; US-Patent-Class-74-385; US-Patent-Class-74-417) Avail: US Patent Office CSCL 21E

Drive means for connecting a gas turbine engine to its accessories are so constructed as to allow the accessories to be selectively positioned to any one of several predetermined circumferential positions about the perimeter of the engine. This feature permits convenient mounting of the same engine upon vehicles demanding radically different engine mounting arrangements. Official Gazette of the U.S. Patent Office

N78-17069*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
CERAMICS IN GAS TURBINE: POWDER AND PROCESS CHARACTERIZATION
Sunil Dutta 1977 16 p refs Presented at the Conf. on Composites and Advanced Materials, Cocoa Beach, Fla., 17-19 Jan. 1977; Sponsored by Am. Ceramic Soc.
(NASA-TM-73875; E-9475) Avail: NTIS HC A02/MF A01 CSCL 21E

Some of the intrinsic properties of various forms of Si_3N_4 and SiC are listed and limitations of such materials' availability are pointed out. The essential features/parameters to characterize a batch of powder are discussed including the standard techniques for such characterization. In process characterization, parameters in sintering, reaction sintering, and hot pressing processes are discussed including the factors responsible for strength limitations in ceramic bodies. Significant improvements in material properties can be achieved by reducing or eliminating the strength limiting factors with consistent powder and process characterization along with process control. Author

N78-17070*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
GENERAL AVIATION ENERGY-CONSERVATION RESEARCH PROGRAMS AT NASA-LEWIS RESEARCH CENTER
Edward A. Willis 1977 26 p refs Presented at the Conf. on Energy Conserv. in Gen. Aviation, Kalamazoo, Mich., 10 - 11 Oct. 1977; sponsored by Western Michigan Univ.
(NASA-TM-73884) Avail: NTIS HC A03/MF A01 CSCL 21E

The major thrust of NASA's nonturbine general aviation engine programs is directed toward (1) reduced specific fuel consumption, (2) improved fuel tolerance, and (3) emission reduction. Current and planned future programs in such areas as lean operation, improved fuel management, advanced cooling techniques and advanced engine concepts, are described. These are expected to lay the technology base, by the mid to latter 1980's, for engines whose total fuel costs are as much as 30% lower than today's conventional engines. Author

N78-18066* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
INTEGRATED GAS TURBINE ENGINE-NACELLE Patent
Arthur P. Adamson, Donald F. Sargisson, and Charles L. Stotler, Jr., inventors (to NASA) Issued 25 Oct. 1977 9 p Filed 3 Nov. 1975 Division of US Patent Appl. SN-522108, filed 8 Nov. 1974
(NASA-Case-LEW-12389-2; US-Patent-4,055,041; US-Patent-Appl-SN-628221; US-Patent-Class-60-226R; US-Patent-Class-60-39.31; US-Patent-Class-244-53A; US-Patent-Class-244-54) Avail: US Patent Office CSCL 21E

A nacelle for use with a gas turbine engine is presented. An integral webbed structure resembling a spoked wheel for rigidly interconnecting the nacelle and engine, provides lightweight support. The inner surface of the nacelle defines the outer limits of the engine motive fluid flow annulus while the outer surface of the nacelle defines a streamlined envelope for the engine.
Official Gazette of the U.S. Patent Office

N78-18067* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
VARIABLE MIXER PROPULSION CYCLE Patent
Dan Joseph Rundell (GE, Cleveland), Donald Patrick McHugh (GE, Cleveland), Tom Foster (GE, Cleveland), and Ralph Harold Brown, inventors (to NASA) (GE, Cleveland) Issued 24 Jan. 1978 10 p Filed 2 Jun. 1975 Sponsored by NASA
(NASA-Case-LEW-12917-1; US-Patent-4,069,661; US-Patent-Appl-SN-583055; US-Patent-Class-60-204; US-Patent-Class-60-262) Avail: US Patent Office CSCL 21E

A design technique, method and apparatus are delineated for controlling the bypass gas stream pressure and varying the bypass ratio of a mixed flow gas turbine engine in order to achieve improved performance. The disclosed embodiments each include a mixing device for combining the core and bypass gas streams. The variable area mixing device permits the static pressures of the core and bypass streams to be balanced prior to mixing at widely varying bypass stream pressure levels. The mixed flow gas turbine engine therefore operates efficiently over a wide range of bypass ratios and the dynamic pressure of the bypass stream is maintained at a level which will keep the engine inlet airflow matched to an optimum design level throughout a wide range of engine thrust settings.
Official Gazette of the U.S. Patent Office

N78-19157*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PREDICTED INLET GAS TEMPERATURES FOR TUNGSTEN FIBER REINFORCED SUPERALLOY TURBINE BLADES
Edward A. Winsa, Leonard J. Westfall, and Donald W. Petrasek 1978 23 p refs Presented at 2d Intern. Conf. on Composite Materials, Toronto, Canada, 16-20 Apr. 1978; sponsored by Am. Inst. of Mining, Metallurgical, and Petroleum Engineers
(NASA-TM-73842) Avail: NTIS HC A02/MF A01 CSCL 21E

Tungsten fiber reinforced superalloy composite (TFRS) impingement cooled turbine blade inlet gas temperatures were calculated taking into account material spanwise strength, thermal conductivity, material oxidation resistance, fiber-matrix interaction, and coolant flow. Measured values of TFRS thermal conductivities are presented. Calculations indicate that blades made of 30 volume percent fiber content TFRS having a 12,000 N-m/kg stress-to-density ratio while operating at 40 atmospheres and a 0.06 coolant flow ratio could permit a turbine blade inlet gas temperature of over 1900K. This is more than 150K greater than similar superalloy blades. Author

N78-19158*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH TEMPERATURE ENVIRONMENTAL EFFECTS ON METALS
S. J. Grisaffe, C. E. Lowell, and C. A. Stearns 1977 19 p refs Presented at 24th Sagamore Army Materials Res. Conf. Risk and Failure Analysis for Reliability, Bolton Landing, N. Y., 22-26 Aug. 1977
(NASA-TM-73878) Avail: NTIS HC A02/MF A01 CSCL 21E

The gas turbine engine was used as an example to predict high temperature environmental attack on metals. Environmental attack in a gas turbine engine derives from high temperature, combustion products of the air and fuel burned, and impurities. Of all the modes of attack associated with impurity effects, hot corrosion was the most complicated mechanistically. Solutions to the hot corrosion problem were sought semi-empirically in: (1) improved alloys or ceramics; (2) protective surface coating; (3) use of additives to the engine environment; and (4) air/fuel cleanup to eliminate harmful impurities. J.C.S.

N78-19161*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL DETERMINATION OF TRANSIENT STRAIN IN A THERMALLY-CYCLED SIMULATED TURBINE BLADE UTILIZING A NON-CONTACT TECHNIQUE
Frederick D. Calfo and Peter T. Bizon Jan. 1978 31 p refs
(NASA-TM-73886; E-9500) Avail: NTIS HC A03/MF A01 CSCL 21E

A type of noncontacting electro-optical extensometer was used to measure the displacement between parallel targets mounted on the leading edge of a simulated turbine blade throughout a complete heating and cooling cycle. The blade was cyclically heated and cooled by moving it into and out of a Mach 1 hot gas stream. The principle of operation and measurement procedure of the electro-optics extensometer are described. Author

N78-20130*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TWO-DIMENSIONAL COLD-AIR CASCADE STUDY OF A FILM-COOLED TURBINE STATOR BLADE. 4: COMPARISON OF EXPERIMENTAL AND ANALYTICAL AERODYNAMIC RESULTS FOR BLADE WITH 12 ROWS OF 0.076-CENTIMETER-(0.030-INCH-) DIAMETER HOLES HAVING STREAMWISE EJECTION ANGLES
Herman W. Prust, Jr. Mar. 1978 30 p refs
(NASA-TP-1151; E-9187) Avail: NTIS HC A03/MF A01 CSCL 21E

Previously published experimental aerodynamic efficiency results for a film cooled turbine stator blade are compared with analytical results computed from two published analytical methods. One method was used as published; the other was modified for certain cases of coolant discharge from the blade suction surface. For coolant ejection from blade surface regions where the surface static pressures are higher than the blade exit pressure, both methods predict the experimental results quite well. However, for ejection from regions with surface static pressures lower than the blade exit pressure, both methods predict too small a change in efficiency. The modified method gives the better prediction. Author

N78-20131*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE OF A SHORT ANNULAR DUMP DIFFUSER USING SUCTION-STABILIZED VORTICES AT INLET MACH NUMBERS TO 0.41
John M. Smith and Albert J. Juhasz Apr. 1978 40 p refs
(NASA-TP-1194; E-9332) Avail: NTIS HC A03/MF A01 CSCL 21E

A short, annular dump diffuser was designed to use suction to establish stabilized vortices on both walls for improved flow expansion in the region of an abrupt area change. The diffuser was tested at near ambient inlet pressure and temperature. The overall diffuser area ratio was 4.0. The inlet height was 2.54 cm and the exit pitot-static rakes were located at a distance from the vortex fence equal to two or six times the inlet height. Performance data were taken at near ambient temperature and pressure for nominal inlet Mach numbers of 0.18 to 0.41 with suction rates of 0 to 18 percent of the total inlet airflow. The exit velocity profile could be shifted toward either wall by adjusting the inner- or outer-wall suction rate. Symmetrical exit velocity profiles were unstable, with a tendency to shift back to hub- or tip-weighted profile. Diffuser effectiveness was increased from about 47 percent without suction to over 85 percent at a total suction rate of about 14 percent. The diffuser total pressure losses at inlet Mach numbers of 0.18 and 0.41 decreased from 1.1 and 5.6 percent without suction to 0.48 and 5.2 percent at total suction rates of 14.4 and 5.6 percent, respectively. Author

N78-20132*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SIMULATED FLIGHT EFFECTS ON NOISE CHARACTERISTICS OF A FAN INLET WITH HIGH THROAT MACH NUMBER
Howard L. Wesoky, Donald A. Dietrich, and John M. Abbott Apr. 1978 45 p refs
(NASA-TP-1199; E-9253) Avail: NTIS HC A03/MF A01 CSCL 21E

An anechoic wind tunnel experiment was conducted to determine the effects of simulated flight on the noise characteristics of a high throat Mach number fan inlet. Comparisons were made with the performance of a conventional low throat Mach number inlet with the same 50.8 cm fan noise source. Simulated forward velocity of 41 m/sec reduced perceived noise levels for both inlets, the largest effect being more than 3 db for the high throat Mach number inlet. The high throat Mach number inlet was as much as 7.5 db quieter than the low throat Mach number inlet with tunnel airflow and about 6 db quieter without tunnel airflow. Effects of inlet flow angles up to 30 deg were seemingly irregular and difficult to characterize because of the complex flow fields and generally small noise variations. Some modifications of tones and directivity at blade passage harmonics resulting from inlet flow angle variation were noted. Author

N78-20133*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TWO-DIMENSIONAL COLD-AIR CASCADE STUDY OF A FILM-COOLED TURBINE STATOR BLADE. 5: COMPARISON OF EXPERIMENTAL AND ANALYTICAL AERODYNAMIC RESULTS FOR BLADE WITH 12 ROWS OF 0.038-CENTIMETER-(0.015 INCH) DIAMETER COOLANT HOLES HAVING STREAMWISE EJECTION ANGLES
Herman W. Prust, Jr. Apr. 1978 23 p refs
(NASA-TP-1204; E-9342) Avail: NTIS HC A02/MF A01 CSCL 21E

Published experimental aerodynamic efficiency results were compared with results predicted from two published analytical methods. This is the second of two such comparisons. One of the analytical methods was used as published; the other was

modified for certain cases of coolant discharge from the blade suction surface. The results show that for 23 cases of single row and multirow discharge covering coolant fractions from 0 to about 9 percent, the difference between the experimental and predicted results was no greater than about 1 percent in any case and less than 1/2 percent in most cases. Author

N78-21109*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPARISON OF THE NOISE CHARACTERISTICS OF TWO LOW PRESSURE RATIO FANS WITH A HIGH THROAT MACH NUMBER INLET

Howard L. Wesoky, John M. Abbott, and Donald A. Dietrich Jan. 1978 31 p refs

(NASA-TM-73880; E-9489) Avail: NTIS HC A03/MF A01 CSCL 21E

Acoustics data obtained in experiments with two low pressure ratio 50.8 cm (20 in.) diameter model fans differing in design tip speed were compared. Determination of the average throat Mach number used to compare high Mach inlet noise reduction characteristics was based on a correlation of inlet wall static pressure measurements with a flow field calculation. The largest noise reductions were generally obtained with the higher tip speed fan. At a throat Mach number of 0.79, the difference in noise reduction was about 3.5 db with static test conditions. Although the noise reduction increased for the lower tip speed fan with a simulated flight velocity of 41 m/sec (80 knots), it was still about 2 db less than that of the high tip speed fan which was only tested at the static condition. However, variations in acoustic performance could not be absolutely attributed to the different fan designs because of differences in inlet lip contours which resulted in small variations of peak wall Mach number and axial extent of supersonic and near-sonic flow. Author

N78-21108*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

GAS PATH SEALING IN TURBINE ENGINES

Lawrence P. Ludwig 1978 44 p refs Presented at AGARD Power, Energetics, and Propulsion Panel Meeting on Seal Technol. in Gas Turbine Engines, London, 6-7 Apr. 1978

(NASA-TM-73890; E-9505) Avail: NTIS HC A03/MF A01 CSCL 21E

A survey of gas path seals is presented with particular attention given to sealing clearance effects on engine component efficiency. The effects on compressor pressure ratio and stall margin are pointed out. Various case-rotor relative displacements, which affect gas path seal clearances, are identified. Forces produced by nonuniform sealing clearances and their effect on rotor stability are discussed qualitatively, and recent work on turbine-blade-tip sealing for high temperature is described. The need for active clearance control and for engine structural analysis is discussed. The functions of the internal-flow system and its seals are reviewed. Author

N78-21110*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PHOTOGRAPHIC CHARACTERIZATION OF SPARK-IGNITION ENGINE FUEL INJECTORS

Peggy L. Evanich Feb. 1978 27 p refs

(NASA-TM-78830; E-9535) Avail: NTIS HC A03/MF A01 CSCL 21E

Manifold port fuel injectors suitable for use in general aviation spark-ignition engines were evaluated qualitatively on the basis of fuel spray characteristics. Photographs were taken at various fuel flow rates or pressure levels. Mechanically and electronically operated pintle injectors generally produced the most atomization. The plain-orifice injectors used on most fuel-injected general aviation engines did not atomize the fuel when sprayed into quiescent air. Author

N78-21112*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AIRFLOW AND THRUST CALIBRATION OF AN F100 ENGINE, S/N P680059, AT SELECTED FLIGHT CONDITIONS

Thomas J. Biesiadny, Douglas Lee, and Jose R. Rodriguez Apr. 1978 27 p refs

(NASA-TP-1069; E-9257) Avail: NTIS HC A03/MF A01 CSCL 21E

An airflow and thrust calibration of an F100 engine, S/N P680059, was conducted to study airframe propulsion system integration losses in turbofan-powered high-performance aircraft. The tests were conducted with and without thrust augmentation for a variety of simulated flight conditions with emphasis on the transonic regime. The resulting corrected airflow data generalized into one curve with corrected fan speed while corrected gross thrust increased as simulated flight conditions increased. Overall agreement between measured data and computed results was 1 percent for corrected airflow and -1 1/2 percent for gross thrust. The results of an uncertainty analysis are presented for both parameters at each simulated flight condition. Author

N78-21114*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THEORETICAL FLOW CHARACTERISTICS OF INLETS FOR TILTING-NACELLE VTOL AIRCRAFT

Michael A. Boles, Rogers W. Luidens, and Norbert O. Stockman Apr. 1978 31 p refs

(NASA-TP-1205; E-9387) Avail: NTIS HC A03/MF A01 CSCL 21E

The results of a theoretical investigation of geometric variables for lift-cruise-fan, tilting nacelle inlets operating at high incidence angles are presented. These geometric variables are investigated for their effects on surface static to free stream pressure ratio, and the separation parameters of maximum to diffuser exit surface velocity ratio and maximum surface Mach number for low speed operating conditions. The geometric parameters varied were the internal lip contraction ratio, external forebody to diffuser exit diameter ratio external forebody length to diameter ratio and internal lip major to minor axis ratio. Author

N78-21122*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PROGRESS IN ADVANCED HIGH TEMPERATURE TURBINE MATERIALS, COATINGS, AND TECHNOLOGY

John C. Freche and G. Marvin Ault *In* AGARD High Temp. Probl. in Gas Turbine Eng. Feb. 1978 31 p refs (For availability see N78-21118 12-07)

Avail: NTIS HC A25/MF A01 CSCL 21E

Advanced materials, coatings, and cooling technology is assessed in terms of improved aircraft turbine engine performance. High cycle operating temperatures, lighter structural components, and adequate resistance to the various environmental factors associated with aircraft gas turbine engines are among the factors considered. Emphasis is placed on progress in development of high temperature materials for coating protection against oxidation, hot corrosion and erosion, and in turbine cooling technology. Specific topics discussed include metal matrix composites, superalloys, directionally solidified eutectics, and ceramics.J.M.S

N78-22087*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

IMPACT BEHAVIOR OF FILAMENT WOUND GRAPHITE/EPOXY FAN BLADES

Kenneth J. Bowles 1978 19 p refs Presented at the 23d Natl. SAMPE Symp. and Exhibition, Anaheim, Calif., 2-4 May 1978

(NASA-TM-78845; E-9562) Avail: NTIS HC A02/MF A01 CSCL 21E

The fabrication and impact tests of graphite/epoxy filament wound fan blades are discussed. Blades which were spin tested at tip speeds up to 305 meters per second retained their structural integrity. Two blades were each impacted with a 454 gram slice of a 908 gram simulated bird at a tip speed of 263 meters

per second and impact angles of 22 and 32 deg. The impact tests were recorded with high-speed movie film. The blade which was impacted at 22 deg sustained some root delamination but remained intact. The 32 deg impact separated the blade from the root. No local damage other than leading edge debonding was observed for either blade. Results of a failure mode analysis are also discussed. Author

N78-22098*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REDUCTION OF AIRCRAFT GAS TURBINE ENGINE POLLUTANT EMISSIONS Status Report
Larry A. Diehl 1978 17 p refs Proposed for presentation at 71st Ann. Meeting of the Air Pollution Control Assoc., Houston, Tex., 26-30 Jun. 1978
(NASA-TM-78870; E-9601) Avail: NTIS HC A02/MF A01 CSCL 21E

To accomplish simultaneous reduction of unburned hydrocarbons, carbon monoxide, and oxides of nitrogen, required major modifications to the combustor. The modification most commonly used was a staged combustion technique. While these designs are more complicated than production combustors, no insurmountable operational difficulties were encountered in either high pressure rig or engine tests which could not be resolved with additional normal development. The emission reduction results indicate that reductions in unburned hydrocarbons were sufficient to satisfy both near and far-termed EPA requirements. Although substantial reductions were observed, the success in achieving the CO and NOx standards was mixed and depended heavily on the engine/engine cycle on which it was employed. Technology for near term CO reduction was satisfactory or marginally satisfactory. Considerable doubt exists if this technology will satisfy all far-term requirements. Author

N78-22093*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LEAN COMBUSTION LIMITS OF A CONFINED PREMIXED-PREVAPORIZED PROPANE JET
Kenneth L. Huck and Cecil J. Marek Apr. 1978 23 p refs
(NASA-TM-78868; E-9453) Avail: NTIS HC A02/MF A01 CSCL 21B

Lean blowout limits were reported for a premixed prevaporized propane jet issuing into a cylindrical combustor. A single hole in a flat plate was used as a flameholder. Flameholders with various hole diameters were used. Jet velocities were varied from 3 to 290 meters per second. The combustor cross sectional area was changed by using different quartz liners of 12.7 and 22.2 millimeters diameters. As a result the combustor Reynolds number varied from 1000 to 9000. Stability was achieved at laminar as well as turbulent conditions. Three zones of flame stability were observed. The blowout equivalence ratio varied with step size and the combustor and jet Reynolds numbers. The combustor inlet mixture temperature was 395 K, and the combustor pressure was 1 atmosphere. Author

N78-22101*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IN-PLACE RECALIBRATION TECHNIQUE APPLIED TO A CAPACITANCE-TYPE SYSTEM FOR MEASURING ROTOR BLADE TIP CLEARANCE
John P. Barranger Apr. 1978 35 p refs
(NASA-TP-1110; E-9395) Avail: NTIS HC A03/MF A01 CSCL 20E

The rotor blade tip clearance measurement system consists of a capacitance sensing probe with self contained tuning elements, a connecting coaxial cable, and remotely located electronics. Tests show that the accuracy of the system suffers from a strong dependence on probe tip temperature and humidity. A novel inplace recalibration technique was presented which partly overcomes this problem through a simple modification of the electronics that permits a scale factor correction. This technique, when applied to a commercial system significantly reduced errors under varying conditions of humidity and temperature. Equations were also found that characterize the important cable and probe design quantities. Author

N78-23022*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NORMAL SHOCK AND RESTART CONTROLS FOR A SUPERSONIC AIRBREATHING PROPULSION SYSTEM
George H. Neiner, Gary L. Cole, and Francis J. Paulovich *In* NASA, Washington Fourth Inter-Center Control Systems Conf. Jan. 1978 p 299-321 refs (For availability see N78-23010 13-99)
Avail: NTIS HC A22/MF A01 CSCL 21E

N78-23024*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OPTIMAL CONTROL OF A SUPERSONIC INLET TO MINIMIZE FREQUENCY OF INLET UNSTART
Bruce Lehtinen, John R. Zeller, and Lucille C. Geyser *In* NASA, Washington Fourth Inter-Center Control Systems Conf. Jan. 1978 p 323-335 refs (For availability see N78-23010 13-99)
Avail: NTIS HC A22/MF A01 CSCL 21E

N78-23068*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
SUPERSONIC THROUGH-FLOW FAN ENGINES FOR SUPERSONIC CRUISE AIRCRAFT
Leo C. Franciscus Apr. 1978 53 p refs
(NASA-TM-78889; E-9626) Avail: NTIS HC A04/MF A01 CSCL 21E

Engine performance, weight and mission studies were carried out for supersonic through flow fan engine concepts. The mission used was a Mach 2.32 cruise mission. The advantages of supersonic through flow fan engines were evaluated in terms of mission range comparisons between the supersonic through flow fan engines and a more conventional turbofan engine. The specific fuel consumption of the supersonic through flow fan engines was 12 percent lower than the more conventional turbofan. The aircraft mission range was increased by 20 percent with the supersonic fan engines compared to the conventional turbofan. Author

N78-23095*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ALTITUDE CALIBRATION OF AN F100, S/N P680063, TURBOFAN ENGINE
Thomas J. Biesiadny, Douglas Lee, and Jose R. Rodriguez May 1978 23 p refs
(NASA-TP-1228; E-9355) Avail: NTIS HC A02/MF A01 CSCL 21E

An airflow and thrust calibration of an F100 engine was conducted in coordination with a flight test program to study airframe-propulsion system integration characteristics of turbofan-powered high-performance aircraft. The tests were conducted with and without augmentation for a variety of simulated flight conditions with emphasis on the transonic regime. Test results for all conditions are presented in terms of corrected airflow and corrected gross thrust as functions of corrected fan speed for nonaugmented power and an augmented thrust ratio as a function of fuel-air ratio for augmented power. Comparisons of measured and predicted data are presented along with the results of an uncertainty analysis for both corrected airflow and gross thrust. Author

N78-25069* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
GAS TURBINE ENGINE WITH RECIRCULATING BLEED Patent
Arthur P. Adamson, inventor (to NASA) (GE, Cincinnati, Ohio) Issued 11 Apr. 1978 5 p Filed 14 Jun. 1976 Sponsored by NASA
(NASA-Case-LEW-12452-1; US-Patent-4,083,181; US-Patent-Appl-SN-695513; US-Patent-Class-60-39.52; US-Patent-Class-60-226R) Avail: US Patent Office CSCL 21E

Carbon monoxide and unburned hydrocarbon emissions in a gas turbine engine are reduced by bleeding hot air from the

engine cycle and introducing it back into the engine upstream of the bleed location and upstream of the combustor inlet. As this hot inlet air is recycled, the combustor inlet temperature rises rapidly at a constant engine thrust level. In most combustors, this will reduce carbon monoxide and unburned hydrocarbon emissions significantly. The preferred locations for hot air extraction are at the compressor discharge or from within the turbine, whereas the preferred reentry location is at the compressor inlet. Official Gazette of the U.S. Patent Office

N78-26080* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COUNTER PUMPING DEBRIS EXCLUDER AND SEPARATOR Patent

Lawrence P. Ludwig, inventor (to NASA) Issued 18 Apr. 1978 5 p Filed 31 Mar. 1976 Supersedes N76-20487 (14 - 11, p 1394)

(NASA-Case-LEW-11855-1; US-Patent-4,084,825; US-Patent-Appl-SN-672222; US-Patent-Class-277-25; US-Patent-Class-277-134) Avail: US Patent Office CSCL 21E

A dirt separator and excluder for removing entrained debris from gas turbine shaft seals is described. A helical groove pattern is constructed on the rotating shaft with the pumping pattern such that it tends to pump seal pressurizing gas toward the gas turbine seal. A second helical groove pattern is provided on the stationary housing or counter rotating member coaxial with the shaft, and this pattern is designed to provide pumping in the direction opposite from that of the groove pattern on the shaft. Gas with entrained debris entering this grooved area will be subjected to high centrifugal forces due to the swirl motion induced by the groove pattern and the rotation of the shaft. This debris is centrifuged outwardly into the outer groove pattern on the housing or counter rotating member. Because the outer groove pattern has a pumping direction opposite from that of the seal, dirt is pumped away from the seal and can be collected in a suitable debris trap remote from the seal location.

Official Gazette of the U.S. Patent Office

N78-26143*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMBUSTOR CONCEPTS FOR AIRCRAFT GAS TURBINE LOW-POWER EMISSIONS REDUCTION

E. J. Mularz, C. C. Gleason (G.E. Co., Evandale, Ohio), and W. J. Dodds (G.E. Co., Evandale, Ohio) Jul. 1978 20 p refs Presented at the 14th Propulsion Conf., Las Vegas, Nev., 25-27 Jul. 1978; co-sponsored by the AIAA and the Soc. of Automotive Engr.

(NASA-TM-78875; AVRADCOM-TR-78-23(PL); AIAA-Paper-78-999) Avail: NTIS HC A02/MF A01 CSCL 20E

Several combustor concepts were designed and tested to demonstrate significant reductions in aircraft engine idle pollutant emissions. Each concept used a different approach for pollutant reductions: the hot wall combustor employs a thermal barrier coating and impingement cooled liners; the recuperative cooling combustor preheats the air before entering the combustion chamber; and the catalytic convorter combustor is composed of a conventional primary zone followed by a catalytic bed for pollutant cleanup. The designs are discussed in detail and test results are presented for a range of aircraft engine idle conditions. The results indicate that ultralow levels of unburned hydrocarbons and carbon monoxide emissions can be achieved. B.B.

N78-26144*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

END-WALL BOUNDARY LAYER PREDICTION FOR AXIAL COMPRESSORS

Peter M. Sockol 1978 19 p refs Presented at the 11th Fluid and Plasma Dynamics Conf., Seattle, 10-12 Jul. 1978; sponsored by AIAA

(NASA-TM-78928; E-9668) Avail: NTIS HC A02/MF A01 CSCL 21E

An integral boundary layer procedure was developed for the computation of viscous and secondary flows along the annulus walls of an axial compressor. The procedure is an outgrowth and extension of the pitch-averaged methods of Mellor and Horlock. In the present work secondary flow theory is used to develop approximations for the velocity profiles inside a rotating blade row and for the blade force deficit terms in the momentum integral equations. The computer code based on this procedure was iteratively coupled to a quasi-one-dimensional model for the external inviscid flow. Computed results are compared with measurements in a compressor cascade. Author

N78-26145*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LIQUID-COOLING TECHNOLOGY FOR GAS TURBINES REVIEW AND STATUS

G. James VanFossen, Jr. (Army Res. and Technol. Labs.) and Francis S. Stepka Aug. 1978 14 p refs Proposed for presentation at the 13th Intersoc. Energy Conversion Eng. Conf., San Diego, Calif., 20-25 Aug. 1978; sponsored by the SAE, ACS, AIAA, ASME, IEEE, AICHE, and ANS

(NASA-TM-78906; AVRADCOM-TR-78-26(PL); E-9517-1) Avail: NTIS HC A02/MF A01 CSCL 21E

A review of research related to liquid cooling of gas turbines was conducted and an assessment of the state of the art was made. Various methods of liquid cooling turbines were reviewed. Examples and results with test and demonstrator turbines utilizing these methods along with the advantages and disadvantages of the various methods are discussed. B.B.

N78-26148*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EMITTANCE AND ABSORPTANCE OF NASA CERAMIC THERMAL BARRIER COATING SYSTEM

Curt H. Liebert Jun. 1978 31 p refs Presented in part at the Intern. Conf. on Met. Coatings, San Francisco, 3-7 Apr. 1978; sponsored by the Am. Vacuum Soc.

(NASA-TP-1190; E-9474) Avail: NTIS HC A03/MF A01 CSCL 20E

Spectral emittance measurements were made on a two-layer ceramic thermal barrier coating system consisting of a metal substrate, a NiCrAly bond coating and a yttria-stabilized zirconia ceramic coating. Spectral emittance data were obtained for the coating system at temperatures of 300 to 1590 K, ceramic thickness of zero to 0.076 centimeter, and wavelengths of 0.4 to 14.6 micrometers. The data were transformed into total hemispherical emittance values and correlated with respect to ceramic coating thickness and temperature using multiple regression curve fitting techniques. The results show that the ceramic thermal barrier coating system is highly reflective and significantly reduces radiation heat loads on cooled gas turbine engine components. Calculation of the radiant heat transfer within the nonisothermal, translucent ceramic coating material shows that the gas-side ceramic coating surface temperature can be used in heat transfer analysis of radiation heat loads on the coating system. Author

N78-27122*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SUPERCRITICAL FUEL INJECTION SYSTEM Patent Application

C. J. Marek and L. P. Cooper, inventors (to NASA) Filed 19 Jun. 1978 10 p

(NASA-Case-LEW-12990-1; US-Patent-Appl-SN-916654) Avail: NTIS HC A02/MF/A01 CSCL 21E

A fuel injection system for gas turbines or the like which includes a pair of high pressure pumps which provide fuel and a carrier fluid such as air at pressures above the critical pressure of the fuel was developed. A supercritical mixing chamber mixes the fuel and carrier fluid and the mixture is sprayed into a combustion chamber for burning therein. The use of fuel and a carrier fluid at supercritical pressures promotes rapid mixing of the fuel in the combustion chamber so as to reduce the formation of pollutants and promote cleaner burning. NASA

N78-27125*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INLET-ENGINE MATCHING FOR SCAR INCLUDING APPLICATION OF A BICONE VARIABLE GEOMETRY INLET

Joseph F. Wasserbauer and William H. Gerstenmaier 1978 23 p refs Presented at the 14th Propulsion Conf., Las Vegas, Nev., 25-27 Jul. 1978; cosponsored by the AIAA and the SAE Engr

(NASA-TM-78955; E-9706) Avail: NTIS HC A02/MF A01 CSCL 21E

Airflow characteristics of variable cycle engines (VCE) designed for Mach 2.32 can have transonic airflow requirements as high as 1.6 ...es the cruise airflow. This is a formidable requirement for conventional, high performance, axisymmetric, translating centerbody mixed compression inlets. An alternate inlet is defined, where the second cone of a two cone center body collapses to the initial cone angle to provide a large off-design airflow capability, and incorporates modest centerbody translation to minimize spillage drag. Estimates of transonic spillage drag are competitive with those of conventional translating centerbody inlets. The inlet's cruise performance exhibits very low bleed requirements with good recovery and high angle of attack capability. *Author*

N78-27126*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A COMPUTER PROGRAM FOR FULL-COVERAGE FILM-COOLED BLADING ANALYSIS INCLUDING THE EFFECTS OF A THERMAL BARRIER COATING

Jun 1978 11 p refs To be presented at the Winter Ann. Meeting of ASME, San Francisco, 10-15 Dec. 1978

(NASA-TM-78951; AVRADCOM-TR-78-31(PL); E-9696) Avail: NTIS HC A02/MF A01 CSCL 21E

The program input, coolant flow and heat transfer model, and the program output are discussed. As an example, sections of the suction and pressure sides of a high temperature, high pressure turbine vane are analyzed to show the effects of a thermal barrier coating. Compared to the uncoated design, the coating halves the required coolant flow, while simultaneously reducing metal outer temperatures by over 111 K. Author

N78-27127*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FUEL CONSERVATIVE AIRCRAFT ENGINE TECHNOLOGY

Donald L. Nored 1978 39 p refs Proposed for presentation at 11th Congr. of the Intern. Council of Aeronautical Sci., Lisbon, Portugal, 10-16 Sep. 1978; sponsored by AIAA

(NASA-TM-78962; E-9719) Avail: NTIS HC A03/MF A01 CSCL 21E

Technology developments for more fuel-efficiency subsonic transport aircraft are reported. Three major propulsion projects were considered: (1) engine component improvement - directed at current engines; (2) energy efficient engine - directed at new turbofan engines; and (3) advanced turboprops - directed at technology for advanced turboprop-powered aircraft. Each project is reviewed and some of the technologies and recent accomplishments are described. G.G.

N78-27130*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

REVERSE-FLOW COMBUSTOR FOR SMALL GAS TURBINES WITH PRESSURE-ATOMIZING FUEL INJECTORS

Carl T. Norgren, Edward J. Mularz (AVRADCOM Res. and Technol. Labs.), and Stephen M. Riddlebaugh Aug. 1978 30 p refs (NASA-TP-1260, AVRADCOM-TR-78-22(PL); E-9458) Avail: NTIS HC A03/MF A01 CSCL 21E

A reverse flow combustor suitable for a small gas turbine (2 to 3 kg/s mass flow) was used to evalute the effect of pressure atomizing fuel injectors on combustor performance. In these tests an experimental combustor was designed to operate with 18 simplex pressure atomizing fuel injectors at sea level takeoff conditions. To improve performance at low power conditions, fuel was redistributed so that only every other injector was operational. Combustor performance, emissions, and liner temperature were compared over a range of pressure and inlet air temperatures corresponding to simulated idle, cruise, and takeoff conditions typical of a 16 to 1 pressure ratio turbine engine. B.B.

N78-28099*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FORTRAN PROGRAM FOR CALCULATING COOLANT FLOW AND METAL TEMPERATURES OF A FULL-COVERAGE-FILM-COOLED VANE OR BLADE

Peter L. Meitner (AVRADCOM R and T Labs., Cleveland) Jul. 1978 92 p refs

(NASA-TP-1259; E-9491; AVRADCOM-TR-78-19(PL)) Avail: NTIS HC A05/MF A01 CSCL 21E

A computer program that calculates the coolant flow and the metal temperatures of a full-coverage-film-cooled vane or blade was developed. The analysis was based on compressible, one-dimensional fluid flow and on one-dimensional heat transfer and treats the vane or blade shell as a porous wall. The calculated temperatures are average values for the shell outer-surface area associated with each film-cooling hole row. A thermal-barrier coating may be specified on the shell outer surface, and centrifugal effects can be included for blade calculations. The program is written in FORTRAN 4 and is operational on a UNIVAC 1100/42 computer. The method of analysis, the program input, the program output, and two sample problems are provided. G.G.

N78-29100*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF AIR TEMPERATURE AND RELATIVE HUMIDITY AT VARIOUS FUEL-AIR RATIOS ON EXHAUST EMISSIONS ON A PER-MODE BASIS OF AN AVCO LYCOMING O-320 DIAD LIGHT AIRCRAFT ENGINE: VOLUME 1: RESULTS AND PLOTTED DATA

Michael Skorobatckyi, Donald V. Cosgrove, Phillip R. Meng, and Erwin E. Kempe, Jr. Jul. 1978 109 p refs

(NASA-TM-73507-Vol-1; E-8916-2) Avail: NTIS HC E06/MF A01 CSCL 21E

A carbureted four cylinder air cooled O-320 DIAD Lycoming aircraft engine was tested to establish the effects of air temperature and humidity at various fuel-air ratios on the exhaust emissions on a per-mode basis. The test conditions include carburetor lean out at air temperatures of 50, 59, 80, and 100 F at relative humidities of 0, 30, 60, and 80 percent. Temperature humidity effects at the higher values of air temperature and relative humidity tested indicated that the HC and CO emissions increased significantly, while the NOx emissions decreased. Even at a fixed fuel air ratio, the HC emissions increase and the NOx emissions decrease at the higher values of air temperature and humidity. B.B.

N78-31103*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

GAS PATH SEAL Patent Application

Robert C. Bill and Lawrence P. Ludwig, inventors (to NASA) Filed 4 Aug. 1978 9 p

(NASA-Case-Lew-12131-2; US-Patent-Appl-SN-931090) Avail: NTIS HC A02/MF A01 CSCL 21E

A gas path seal for a turbine engine or compressor is provided. The gas path seal comprises a shroud of material wearable or abradable relative to the material of the turbine or compressor blades and closely spaced from the blade tips. A compliant backing, preferably of several layers of corrugated metal or a compliant material covered with a thin layer of ductile material, is provided about the shroud, and a rigid mounting surrounds the compliant backing. The novel feature is a compliant backing between the shroud and mounting. As a result normal forces during a blade rub are limited and wear is reduced and the life of the shroud is lengthened for a design of comparable clearance of blade to shroud. NASA

N78-33100*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYSIS OF METAL TEMPERATURE AND COOLANT FLOW WITH A THERMAL-BARRIER COATING ON A FULL-COVERAGE-FILM-COOLED TURBINE VANE
Peter L. Meitner (AVRADCOM Res. and Technol. Labs.) Aug. 1978 15 p refs
(NASA-TP-1310; AVRADCOM-TR-78-20) Avail: NTIS HC A02/MF A01 CSCL 21E

The potential benefits of combining full-coverage film cooling with a thermal-barrier coating were investigated analytically for sections on the suction and pressure sides a high-temperature, high-pressure turbine vane. Metal and ceramic coating temperatures were calculated as a function of coating thickness and coolant flow. With a thermal-barrier coating, the coolant flows required for the chosen sections were half those of an uncoated design, and the metal outer temperatures were simultaneously reduced by over 111 K (200 F). For comparison, transpiration cooling was also investigated. Full-coverage film cooling of a coated vane required more coolant flow than did transpiration cooling. Author

N78-33101* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REDUNDANT DISC Patent
William N. Barack (GE, Cincinnati), Paul A. Domas (GE, Cincinnati), and Stephen W. Beekman, inventors (to NASA) (GE, Cincinnati) Issued 27 Jun. 1978 7 p Filed 22 Mar. 1976 Sponsored by NASA
(NASA-Case-LEW-12496-1; US-Patent-4,097,194; US-Patent-Appl-SN-668971; US-Patent-Class-416-244A; US-Patent-Class-416-214A; US-Patent-Class-74-572; US-Patent-Class-29-463) Avail: US Patent Office CSCL 21E

A rotatable disc is described that consists of parallel plates tightly joined together for rotation about a hub. Each plate is provided with several angularly projecting spaced lands. The lands of each plate are interposed in alternating relationship between the lands of the next adjacent plate. In this manner, circumferential displacement of adjacent sectors in any one plate is prevented in the event that a crack develops. Each plate is redundantly sized so that, in event of structural failure of one plate, the remaining plates support a proportionate share of the load of the failed plate. The plates are prevented from separating laterally through the inclusion of generally radially extending splines which are inserted to interlock cooperating, circumferentially adjacent lands. Official Gazette of the U.S. Patent Office

N78-33102*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RESULTS AND STATUS OF THE NASA AIRCRAFT ENGINE EMISSION REDUCTION TECHNOLOGY PROGRAMS
R. E. Jones, L. A. Diehl, D. A. Petrash, and J. Grobman Oct. 1978 53 p refs
(NASA-TM-79009; E-9793) Avail: NTIS HC A04/MF A01 CSCL 21E

The results of an aircraft engine emission reduction study are reviewed in detail. The capability of combustor concepts to produce significantly lower levels of exhaust emissions than present production combustors was evaluated. The development status of each combustor concept is discussed relative to its potential for implementation in aircraft engines. Also, the ability of these combustor concepts to achieve proposed NME and NCE EPA standards is discussed B.B.

N78-33107*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
PERFORMANCE OF A TRANSONIC FAN STAGE DESIGNED FOR A LOW MERIDIONAL VELOCITY RATIO
Royce D. Moore, George W. Lewis, Jr., and Walter M. Osborn Nov. 1978 83 p refs
(NASA-TP-1298, E-8994) Avail: NTIS HC A05/MF A01 CSCL 21E

The aerodynamic performance and design parameters of a transonic fan stage are presented. The fan stage was designed for a meridional velocity ratio of 0.8 across the tip of the stage, a pressure ratio of 1.67, a flow of 29.5 kilograms per second, and a tip speed of 426 meters per second. Radial surveys were obtained over the stable operating range from 60 to 100 percent of design speed. The measured, peak efficiency (0.81) of the stage occurred at a pressure ratio of 1.58 and a flow of 28.7 kilograms per second. L.S.

N78-33108*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESIGN AND OVERALL PERFORMANCE OF FOUR HIGHLY LOADED, HIGH SPEED INLET STAGES FOR AN ADVANCED HIGH-PRESSURE-RATIO CORE COMPRESSOR
Lonnie Reid and Royce D. Moore Oct. 1978 122 p refs
(NASA-TP-1337; E-9302) Avail: NTIS HC A06/MF A01 CSCL 21E

The detailed design and overall performances of four inlet stages for an advanced core compressor are presented. These four stages represent two levels of design total pressure ratio (1.82 and 2.05), two levels of rotor aspect ratio (1.19 and 1.63), and two levels of stator aspect ratio (1.26 and 1.78). The individual stages were tested over the stable operating flow range at 70, 90, and 100 percent of design speeds. The performances of the low aspect ratio configurations were substantially better than those of the high aspect ratio configurations. The two low aspect ratio configurations achieved peak efficiencies of 0.876 and 0.872 and corresponding stage efficiencies of 0.845 and 0.840. The high aspect ratio configurations achieved peak ratio efficiencies of 0.851 and 0.849 and corresponding stage efficiencies of 0.821 and 0.831. Author

N78-33109*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESIGN AND PERFORMANCE OF A 427-METER-PER-SECOND-TIP-SPEED TWO-STAGE FAN HAVING A 2.40 PRESSURE RATIO
Walter S. Cunnan, William Stevans, and Donald C. Urasek Oct. 1978 96 p refs
(NASA-TP-1314; E-9005) Avail: NTIS HC A05/MF A01 CSCL 21E

The aerodynamic design and the overall and blade-element performances are presented of a 427-meter-per-second-tip-speed two-stage fan designed with axially spaced blade rows to reduce noise transmitted upstream of the fan. At design speed the highest recorded adiabatic efficiency was 0.796 at a pressure of 2.30. Peak efficiency was not established at design speed because of a damper failure which terminated testing prematurely. The overall efficiencies, at 60 and 80 percent of design speed, peaked at approximately 0.83. Author

N78-33110*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DYGABCD: A PROGRAM FOR CALCULATING LINEAR A, B, C, AND D MATRICES FROM A NONLINEAR DYNAMIC ENGINE SIMULATION
Lucille C. Geyser Sep. 1978 203 p refs
(NASA-TP-1295; E-9464) Avail: NTIS HC A10/MF A01 CSCL 21E

A digital computer program, DYGABCD, was developed that generates linearized, dynamic models of simulated turbofan and turbojet engines. DYGABCD is based on an earlier computer program, DYNGEN, that is capable of calculating simulated nonlinear steady-state and transient performance of one- and two-spool turbojet engines or two- and three-spool turbofan engines. Most control design techniques require linear system descriptions. For multiple-input/multiple-output systems such as turbine engines, state space matrix descriptions of the system are often desirable. DYGABCD computes the state space matrices commonly referred to as the A, B, C, and D matrices required for a linear system description. The report discusses the analytical approach and provides a users manual, FORTRAN listings, and a sample case. L.S.

A78-20651 * # **A review of NASA's propulsion programs for civil aviation.** W. L. Stewart (NASA, Lewis Research Center, Cleveland, Ohio), H. W. Johnson (NASA, Aeronautical Propulsion Div., Washington, D.C.), and R. J. Weber (NASA, Lewis Research Center, Mission Analysis Branch, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 16th, Huntsville, Ala., Jan. 16-18, 1978, Paper 78-43.* 14 p. 19 refs.

Five NASA engine-oriented propulsion programs of major importance to civil aviation are presented and discussed. Included are programs directed at exploring propulsion-system concepts for (1) energy-conservative subsonic aircraft (improved current turbofans, advanced turbofans, and advanced turboprops), (2) supersonic cruise aircraft (variable-cycle engines), (3) general aviation aircraft (improved reciprocating engines and small gas turbines), (4) powered-lift aircraft (advanced turbofans), and (5) advanced rotorcraft. These programs reflect the opportunities still existing for significant improvements in civil aviation through the application of advanced propulsion concepts. (Author)

A78-23840 * **Preliminary QCSEE program - Test results.** C. C. Ciepluch (NASA, Lewis Research Center, Cleveland, Ohio). *Society of Automotive Engineers, Aerospace Meeting, Los Angeles, Calif., Nov. 14-17, 1977, Paper 771008.* 11 p.

Preliminary results are reported for the Quiet Clean Short-haul Experimental Engine (QCSEE) program initiated by NASA in 1974 to develop propulsion system technology suitable for powered-lift short-range commercial aircraft. The QCSEE technology also has applications to the proposed U.S. Navy V/STOL aircraft. Emphasis in the QCSEE program is placed on developing engines with low noise characteristics; in addition, the power plants are required to conform to EPA 1979 pollutant emissions standards. Thrust performance, fan design, and thrust/weight ratio are discussed for both the over-the-wing and under-the-wing engine configurations under study. J.M.B.

A78-23891 * **The application of the Routh approximation method to turbofan engine models.** W. C. Merrill (NASA, Lewis Research Center, Cleveland, Ohio). In: Joint Automatic Control Conference, San Francisco, Calif., June 22-24, 1977 Proceedings. Volume 2. (A78-23851 08-63) New York, Institute of Electrical and Electronics Engineers, Inc., 1977, p. 1019-1028. 9 refs.

The Routh approximation technique is applied in the frequency domain to a 16th order state variable turbofan engine model. The results obtained motivate the extension of the frequency domain formulation of the Routh method to the time domain to handle the state variable formulation directly. The time domain formulation is derived and a new characterization, which specifies all possible Routh similarity transformations, is given. This characterization is computed by the solution of two eigenvalue-eigenvector problems. The application of the time domain Routh technique to the state variable engine model is described and some results are given. Additional computational problems are discussed including an optimization procedure which can improve the approximation accuracy by taking advantage of the transformation characterization. (Author)

A78-23892 * ***Minimum-time acceleration of aircraft* turbofan engines.** F. Teren (NASA, Lewis Research Center, Cleveland, Ohio). In: Joint Automatic Control Conference, San Francisco, Calif., June 22-24, 1977, Proceedings. Volume 2. (A78-23851 08-63) New York, Institute of Electrical and Electronics Engineers, Inc., 1977, p. 1029-1037. 12 refs.

Minimum-time accelerations of the F100 turbofan engine are presented. A piecewise-linear engine model, having three state variables and four control variables, is used to obtain the minimum-time solutions. The linear model which applies at a given time in the trajectory is determined by calculating a normalized 'distance' from the current state to the equilibrium state associated with each linear model. The linear model associated with the closest equilibrium point is then used. The control histories for the minimum-time solutions are used as input to a nonlinear simulation of the F100 engine to verify the accuracy of the piecewise-linear solutions. (Author)

A78-23907 * **Design of turbofan engine controls using output feedback regulator theory.** W. C. Merrill (NASA, Lewis Research Center, Cleveland, Ohio). In: Joint Automatic Control Conference, San Francisco, Calif., June 22-24, 1977, Proceedings. Volume 2. (A78-23851 08-63) New York, Institute of Electrical and Electronics Engineers, Inc., 1977, p. 1504-1509. 9 refs.

A multivariable control design procedure based on output feedback regulator (OFR) theory is applied to the F100 turbofan engine. Results for the OFR design are compared to a design based on linear quadratic regulator (LQR) theory. This LQR design was obtained as part of the F100 Multivariable Control Synthesis (MVCS) program. In the MVCS program the LQR feedback control was designed in a reduced dimension state space and then applied to the original system. However, the OFR feedback control is designed in the full order state space and thus eliminates any need for model reduction techniques. Using the performance measure and control structure of the MVCS program LQR design, an equivalent OFR feedback control is obtained. The flexibility of the OFR as a control design procedure is demonstrated and differing feedback control structures are evaluated. (Author)

A78-24877 * # **Noise of deflectors used for flow attachment with STOL-OTW configurations.** U. von Glahn and D. Groesbeck (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 94th, Miami Beach, Fla., Dec. 13-16, 1977, Paper.* 16 p.

Future STOL aircraft may utilize engine-over-the-wing (OTW) installations in which the exhaust nozzles are located above and separated from the upper surface of the wing. An external jet-flow deflector can be used with such installations to provide flow attachment to the wing/flap surfaces for lift augmentation. In the present work, the deflector noise in the flyover plane measured with several model-scale nozzle/deflector/wing configurations is examined. The deflector-associated noise is correlated in terms of velocity and geometry parameters. The data also indicate that the effective overall sound pressure level of the deflector-associated noise peaks in the forward quadrant near 40 deg from the inlet axis. (Author)

A78-24878 * # **Combustor fluctuating pressure measurements in-engine and in a component test facility - A preliminary comparison.** M. Reshotko and A. Karchmer (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 94th, Miami Beach, Fla., Dec. 13-16, 1977, Paper.* 18 p. 5 refs.

Combustor internal fluctuating pressure and far-field noise generated in a YF-102 turbofan engine are investigated; combustor internal measurements are also made in a duct-component test facility operating over a range of conditions encompassing those characteristic of the aircraft engine. Although directly measured spectra for the engine and the duct-component test facility show discrepancies, the results of coherence function, transfer function and phase relationship comparisons suggest that the internal dynamics of the combustor as an acoustic source may be preserved in a component test facility. J.M.B.

A78-24879 * # **An empirical model for inverted-velocity-profile jet noise prediction.** J. R. Stone (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 94th, Miami Beach, Fla., Dec. 13-16, 1977, Paper.* 28 p. 12 refs.

It is known that the noise generated by inverted-velocity-profile coaxial (without center plug) and coannular (with center plug) nozzles should be modeled as the combined contributions of various

source regions and noise generation mechanisms. In this paper, an empirical noise-prediction model is described which considers the noise generated by two jet-mixing regions and two potential regions of shock/turbulence interaction. Results calculated from the empirical model are compared with model-scale experimental data for static and simulated flight conditions. These comparisons are made for cases where both streams are subsonic, where the outer stream is supersonic with the inner stream subsonic, and where both streams are supersonic. The cases considered cover a range of inner-to-outer-stream area ratios and include both coaxial and coannular nozzles. It is shown that the model gives reasonable predictions of absolute noise spectra and even better predictions of incremental changes.
S.D.

A78-24880 * # Effectiveness of an inlet flow turbulence control device to simulate flight fan noise in an anechoic chamber. R. P. Woodward, J. A. Wazyniak, L. M. Shaw, and M. J. MacKinnon (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 94th, Miami Beach, Fla., Dec. 13-16, 1977, Paper.* 21 p. 13 refs.

A hemispherical inlet flow control device was tested on a 50.8 cm. (20-inch) diameter fan stage in the NASA-Lewis Anechoic Chamber. The control device used honeycomb and wire mesh to reduce turbulence intensities entering the fan. Far field acoustic power level results showed about a 5 dB reduction in blade passing tone and about 10 dB reduction in multiple pure tone sound power at 90% design fan speed with the inlet device in place. Hot film cross probes were inserted in the inlet to obtain data for two components of the turbulence at 65 and 90% design fan speed. Without the flow control device the axial intensities were below 1.0%, while the circumferential intensities were almost twice this value. The inflow control device significantly reduced the circumferential turbulence intensities and also reduced the axial length scale. (Author)

A78-24898 * # Output feedback regulator design for jet engine control systems. W. Merrill (NASA, Lewis Research Center, Cleveland, Ohio). *National Electronics Conference, Chicago, Ill., Oct. 13, 14, 1977, Paper.* 13 p. 6 refs.

A multivariable control design procedure based on the output feedback regulator formulation is described and applied to an F100 turbofan engine model. Full order model dynamics, are incorporated in the example design. The effect of actuator dynamics on closed loop performance is investigated. Also, the importance of turbine inlet temperature as an element of the dynamic feedback is studied. Step responses are given to indicate the improvement in system performance with this control. Calculation times for all experiments are given in CPU seconds for comparison purposes. (Author)

A78-29330 * # General aviation energy-conservation research programs at NASA-Lewis Research Center. E. A. Willis (NASA, Lewis Research Center, Cleveland, Ohio). *Western Michigan University, Conference on Energy Conservation in General Aviation, Kalamazoo, Mich., Oct. 10, 11, 1977, Paper.* 23 p. 14 refs.

A review is presented of non-turbine general aviation engine programs underway at the NASA-Lewis Research Center in Cleveland, Ohio. The program encompasses conventional, lightweight diesel and rotary engines. Its three major thrusts are, in order of priority: (1) reduced SFCs; (2) improved fuels tolerance; and (3) reducing emissions. Current and planned future programs in such areas as lean operation, improved fuel management, advanced cooling techniques and advanced engine concepts, are described. These are expected to lay the technology base, by the mid to latter 1980s, for engines whose total fuel costs are as much as 30% lower than today's conventional engines. (Author)

A78-33111 * Effect of airstream velocity on mean drop diameters of water sprays produced by pressure and air atomizing nozzles. R. D. Ingebo (NASA, Lewis Research Center, Cleveland, Ohio). In: Gas turbine combustion and fuels technology; Proceedings of the Winter Annual Meeting, Atlanta, Ga., November 27-December 2, 1977. (A78-33108 13-31) New York, American Society of Mechanical Engineers, 1977, p. 31-35. 6 refs.

A scanning radiometer was used to determine the effect of airstream velocity on the mean drop diameter of water sprays produced by pressure atomizing and air atomizing fuel nozzles used in previous combustion studies. Increasing airstream velocity from 23 to 53.4 meters per second reduced the Sauter mean diameter by approximately 50 percent with both types of fuel nozzles. The use of a sonic cup attached to the tip of an air assist nozzle reduced the Sauter mean diameter by approximately 40 percent. Test conditions included airstream velocities of 23 to 53.4 meters per second at 293 K and atmospheric pressure. (Author)

A78-33218 * # Gas path sealing in turbine engines. L. P. Ludwig (NASA, Lewis Research Center, Cleveland, Ohio). *NATO, AGARD, Power, Energetics, and Propulsion Panel Meeting on Seal Technology in Gas Turbine Engines, London, England, Apr. 6, 7, 1978, Paper.* 45 p. 54 refs.

Survey of gas path seals is presented with particular attention given to sealing clearance effects on engine component efficiency. The effects on compressor pressure ratio and stall margin are pointed out. Various case-rotor relative displacements, which affect gas path seal clearances, are identified. Forces produced by nonuniform sealing clearances and their effect on rotor stability are discussed qualitatively, and recent work on turbine-blade-tip sealing for high temperatures is described. The need for active clearance control and for engine structural analysis is discussed. The functions of the internal-flow system and its seals are reviewed. (Author)

A78-35[illegible] * State-of-the-art of turbofan engine noise control. W. L. Jones and J. F. Groeneweg (NASA, Lewis Research Center, Cleveland, Ohio). In: NOISE-CON 77; Proceedings of the National Conference on Noise Control Engineering, Hampton, Va., October 17-19, 1977. (A78-35651 14-01) New York, Noise Control Foundation, 1977, p. 361-380. 22 refs.

A description is presented of some of the recent advances in the technology of turbofan engine noise reduction, taking into account turbomachinery noise sources, new fans for low noise, fan and core noise suppression, and a new program for improving static noise testing of fans and engines. The problem of jet noise has been substantially reduced in connection with the lower jet velocities employed in the case of the high bypass turbofan engines. The dominant noise sources are now related to the turbomachinery with the fan stage, the compressor, and the turbine. Since the fan stage is the primary source of turbomachinery noise, it has been considered in a major part of the investigations designed to reduce turbofan engine noise. G.R.

A78-37683 * # On the use of relative velocity exponents for jet engine exhaust noise. J. R. Stone (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 95th, Providence, R.I., May 16-19, 1978, Paper.* 16 p. 14 refs.

The effect of flight on jet engine exhaust noise has often been presented in terms of a relative velocity exponent, n, as a function of radiation angle. The value of n is given by the OASPL reduction due to relative velocity divided by 10 times the logarithm of the ratio of relative jet velocity to absolute jet velocity. It is shown in this paper that the exponent n is positive for pure subsonic jet mixing noise and varies, in a systematic manner, as a function of flight conditions and jet velocity. On the basis of calculations from simple empirical models for jet mixing noise, shock noise and internally-generated noise, it is shown that when other sources are present, the resulting range of n is increased over the range for jet mixing noise, and in some cases negative values of n are obtained. (Author)

A78-43380 * # **Propulsion.** D. L. Nored (NASA, Lewis Research Center, Energy Conservative Engines Office, Cleveland, Ohio). *Astronautics and Aeronautics*, vol. 16, July-Aug. 1978, p. 47-54, 119. 14 refs.

NASA aims at developing propulsion technology to reduce the fuel consumption of present engines by 5%, that of new engines of the late 1980s by at least 12%, and that of an advanced early 1990s turboprop by an additional 16%. This paper reviews three separate NASA programs which take up these aims. They are, respectively, Engine Component Improvement, Energy Efficient Engine, and Advanced Turboprops. B.J.

A78-43604 * # **Design approaches to more energy efficient engines.** N. T. Saunders, R. S. Colladay, and L. E. Macioce (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Joint Propulsion Conference, 14th, Las Vegas, Nev., July 25-27, 1978, AIAA Paper 78-931*. 10 p. 5 refs.

In 1976 NASA initiated the Aircraft Energy Efficiency (ACEE) Program to assist in the development of technology for more fuel-efficient aircraft for commercial airline use. The Energy Efficient Engine (EEE) Project of the ACEE program is intended to lay the advanced-technology foundation for a new generation of turbofan engines. This project, planned as a seven-year cooperative government-industry effort, is aimed at developing and demonstrating advanced component and systems technologies for engines that could be introduced into airline service by the late 1980s or early 1990s. In addition to fuel savings, new engines must offer potential for being economically attractive to the airline users and environmentally acceptable. A description is presented of conceptual energy-efficient engine designs which offer potential for achieving all of the goals established for the EEE Project. G.R.

A78-43505 * # **General aviation internal combustion engine research programs at NASA-Lewis Research Center.** E. A. Willis (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Joint Propulsion Conference, 14th, Las Vegas, Nev., July 25-27, 1978, AIAA Paper 78-932*. 15 p. 17 refs.

An update is presented of non-turbine general aviation engine programs underway at the NASA-Lewis Research Center in Cleveland, Ohio. The program encompasses conventional, lightweight diesel and rotary engines. Its three major thrusts are: (a) reduced SFC's; (b) improved fuels tolerance; and (c) reducing emissions. Current and planned future programs in such areas as lean operation, improved fuel management, advanced cooling techniques and advanced engine concepts, are described. These are expected to lay the technology base, by the mid to late 1980's, for engines whose life cycle fuel costs are 30 to 50% lower than today's conventional

A78-43544 * # **Design and preliminary results of a semi-transpiration cooled /Lamilloy/ liner for a high-pressure high-temperature combustor.** J. D. Wear, A. M. Trout, J. M. Smith, and R. E. Jones (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Joint Propulsion Conference, 14th, Las Vegas, Nev., July 25-27, 1978, AIAA Paper 78-997*. 8 p. 5 refs

A Lamilloy combustor liner has been designed, fabricated and tested in a combustor at pressures up to 8 atmospheres. The liner was fabricated of a three layer Lamilloy structure and designed to replace a conventional step-louver liner. The liner will be used in a combustor that provides hot gases to a turbine cooling test facility at pressures up to 40 atmospheres. The Lamilloy liner was tested extensively at lower pressures and demonstrated lower metal temperatures than the conventional liner, while at the same time requiring about 40 percent less cooling air flow. Tests conducted at combustor exit temperatures in excess of 2200 K have not indicated any cooling or durability problems with the Lamilloy liner. (Author)

A78-43548 * # **Combustor concepts for aircraft gas turbine low-power emissions reduction.** E. J. Mularz (NASA, Lewis Research Center; U.S. Army, Air Mobility Research and Development Laboratory, Cleveland, Ohio), C. C. Gleason, and W. J. Dodds (NASA, Lewis Research Center, Cleveland; General Electric Co., Evendale, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Joint Propulsion Conference, 14th, Las Vegas, Nev., July 25-27, 1978, AIAA Paper 78-999*. 11 p. 6 refs. Contract No. NAS3-20680.

Three combustor concepts have been designed and tested to demonstrate significant reductions in aircraft engine idle pollutant emissions. Each concept used a different approach for pollutant reductions: the Hot Wall Combustor employs a thermal barrier coating and impingement cooled liners, the Recuperative Cooling Combustor preheats the air before entering the combustion chamber, and the Catalytic Converter Combustor is composed of a conventional primary zone followed by a catalytic bed for pollutant cleanup. The designs are discussed in detail and test results are presented for a range of aircraft engine idle conditions. The results indicate that ultra-low levels of unburned hydrocarbons and carbon monoxide emissions can be achieved with this technology. (Author)

A78-45098 * # **NASA/General Electric Engine Component Improvement Program.** A. J. Albright, D. J. Lennard (General Electric Co., Cincinnati, Ohio), and J. A. Ziemianski (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Joint Propulsion Conference, 14th, Las Vegas, Nev., July 25-27, 1978, AIAA Paper 78-929*. 7 p. Contracts No. NAS3-20629; No. NAS3-20631.

The Engine Component Improvement (ECI) Program has been initiated in connection with projects designed to reduce the impact of the world-wide energy crisis in the area of aviation. The two parts of the ECI program have the overall objective to identify and quantify the sources and causes of CF6 engine performance deterioration, and to reduce the fuel consumption of CF6 engines through the development and the incorporation of various performance improvement concepts. The CF6 high-bypass turbofan engine was selected as a basis for this effort, since it is expected to be a significant fuel user in commercial revenue service for the next 15 to 20 years. The first part of the ECI program represents the initial step in an effort to achieve a goal of five percent reduction in fuel usage for CF6 engines in the 1979-82 time period. The first performance improvement concept selected is an improved efficiency fan blade. Other improvements are related to a short core exhaust system and an improved high pressure turbine. G.R.

A78-48452 * # **NASA engine system technology programs - An overview.** H. W. Johnson (NASA, Aeronautical Propulsion Div., Washington, D.C.) and E. W. Conrad (NASA, Lewis Research Center, Energy Conservation Engines Office, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Joint Propulsion Conference, 14th, Las Vegas, Nev., July 25-27, 1978, AIAA Paper 78-928*. 5 p.

The various propulsion systems technology programs are examined. The Stratospheric Cruise Emission Reduction program has the objective to explore and demonstrate advanced technology fuel preparation and combustion systems which produce very low emission levels, particularly with respect to the oxides of nitrogen, during high altitude cruising flight. Other programs considered include the Quiet, Clean, General Aviation Turbofan program, the Variable Cycle Engine Technology program, the Helicopter Transmission Technology program, the Broad Specification Fuels Technology program, the Engine Component Improvement program, the Advanced Turboprop Technology program, the Supersonic Cruise Propulsion Technology program, the Materials for Advanced Turbine Engines program, and the Aeroelasticity of Turbine Engines program. G.R.

N78-10082*# TRW, Inc., Cleveland, Ohio.
COST ANALYSIS OF ADVANCED TURBINE BLADE MANUFACTURING PROCESSES Final Report, Oct. 1976 - April 1977
C. F. Barth, D. E. Blake, and T. S. Stelson Oct. 1977 89 p refs
(NAS3-20378)
(NASA-CR-135203; TRW-1ER-7930) Avail: NTIS HC A05/MF A01 CSCL 21E

A rigorous analysis was conducted to estimate relative manufacturing costs for high technology gas turbine blades prepared by three candidate materials process systems. The manufacturing costs for the same turbine blade configuration of directionally solidified eutectic alloy, an oxide dispersion strengthened superalloy, and a fiber reinforced superalloy were compared on a relative basis to the costs of the same blade currently in production utilizing the directional solidification process. An analytical process cost model was developed to quantitatively perform the cost comparisons. The impact of individual process yield factors on costs was also assessed as well as effects of process parameters, raw materials, labor rates and consumable items. Author

N78-10083*# Douglas Aircraft Co., Inc., Long Beach, Calif.
EFFECT OF FORWARD MOTION ON ENGINE NOISE
G. L. Blankenship, J. K. C. Low, J. A. Watkins, and J. E. Merriman Oct. 1977 198 p refs
(Contract NAS3-20031)
(NASA-CR-134954; MDC-J7708) Avail: NTIS HC A09/MF A01 CSCL 20A

Methods used to determine a procedure for correcting static engine data for the effects of forward motion are described. Data were analyzed from airplane flyover and static-engine tests with a JT8D-109 low-bypass-ratio turbofan engine installed on a DC-9-30, with a CF6-6D high-bypass-ratio turbofan engine installed on a DC-10-10, and with a JT9D-59A high-bypass-ratio turbofan engine installed on a DC-10-40. The observed differences between the static and the flyover data bases are discussed in terms of noise generation, convective amplification, atmospheric propagation, and engine installation. The results indicate that each noise source must be adjusted separately for forward-motion and installation effects and then projected to flight conditions as a function of source-path angle, directivity angle, and acoustic range relative to the microphones on the ground. Author

N78-11062*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
ADVANCED SUPERSONIC PROPULSION STUDY, PHASE 4 Final Report
R. A. Howlett Sep. 1977 109 p
(Contract NAS3-19540)
(NASA-CR-135273; PWA-5547-4) Avail: NTIS HC A06/MF A01 CSCL 21E

Installation characteristics for a Variable Stream Control Engine (VSCE) were studied for three advanced supersonic airplane designs. Sensitivity of the VSCE concept to change in technology projections was evaluated in terms of impact on overall installed performance. Based on these sensitivity results critical technology requirements were reviewed resulting in the reaffirmation of the following requirements: low noise nozzle system, a high performance low emissions duct burner and main burner, hot section technology, variable geometry components and propulsion integration features including an integrated electronic control system. Author

N78-11081*# General Electric Co., Cincinnati, Ohio.
COST BENEFIT STUDY OF ADVANCED MATERIALS TECHNOLOGY FOR AIRCRAFT TURBINE ENGINES
R. V. Hillery and R. P. Johnston Sep. 1977 89 p refs
(Contract NAS3-20074)
(NASA-CR-135235) Avail: NTIS HC A05/MF A01 CSCL 21E

The cost benefits of eight advanced materials technologies were evaluated for two aircraft missions. The overall study was based on a time frame of commercial engine use of the advanced material technologies by 1985. The material technologies evaluated were eutectic turbine blades, titanium aluminide components, ceramic vanes, shrouds and combustor liners, tungsten composite FeCrAly blades, gamma prime oxide dispersion strengthened (ODS) alloy blades, and no cost ODS alloy combustor liners. They were evaluated in two conventional takeoff and landing missions, one transcontinental and one intercontinental. Author

N78-11082*# Rocketdyne, Canoga Park, Calif.
LINEAR AEROSPIKE ENGINE STUDY Final Report, Jun. 1976 - Apr. 1977
H. G. Daem and F. M. Kirby Nov. 1977 236 p refs
(Contract NAS3-20114)
(NASA-CR-135231; RI/RD77-170) Avail: NTIS HC A11/MF A01 CSCL 21A

Parametric data on split-combustor linear engine propulsion systems are presented for use in mixed mode single-stage-to-orbit (SSTO) vehicle studies. Preliminary design data for two selected engine systems are included. The split combustor was investigated for mixed-mode operations with oxygen/hydrogen propellants used in the inner combustor in Mode 2 and in conjunction with either oxygen/RP-1, oxygen/RJ-5, O2/CH4, or O2/H2 propellants in the outer combustor for Mode 1. Both gas generator and staged combustion power cycles were analyzed for providing power to the turbopumps of the inner and outer combustors. Numerous cooling circuits and cooling fluids (propellants) were analyzed and hydrogen was selected as the preferred coolant for both combustors and the linear aerospike nozzle. The maximum operating chamber pressure was determined to be limited by the availability of hydrogen coolant pressure drop in the coolant circuit. Author

N78-12081*# Pratt and Whitney Aircraft Group, West Palm Beach, Fla. Government Products Div.
EVALUATION OF A LOW ASPECT RATIO SMALL AXIAL COMPRESSOR STAGE, VOLUME 1 Final Report
C. W. Sawyer, III Nov. 1977 148 p refs
(Contract NAS3-19424)
(NASA-CR-135240; PWA-FR-8499-Vol-1) Avail: NTIS HC A07/MF A01 CSCL 21E

A program was conducted to evaluate the effects of scaling tip clearance and IGV reset on the performance of a low aspect ratio compressor stage. Stage design was obtained by scaling an existing single stage compressor by a linear factor of 0.304. The design objective was to maintain the meanline velocity field of the base machine in the smaller size. Adjustments were made to account for predicted blockage differences and to chord lengths and airfoil edge radii to obtain reasonable blade geometries. Meanline velocity diagrams of the base stage were not maintained at the scaled size. At design speed and flowrate the scaled stage achieved a pressure ratio of 1.423, adiabatic efficiency of 0.822 and surge margin of 18.5%. The corresponding performance parameters for the base stage were 1.480, 0.872, and 23.2%, respectively. The base stage demonstrated a peak efficiency at design speed of 0.872; the scaled stage achieved a level of 0.838. When the scaled stage rotor and stator tip clearances were doubled, the stage achieved a pressure ratio of 1.413, efficiency of 0.799, and surge margin of 16.0% at the design flowrate. The peak stage efficiency at design speed was 0.825 with the increased clearance. Increased prewhirl lowered the stage pressure ratio as expected. Stage efficiency was maintained with ten degrees of increased prewhirl and then decreased substantially with ten additional degrees of reset. Author

N78-12082*# Pratt and Whitney Aircraft Group, West Palm Beach, Fla. Government Products Div.
EVALUATION OF A LOW ASPECT RATIO SMALL AXIAL COMPRESSOR STAGE, VOLUME 2 Final Report
C. W. Sawyer, III Nov. 1977 222 p refs
(Contract NAS3-19424)
(NASA-CR-135241; PWA-FR-8499-Vol-2) Avail: NTIS HC A10/MF A01 CSCL 21E

For abstract, see N78-12081.

N78-13062*# AiResearch Mfg. Co., Phoenix, Ariz.
COST/BENEFIT ANALYSIS OF ADVANCED MATERIAL TECHNOLOGIES FOR SMALL AIRCRAFT TURBINE ENGINES
D. H. Comey Sep. 1977 68 p refs
(Contract NAS3-20073)
(NASA-CR-135265; AiResearch-21-2381) Avail: NTIS HC A04/MF A01 CSCL 21E

Cost/benefit studies were conducted on ten advanced material technologies applicable to small aircraft gas turbine engines to be produced in the 1985 time frame. The cost/benefit studies were applied to a two engine, business-type jet aircraft in the 6800- to 9100-Kg (15,000- to 20,000-lb) gross weight class. The new material technologies are intended to provide improvements in the areas of high-pressure turbine rotor components, high-pressure turbine rotor components, high-pressure turbine stator airfoils, and static structural components. The cost/benefit of each technology is presented in terms of relative value, which is defined as a change in life cycle cost times probability of success divided by development cost. Technologies showing the most promising cost/benefits based on relative value are uncooled single crystal MAR-M 247 turbine blades, cooled DS MAR-M 247 turbine blades, and cooled DOS NiCrAl laminate turbine stator vanes. Author

N78-13067*# General Electric Co., Cincinnati, Ohio
AUGMENTOR EMISSIONS REDUCTION TECHNOLOGY PROGRAM. Final Report
W. C. Colley, M. J. Kenworthy, and D. W. Bahr Nov. 1977 185 p refs
(Contract NAS3-19737)
(NASA-CR-135215; R77AEG593) Avail: NTIS HC A08/MF A01 CSCL 21E

Technology to reduce pollutant emissions from duct burner type augmentors for use on advanced supersonic cruise aircraft was investigated. Test configurations representing variations of two duct burner design concepts, were tested in a rectangular sector rig at inlet temperature and pressure conditions corresponding to takeoff, transonic climb, and supersonic cruise flight conditions. Both design concepts used piloted flameholders to stabilize combustion of lean, premixed fuel/air mixtures. The concepts differed in the flameholder type used. High combustion efficiency (97%) and low levels of emissions (1.19 g/kg fuel) were achieved. The detailed measurements suggested the direction that future development efforts should take to obtain further reductions in emission levels and associated improvements in combustion efficiency over an increased range of temperature rise conditions. Author

N78-13068*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group
ADVANCED SUPERSONIC PROPULSION STUDY. PHASES 3 AND 4
Roy D. Allan and Warren Joy Nov. 1977 297 p refs
(Contract NAS3-19544)
(NASA-CR-135236; R77AEG635) Avail: NTIS HC A13/MF A01 CSCL 21E

An evaluation of various advanced propulsion concepts for supersonic cruise aircraft resulted in the identification of the double bypass variable cycle engine as the most promising concept. This engine design utilizes special variable geometry components and an annular exhaust nozzle to provide high take off thrust and low jet noise. The engine also provides good performance at both supersonic cruise and subsonic cruise. Emission characteristics are excellent. The advanced technology double bypass variable cycle engine offers an improvement in aircraft range performance relative to earlier supersonic jet engine designs and yet at a lower level of engine noise. Research and technology programs required in certain design areas for this engine concept to realize its potential benefits include refined parametric analysis of selected variable cycle engines, screening of additional unconventional concepts, and engine preliminary design studies. Required critical technology programs are summarized. Author

N78-13069*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
HIGH FREQUENCY DYNAMIC ENGINE SIMULATION
J. A. Schuerman, K. E. Fischer, and P. W. McLaughlin Jul. 1977 168 p refs
(Contract NAS3-20292)
(NASA-CR-135313; PWA-5543) Avail: NTIS HC A08/MF A01 CSCL 21E

A digital computer simulation of a mixed flow, twin spool turbofan engine was assembled to evaluate and improve the dynamic characteristics of the engine simulation to disturbance frequencies of at least 100 Hz. One dimensional forms of the dynamic mass, momentum and energy equations were used to model the engine. A TF30 engine was simulated so that dynamic characteristics could be evaluated against results obtained from testing of the TF30 engine at the NASA Lewis Research Center. Dynamic characteristics of the engine simulation were improved by modifying the compression system model. Modifications to the compression system model were established by investigating the influence of size and number of finite dynamic elements. Based on the results of this program, high frequency engine simulations using finite dynamic elements can be assembled so that the engine dynamic configuration is optimum with respect to dynamic characteristics and computer execution time. Resizing of the compression systems finite elements improved the dynamic characteristics of the engine simulation but showed that additional refinements are required to obtain close agreement simulation and actual engine dynamic characteristics. Author

N78-14067*# Solar Turbines International, San Diego, Calif.
WIDE RANGE OPERATION OF ADVANCED LOW NO_x COMBUSTORS FOR SUPERSONIC HIGH-ALTITUDE AIRCRAFT GAS TURBINES. Technical Report, Nov. 1975 - Aug. 1977
P. B. Roberts and R. J. FioRito Oct. 1977 44 p
(Contract NAS3-19770)
(NASA-CR-135297; RDR-1817-22) Avail: NTIS HC A03/MF A01 CSCL 21E

An initial rig program tested the Jet Induced Circulation (JIC) and Vortex Air Blast (VAB) systems in small can combustor configurations for NO_x emissions at a simulated high altitude, supersonic cruise condition. The VAB combustor demonstrated the capability of meeting the NO_x goal of 10 g NO_2/kg fuel at the cruise condition. In addition, the program served to demonstrate the limited low-emissions range available from the lean premixed combustor. A follow-on effort was concerned with the problem of operating these lean, premixed combustors with acceptable emissions at simulated engine idle conditions. Various techniques have been demonstrated that allow satisfactory operation on both the JIC and VAB combustors at idle with CO emissions below 20 g/kg fuel. The VAB combustor was limited by flashback, autoignition phenomena at the cruise conditions to a pressure of 8 atmospheres. The JIC combustor was operated up to the full design cruise pressure of 14 atmospheres without encountering an autoignition limitation although the NO_x levels, in the 2-3 g NO_2/kg fuel range, exceeded the program goal. Author

N78-15041*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
EXPERIMENTAL CLEAN COMBUSTOR PROGRAM: TURBULENCE CHARACTERISTICS OF COMPRESSOR DISCHARGE FLOWS
P. S. Follansbee and R. R. Dils Oct. 1977 43 p refs
(Contract NAS3-19447)
(NASA-CR-135277; PWA-5540) Avail: NTIS HC A03/MF A01 CSCL 21E

The results of turbulence measurements at the entrance to the diffuser duct of a large gas turbine are presented. Hot film and hot wire measurements were conducted over a compressor discharge temperature range of 450K to 808K. It was found that the turbulent intensity at the ID and midspan locations increases gradually from 6 + or - 1 percent at idle to 7 + or - 1 percent at approach; the turbulent intensity at the OD location increases from 7.5 + or - 0.5 percent at idle to 15 + or - 0.5 percent at approach. The energy in the velocity waves is

uniformly distributed over a 0.1 to 5 kHz bandwidth, and the cut-off frequency is not a strong function of the engine operation. The axial length of the Fourier components within this bandwidth varies from 0.021 to 1.05m. The turbulence near the diffuser O.D. is of sufficient amplitude and scale to affect the flow to the front end sections of the burner. Author

N78-18052*# Fiber Science, Inc., Gardena, Calif.
FILAMENT-WINDING FABRICATION OF QCSEE CONFIGURATION FAN BLADES
Sam Yao Jan 1978 22 p
(Contract NAS3-20039)
(NASA-CR-135332) Avail: NTIS HC A02/MF A01 CSCL 21E

The design and fabrication of twelve NASA-QCSEE type composite fan blades utilizing wet filament winding fabrication techniques is described. All composite fibers were continuous and attached to the root end. All components were formed, bonded, and co-cured in one molding process. Advanced fiber materials used in the blade fabrication were Thornel-300, Carbolon Z-2-1, and Carbolon Z-3 graphite in an epoxy resin matrix. Author

N78-18054*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
AN ANALYTICAL STUDY OF THERMAL BARRIER COATED FIRST STAGE BLADES IN A JT9D ENGINE
William R. Savcik and Barry L. Stoner Jan 1978 31 p refs
(Contract NAS3-21033)
(NASA-CR-135360, PWA-5590) Avail: NTIS HC A03/MF A01 CSCL 21E

Steady state and transient heat transfer and structural calculations were completed to determine the coating and base alloy temperatures and strains. Results indicate potential for increased turbine life using thin durable thermal barrier coatings on turbine airfoils due to a significant reduction in blade average and maximum temperatures and alloy strain range. An interpretation of the analytical results is compared to the experimental engine test data. Author

N78-17088*# Pratt and Whitney Aircraft, West Palm Beach, Fla. Government Products Div.
ANALYTICAL STUDY OF THERMAL BARRIER COATED FIRST-STAGE BLADES IN AN F100 ENGINE Progress Report, 1 Sep. 1977 - 31 Jan. 1978
D. E. Andrews Feb 1978 27 p
(Contract NAS3-21032)
(NASA-CR-135359; FR-9609) Avail: NTIS HC A03/MF A01 CSCL 21E

Heat transfer and stress analyses were performed on two sections of a thermal barrier coated (TBC) F100 1st-stage turbine blade. Results of the analyses indicate that the TBC on the leading edges of both sections experience the highest elastic strain ranges and these occur during transient engine operation. Further study is recommended to determine the effects of plastic deformation (creep) and creep-fatigue interaction on coating life. Author

N78-17084*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
METHOD OF FAN SOUND MODE STRUCTURE DETERMINATION Final Report
G. F. Pickett, T. G. Sofrin, and R. W. Wells Aug 1977 160 p refs
(Contract NAS3-20047)
(NASA-CR-135293, PWA 5554-3) Avail: NTIS HC A08/MF A01 CSCL 21E

A method for the determination of fan sound mode structure in the inlet of turbofan engines using in-duct acoustic pressure measurements is presented. The method is based on the simultaneous solution of a set of equations whose unknowns are modal amplitude and phase. A computer program for the solution of the equation set was developed. An additional computer program was developed which calculates microphone locations the use of which results in an equation set that does not give rise to numerical instabilities. In addition to the development of a method for determination of coherent modal structure, experimental and analytical approaches are developed for the determination of the amplitude frequency spectrum of randomly generated sound models for use in narrow annulus ducts. Two approaches are defined: one based on the use of cross-spectral techniques and the other based on the use of an array of microphones. Author

N78-17086*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
METHOD OF FAN SOUND MODE STRUCTURE DETERMINATION COMPUTER PROGRAM USER'S MANUAL: MICROPHONE LOCATION PROGRAM
G. F. Pickett, R. A. Wells, and R. A. Love Aug 1977 72 p refs
(Contract NAS3-20047)
(NASA-CR-135294; PWA-5554-4) Avail: NTIS HC A04/MF A01 CSCL 21E

A computer user's manual describing the operation and the essential features of the microphone location program is presented. The Microphone Location Program determines microphone locations that ensure accurate and stable results from the equation system used to calculate modal structures. As part of the computational procedure for the Microphone Location Program, a first-order measure of the stability of the equation system was indicated by a matrix 'conditioning' number. Author

N78-17085*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
METHOD OF FAN SOUND MODE STRUCTURE DETERMINATION COMPUTER PROGRAM USER'S MANUAL: MODAL CALCULATION PROGRAM
G. F. Pickett, R. A. Wells, and R. A. Love Aug 1977 74 p refs
(Contract NAS3-20047)
(NASA-CR-135295, PWA 5554-5) Avail: NTIS HC A04/MF A01 CSCL 21E

A computer user's manual describing the operation and the essential features of the Modal Calculation Program is presented. The modal Calculation Program calculates the amplitude and phase of modal structures by means of acoustic pressure measurements obtained from microphones placed at selected locations within the fan inlet duct. In addition the Modal Calculation Program also calculates the first-order errors in the modal coefficients that are due to tolerances in microphone location coordinates and inaccuracies in the acoustic pressure measurements. Author

N78-18070*# Pratt and Whitney Aircraft Group, West Palm Beach, Fla. Government Products Div.
F-15/NONAXISYMMETRIC NOZZLE SYSTEM INTEGRATION STUDY SUPPORT PROGRAM Contractor Report, 24 Feb. 1977 - 30 Sep. 1977
H. L. Stevens Feb 1978 171 p ref.
(Contract NAS3-20608)
(NASA-CR-135252, FR-9232) Avail: NTIS HC A08/MF A01 CSCL 21E

Nozzle and cooling methods were defined and analyzed to provide a viable system for demonstration 2-D nozzle technology on the F-15 aircraft. Two candidate cooling systems applied to each nozzle were evaluated. The F-100 engine mount and case modifications requirements were analyzed and the actuation and control system requirements for two dimensional nozzles were defined. Nozzle performance changes relative to the axisymmetric baseline nozzle were evaluated and performance and weight characteristics for axisymmetric reference configurations were estimated. The infrared radiation characteristics of these nozzles installed on the F-100 engine were predicted. A full scale development plan with associated costs to carry the F100 engine/two-dimensional (2-D) nozzle through flight tests was defined. Author

N78-19163*# Cincinnati Univ., Ohio. Dept. of Aerospace Engineering and Applied Mechanics.
ANALYSIS OF THE CROSS FLOW IN A RADIAL INFLOW TURBINE SCROLL
A Hamed, S. Abdallah, and W. Tabakoff Nov. 1977 61 p
(Grant NsG-3066)
(NASA-CR-135320) Avail: NTIS HC A04/MF A01 CSCL 21E

Equations of motion were derived, and a computational procedure is presented, for determining the nonviscous flow characteristics in the cross-sectional planes of a curved channel due to continuous mass discharge or mass addition. An analysis was applied to the radial inflow turbine scroll to study the effects of scroll geometry and the through flow velocity profile on the flow behavior. The computed flow velocity component in the scroll cross-sectional plane, together with the through flow velocity profile which can be determined in a separate analysis, provide a complete description of the three dimensional flow in the scroll. Author

N78-19164*# Cincinnati Univ., Ohio. Dept. of Aerospace Engineering and Applied Mechanics.
COMPUTER PROGRAM FOR THE ANALYSIS OF THE CROSS FLOW IN A RADIAL INFLOW TURBINE SCROLL
A Hamed, S Abdallah, and W. Tabakoff Nov. 1977 56 p
(Grant NsG-3066)
(NASA-CR-135321) Avail: NTIS HC A04/MF A01 CSCL 21E

A computer program was used to solve the governing of the potential flow in the cross sectional planes of a radial inflow turbine scroll A list of the main program, the subroutines, and typical output example are included. Author

N78-19180*# Pratt and Whitney Aircraft, East Hartford, Conn. Commercial Products Div
VCE TESTBED PROGRAM PLANNING AND DEFINITION STUDY Final Report
J S Westmoreland and J. Godston Jan 1978 82 p
(Contract NAS3-20048)
(NASA-CR-135362; PWA-5546-7) Avail: NTIS HC A05/MF A01 CSCL 21E

The flight definition of the Variable Stream Control Engine (VSCE) was updated to reflect design improvements in the two key components: (1) the low emissions duct burner, and (2) the coannular exhaust nozzle The testbed design was defined and plans for the overall program were formulated The effect of these improvements was evaluated for performance, emissions, noise, weight, and length For experimental large scale testing of the duct burner and coannular nozzle, a design definition of the VCE testbed configuration was made This included selecting the core engine, determining instrumentation requirements, and selecting the test facilities, in addition to defining control system and assembly requirements Plans for a comprehensive test program to demonstrate the duct burner and nozzle technologies were formulated. The plans include both aeroacoustic and emissions testing Author

N78-20129*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group
LONG-TERM CF6 ENGINE PERFORMANCE DETERIORATION: EVALUATION OF ENGINE S/N 481-479 Final Report
W H Kramer and J J Smith Feb 1978 118 p
(Contract NAS3-20631)
(NASA-CR-135381) Avail NTIS HC A06/MF A01 CSCL 21E

The performance testing and analytical teardown of CF6-6D engine is summarized This engine had completed its initial installation on DC-10 aircraft The investigative test program was conducted inbound prior to normal overhaul/refurbishment. The performance testing included an inbound test, a test following cleaning of the low pressure turbine airfoils, and a final test after leading edge rework and cleaning the stage one fan blades The analytical teardown consisted of detailed disassembly inspection measurements and airfoil surface finish checks of the as received deteriorated hardware. Included in this report is a detailed analysis of the test cell performance data, a complete analytical teardown report with a detailed description of all observed hardware distress, and an analytical assessment of the performance loss (deterioration) relating measured hardware conditions to losses in both SFC (specific fuel consumption) and EGT (exhaust gas temperature). Author

N78-21111*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commerical Products Div.
EVALUATION OF FEDERAL AVIATION ADMINISTRATION ION ENGINE EXHAUST SAMPLING RAKE Final Report
A. J. Fiorentino, W. Greene, and R. Roberts Jun. 1977 61 p ref
(Contracts NAS3-19447; DOT-FA77WAI-708)
(NASA-CR-135213; PWA-5534; FAA-RD-77-115) Avail: NTIS HC A04/MF A01 CSCL 21E

A FAA exhaust emissions rake was tested in the Experimental Clean Combustor Program, Phase 3 to permit comparison of the values of gaseous emissions and smoke measured by the FAA rake with those measured with the NASA Pratt and Whitney Aircraft (P and WA) rake used in the Phase 3 Experimental Clean Combustor Program and with station seven probes. The results showed that the levels of CO, THC, NOx and smoke measured by the FAA and NASA/P and WA rakes agree well at high power, but that CO emissions measured by the FAA rake were approximately 10 percent higher than those measured by the NASA/P and WA rake at low power. Author

N78-21147*# General Electric Co., Evendale, Ohio. Aircraft Engine Group.
EFFECTS OF FILM INJECTION ON PERFORMANCE OF A COOLED TURBINE
James D. McDonel and James E Eiswerth *In* AGARD High Temp. Probl. in Gas Turbine Eng. Feb. 1978 11 p refs (For availability see N78-21118 12-07)
(Contract NAS3-16732)
Avail: NTIS HC A25/MF A01

Tests were conducted in a 20 inch diameter single stage air cooled turbine designed to evaluate the effects of film cooling air on turbine aerodynamic performance. A comparison was made of the experimental results and an analytical method of evaluating film injection effects on turbine performance. The results are used to determine the effects of film cooling on overall engine performance for selected cycle conditions The engine performance studies are used to show the cycle benefits of increased gas temperature at various coolant flow rates. Author

N78-22086*# Pratt and Whitney Aircraft Group, East Hartford, Conn.
F100(3) PARALLEL COMPRESSOR COMPUTER CODE AND USER'S MANUAL Contractor Report, Mar. 1977 - Feb. 1978
R. S. Mazzawy, D. A. Fulkerson, D. E. Haddad, and T. A. Clark May 1978 52 p refs
(Contract NAS3-20610)
(NASA-CR-135388; PWA-5549-8) Avail: NTIS HC A04/MF A01 CSCL 21E

The Pratt & Whitney Aircraft multiple segment parallel compressor model has been modified to include the influence of variable compressor vane geometry on the sensitivity to circumferential flow distortion. Further, performance characteristics of the F100 (3) compression system have been incorporated into the model on a blade row basis. In this modified form, the distortion's circumferential location is referenced relative to the variable vane controlling sensors of the F100 (3) engine so that the proper solution can be obtained regardless of distortion orientation. This feature is particularly important for the analysis of inlet temperature distortion. Compatibility with fixed geometry compressor applications has been maintained in the model.
Author

N78-23089*# General Electric Co., Cincinnati, Ohio.
QCSEE TASK 2: ENGINE AND INSTALLATION PRELIMINARY DESIGN Final Report
R. Neitzel, R. Lee, and A. J. Chamay Jun. 1973 350 p refs (Contract NAS3-16726)
(NASA-CR-134738) Avail: NTIS HC A15/MF A01 CSCL 21E

High-bypass turbofan engines with features required for commercial short haul powered lift transports were designed. Two engines were configured for each of the externally blown flap installations, under-the-wing and over-the-wing. Estimates of installed and uninstalled performance, noise, and weight were defined for each propulsion system. Author

N78-24141*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
DEVELOPMENT OF A PLASMA SPRAYED CERAMIC GAS PATH SEAL FOR HIGH PRESSURE TURBINE APPLICATION Final Report, 9 Jun. 1977 - 9 Jan. 1978
L. T. Shiembob May 1978 86 p
(Contract NAS3-20623)
(NASA-CR-135387; PWA-5569-12) Avail: NTIS HC A05/MF A01 CSCL 21E

Development of the plasma sprayed graded, layered ZRO2/CoCrAlY seal system for gas turbine engine blade tip seal applications up to 1589 K (2400 F) surface temperature was continued. The effect of changing ZRO2/CoCrAlY ratios in the intermediate layers on thermal stresses was evaluated analytically with the goal of identifying the materials combinations which would minimize thermal stresses in the seal system. Three methods of inducing compressive residual stresses in the sprayed seal materials to offset tensile thermal stresses were analyzed. The most promising method, thermal prestraining, was selected based upon potential, feasibility and complexity considerations. The plasma spray equipment was modified to heat, control and monitor the substrate temperature during spraying. Specimens were fabricated and experimentally evaluated to (1) substantiate the capability of the thermal prestrain method to develop compressive residual stresses in the sprayed structure and (2) define the effect of spraying on a heated substate on abradability, erosion and thermal shock characteristics of the seal system. Thermal stress analysis, including residual stresses and material properties variations, was performed and correlated with thermal shock test results. Seal system performance was assessed and recommendations for further development were made. Author

N78-26147*# General Applied Science Labs., Inc., Westbury, N. Y.
EXPERIMENTAL STUDY OF THE EFFECTS OF FLAMEHOLDER GEOMETRY ON EMISSIONS AND PERFORMANCE OF LEAN PREMIXED COMBUSTORS Final Report
Gerald Rolfe and K. S. Venkataramani Apr. 1978 89 p refs (Contract NAS3-20603)
(NASA-CR-135424; GASL-TR-249) Avail: NTIS HC A05/MF A01 CSCL 21E

Emissions of NOx, CO, and unburned hydrocarbons (UHC) are reported for a lean premixed propane-air system at inlet conditions of 800K and 1MPa using twelve flameholder designs. The flameholders tested represent six design concepts with two values of blockage for each concept. Data were obtained at reference velocities of 35 m/s, 25 m/s and 20 m/s at combustor stations 10 cm and 30 cm downstream of the flameholders. Flameholder pressure drop was found to be a principal determinant of emissions performance. Designs producing larger pressure drops also produced less NOx, CO, and UHC emissions. The lean stability limit equivalence ratio was found to be approximately 0.35 for all designs. Flashback velocities (axial components in the flameholder passages) varied between 30 m/s and 40 m/s. A perforated plate flameholder was operated with a velocity as low as 23 m/s through the perforations at equivalence ratio 0.7 without producing flashback. Author

N78-27126*# Boeing Commercial Airplane Co., Seattle, Wash.
JT9D ENGINE DIAGNOSTICS. TASK 2: FEASIBILITY STUDY OF MEASURING IN-SERVICE FLIGHT LOADS
P. G. Kafka, M. A. Skibo, and J. L. White 15 Oct. 1977 68 p refs
(Contract NAS3-20632)
(NASA-CR-135395; D8-44664) Avail: NTIS HC A04/MF A01 CSCL 21E

The feasibility of measuring JT9D propulsion system flight inertia loads on a 747 airplane is studied. Flight loads background is discussed including the current status of 747/JT9D loads knowledge. An instrumentation and test plan is formulated for an airline-owned in-service airplane and the Boeing-owned RA001 test airplane. Technical and cost comparisons are made between these two options. An overall technical feasibility evaluation is made and a cost summary presented. Conclusions and recommendations are presented in regard to using existing inertia loads data versus conducting a flight test to measure inertia loads. Author

N78-27129*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
FABRICATION AND TEST OF DIGITAL OUTPUT INTERFACE DEVICES FOR GAS TURBINE ELECTRONIC CONTROLS Final Report
D. M. Newirth and E. W. Koenig May 1978 59 p
(Contract NAS3-19898)
(NASA-CR-135427; PWA-5544-13) Avail: NTIS HC A04/MF A01 CSCL 21E

A program was conducted to develop an innovative digital output interface device, a digital effector with optical feedback of the fuel metering valve position, for future electronic controls for gas turbine engines. A digital effector (on-off solenoids driven directly by on-off signals from a digital electronic controller) with optical position feedback was fabricated, coupled with the fuel metering valve, and tested under simulated engine operating conditions. The testing indicated that a digital effector with optical position feedback is a suitable candidate, with proper development for future digital electronic gas turbine controls. The testing also identified several problem areas which would have to be overcome in a final production configuration. Author

N78-28086*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
ACOUSTIC TESTS OF DUCT-BURNING TURBOFAN JET NOISE SIMULATION: COMPREHENSIVE DATA REPORT. VOLUME 1, SECTION 2: FULL SIZE DATA Final Report
P. H. Heck, D. Latham, J. F. Brausch, E. J. Stringas, P. S. Staid, and P. R. Knott Aug. 1978 832 p
(Contract NAS3-18008)
(NASA-CR-135239-Vol-1-Sect-2) Avail: NTIS HC A99/MF A01 CSCL 21E

Acoustic data are presented scaled to a full size engine by a factor of 8 on a 96.9 m (320 ft) arc and a 731.5 m (2400 ft) sideline. D.L.G.

N78-28087*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
ACOUSTIC TESTS OF DUCT-BURNING TURBOFAN JET NOISE SIMULATION: COMPREHENSIVE DATA REPORT. VOLUME 1, SECTION 3: DATA PLOTS Final Report
P. H. Heck, D. Latham, J. F. Brausch, E. J. Stringas, P. S. Staid, and P. R. Knott Aug. 1978 520 p
(Contract NAS3-18008)
(NASA-CR-135239-Vol-1-Sect-3) Avail: NTIS HC A22/MF A01 CSCL 21E

Acoustic data plots are presented which were obtained in the tests on scale nozzles for use on duct-burning turbofan engines. D.L.G.

N78-28087*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
ACOUSTIC TESTS OF DUCT-BURNING TURBOFAN JET NOISE SIMULATION: COMPREHENSIVE DATA REPORT. VOLUME 2: MODEL DESIGN AND AERODYNAMIC TEST RESULTS Final Report
P. H. Heck, D. Latham, J. F. Brausch, E. J. Stringas, P. S. Staid, and P. R. Knott Aug. 1978 229 p refs
(Contract NAS3-18008)
(NASA-CR-135239-Vol-2) Avail: NTIS HC A11/MF A01 CSCL 21E

The selection procedure is described which was used to arrive at the configurations tested, and the performance characteristics of the test nozzles are given. D.L.G.

N78-28088*# General Applied Science Labs., Inc., Westbury, N. Y.
EXPERIMENTAL STUDY OF THE EFFECT OF CYCLE PRESSURE ON LEAN COMBUSTION EMISSIONS Final Report
Gerald Roffe and K. S. Venkataramani Washington NASA Jul. 1978 51 p
(Contract NAS3-20581)
(NASA-CR-3032; GASL-TR-248) Avail: NTIS HC A04/MF A01 CSCL 21E

Experiments were conducted in which a stream of premixed propane and air was burned under conditions representative of gas turbine operation. Emissions of NOx, CO, and unburned hydrocarbons (UHC) were measured over a range of combustor inlet temperature, pressure, and residence time at equivalence ratios from 0.7 down to the lean stability limit. At an inlet temperature of 600 K, observed NOx levels dropped markedly with decreasing pressure for pressures below 20 atm. The NOx levels are proportional to combustor residence time and formation rates were principally a function of adiabatic flame temperature. For adiabatic flame temperatures of 2050 K and higher, CO reached chemical equilibrium within 2 msec. Unburned hydrocarbon species dropped to a negligible level within 2 msec regardless of inlet temperature, pressure, or equivalence ratio. For a combustor residence time of 2.5 msec, combustion inefficiency became less than 0.01% at an adiabatic flame temperature of 2050 K. The maximum combustion inefficiency observed was on the order of 1% and corresponded to conditions near the lean stability limit. Using a perforated plate flameholder, this limit is well represented by the condition of 1800 K adiabatic flame temperature. Author

N78-28089*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
CORE COMPRESSOR EXIT STAGE STUDY. VOLUME 1: BLADING DESIGN Design Report, Oct. 1976 - Apr. 1977
D. C. Wisler Dec. 1977 67 p refs
(Contract NAS3-20070)
(NASA-CR-135391; Doc-R77AEG400-Vol-1) Avail: NTIS HC A04/MF A01 CSCL 21E

A baseline compressor test stage was designed as well as a candidate rotor and two candidate stators that have the potential of reducing endwall losses relative to the baseline stage. These test stages are typical of those required in the rear stages of advanced, highly-loaded core compressors. The baseline Stage A is a low-speed model of Stage 7 of the 10 stage AMAC compressor. Candidate Rotor B uses a type of meanline in the tip region that unloads the leading edge and loads the trailing edge relative to the baseline Rotor A design. Candidate Stator B embodies twist gradients in the endwall region. Candidate Stator C embodies airfoil sections near the endwalls that have reduced trailing edge loading relative to Stator A. Tests will be conducted using four identical stages of blading so that the designs described will operate in a true multistage environment. A.R.H.

N78-28103*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
LONG-TERM CF6 ENGINE PERFORMANCE DETERIORATION: EVALUATION OF ENGINE S/N 451-380 Final Report
W. H. Kramer and J. J. Smith Aug. 1978 112 p
(Contract NAS3-20631)
(NASA-CR-159390) Avail: NTIS HC A06/MF A01 CSCL 21E

The performance testing and analytical teardown of CF6-6D engine serial number 451-380 which was recently removed from a DC-10 aircraft is summarized. The investigative test program was conducted inbound prior to normal overhaul/refurbishment. The performance testing included an inbound test, a test following cleaning of the low pressure turbine airfoils, and a final test after leading edge rework and cleaning the stage one fan blades. The analytical teardown consisted of detailed disassembly inspection measurements and airfoil surface finish checks of the as-received deteriorated hardware. Aspects discussed include the analysis of the test cell performance data, a complete analytical teardown report with a detailed description of all observed hardware distress, and an analytical assessment of the performance loss (deterioration) relating measured hardware conditions to losses in both specific fuel consumption and exhaust gas temperature. A.R.H.

N78-28104*# General Electric Co., Cincinnati, Ohio.
DESIGN OF IMPACT-RESISTANT BORON/ALUMINUM LARGE FAN BLADE
C. T. Salemme and S. A. Yokel Jul. 1978 93 p refs
(Contract NAS3-21041)
(NASA-CR-135417) Avail: NTIS HC A05/MF A01 CSCL 21E

The technical program was comprised of two technical tasks. Task 1 encompassed the preliminary boron/aluminum fan blade design effort. Two preliminary designs were evolved. An initial design consisted of 32 blades per stage and was based on material properties extracted from manufactured blades. A final design of 36 blades per stage was based on rule-of-mixture material properties. In Task 2, the selected preliminary blade design was refined via more sophisticated analytical tools. Detailed finite element stress analysis and aero performance analysis were carried out to determine blade material frequencies and directional stresses. L.S.

N78-28105*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
EFFECT OF STEADY FLIGHT LOADS ON JT9D-7 PERFORMANCE DETERIORATION
A. Jay and E. S. Todd 9 Jun. 1978 103 p refs
(Contract NAS3-20632)
(NASA-CR-135407; PWA-5512-24) Avail: NTIS HC A06/MF A01 CSCL 21E

Short term engine deterioration occurs in less than 250 flights on a new engine and in the first flights following engine repair; while long term deterioration involves primarily hot section distress and compression system losses which occur at a somewhat slower rate. The causes for short-term deterioration are associated with clearance changes which occur in the flight environment. Analytical techniques utilized to examine the effects of flight loads and engine operating conditions on performance deterioration are presented. The role of gyroscopic, gravitational, and aerodynamic loads are discussed along with the effect of variations in engine build clearances. These analytical results are compared to engine test data along with the correlation between analytically predicted and measured clearances and rub patterns. Conclusions are drawn and important issues are discussed. A.R.H.

N78-31103*# Pratt and Whitney Aircraft Group, West Palm Beach, Fla. Government Products Div.
ADVANCED OPTICAL BLADE TIP CLEARANCE MEASUREMENT SYSTEM
M. J. Ford, R. E. Honeycutt, R. E. Nordlund, and W. W. Robinson Jul. 1978 85 p refs
(Contract NAS3-20479)
(NASA-CR-159402; FR-10200A) Avail: NTIS HC A05/MF A01 CSCL 21E

An advanced electro-optical system was developed to measure single blade tip clearances and average blade tip clearances between a rotor and its gas path seal in an operating gas turbine engine. This system is applicable to fan, compressor, and turbine blade tip clearance measurement requirements, and the system probe is particularly suitable for operation in the extreme turbine environment. A study of optical properties of blade tips was conducted to establish measurement system application limitations. A series of laboratory tests was conducted to determine the measurement system's operational performance characteristics and to demonstrate system capability under simulated operating gas turbine environmental conditions. Operational and environmental performance test data are presented. Author

N78-31108*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
ENERGY EFFICIENT ENGINE: PRELIMINARY DESIGN AND INTEGRATION STUDIES Final Report, Jan. 1977 - Apr. 1978
R. P. Johnston, R. Hirschkron, C. C. Koch, R. E. Neitzel, and P. W. Vinson Sep. 1978 417 p refs
(Contract NAS3-20627)
(NASA-CR-135444; R78AEG510) Avail: NTIS HC A18/MF A01 CSCL 21E

Parametric design and mission evaluations of advanced turbofan configurations were conducted for future transport aircraft application. Economics, environmental suitability and fuel efficiency were investigated and compared with goals set by NASA. Of the candidate engines which included mixed- and separate-flow, direct-drive and geared configurations, an advanced mixed-flow direct-drive configuration was selected for further design and evaluation. All goals were judged to have been met except the acoustic goal. Also conducted was a performance risk analysis and a preliminary aerodynamic design of the 10 stage 23:1 pressure ratio compressor used in the study engines. Author

N78-32086*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
COMPRESSOR SEAL RUB ENERGETICS STUDY Final Report, 8 Apr. 1977 - 8 Apr. 1978
W. F. Laverty May 1978 139 p refs
(Contract NAS 3-20613)
(NASA-CR-159424; PWA-5616) Avail: NTIS HC A07/MF A01 CSCL 21E

The rub mechanics of compressor abradable blade tip seals at simulated engine conditions were investigated. Twelve statistically planned, instrumented rub tests were conducted with titanium blades and Feltmetal fibermetal rubstrips. The tests were conducted with single stationary blades rubbing against seal material bonded to rotating test disks. The instantaneous rub torque, speed, incursion rate and blade temperatures were continuously measured and recorded. Basic rub parameters (incursion rate, rub depth, abradable density, blade thickness and rub velocity) were varied to determine the effects on rub energy and heat split between the blade, rubstrip surface and rub debris. The test data was reduced, energies were determined and statistical analyses were completed to determine the primary and interactive effects. Wear surface morphology, profile measurements and metallographic analysis were used to determine wear, glazing, melting and material transfer. The rub energies for these tests were most significantly affected by the incursion rate while rub velocity and blade thickness were of secondary importance. The ratios of blade wear to seal wear were representative of those experienced in engine operation of these seal system materials. Author

N78-32087*# General Electric Co., Cincinnati, Ohio.
AIRCRAFT GAS TURBINE LOW-POWER EMISSIONS REDUCTION TECHNOLOGY PROGRAM Final Report
W. J. Dodds, C. C. Gleason, and D. W. Behr Oct. 1978 161 p refs
(Contract NAS3-20580)
(NASA-CR-135434; Doc-R78AEG408) Avail: NTIS HC A08/MF A01 CSCL 21E

Advanced aircraft turbine engine combustor technology was used to reduce low-power emissions of carbon monoxide and unburned hydrocarbons to levels significantly lower than those which were achieved with current technology. Three combustor design concepts, which were designated as the hot-wall liner concept, the recuperative-cooled liner concept, and the catalyst converter concept, were evaluated in a series of CF6-50 engine size 40 degree-sector combustor rig tests. Twenty-one configurations were tested at operating conditions spanning the design condition which was an inlet temperature and pressure of 422 K and 304 kPa, a reference velocity of 23 m/s and a fuel-air-ratio of 10.5 g/kg. At the design condition typical of aircraft turbine engine ground idle operation, the best configurations of all three concepts met the stringent emission goals which were 10, 1, and 4 g/kg for CO, HC, and Nox, respectively. G.G.

N78-33103*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
BLADE ROW DYNAMIC DIGITAL COMPRESSION PROGRAM. VOLUME 2: JSC CIRCUMFERENTIAL DISTORTION REDISTRIBUTION MODEL, EFFECT OF STATOR CHARACTERISTICS, AND STAGE CHARACTERISTICS SENSITIVITY STUDY
W. A. Tesch and W. G. Steenken Jul. 1978 76 p refs
(Contract NAS3-18526)
(NASA-CR-134953; R78AEG484-Vol-2) Avail: NTIS HC A04/MF A01 CSCL 21E

The results of dynamic digital blade row compressor model studies of a J85-13 engine are reported. The initial portion of the study was concerned with the calculation of the circumferential redistribution effects in the blade-free volumes forward and aft of the compression component. Although blade-free redistribution effects were estimated, no significant improvement over the parallel-compressor type solution in the prediction of total-pressure inlet distortion stability limit was obtained for the J85-13 engine. Further analysis was directed to identifying the rotor dynamic response to spatial circumferential distortions. Inclusion of the rotor dynamic response led to a considerable gain in the ability of the model to match the test data. The impact of variable stator loss on the prediction of the stability limit was evaluated. An assessment of measurement error on the derivation of the stage characteristics and predicted stability limit of the compressor was also performed. Author

N78-33104*# AiResearch Mfg. Co., Phoenix, Ariz.
POLLUTION REDUCTION TECHNOLOGY PROGRAM FOR SMALL JET AIRCRAFT ENGINES, PHASE 2 Final Report
T. W. Bruce, F. G. Davis, T. E. Kuhn, and H. C. Mongia Sep. 1978 187 p refs
(Contract NAS3-20044)
(NASA-CR-159415; AiResearch-21-2817) Avail: NTIS HC A09/MF A01 CSCL 21A

A series of iterative combustor pressure rig tests were conducted on two combustor concepts applied to the AiResearch TFE731-2 turbofan engine combustion system for the purpose of optimizing combustor performance and operating characteristics consistant with low emissions. The two concepts were an axial air-assisted airblast fuel injection configuration with variable-geometry air swirlers and a staged premix/prevaporization configuration. The iterative rig testing and modification sequence on both concepts was intended to provide operational compatibility with the engine and determine one concept for further evaluation in a TFE731-2 engine. Author

A78-17396 * Sound separation probes for flowing duct noise measurements. M. T. Moore (General Electric Co., Aircraft Engine Group, Cincinnati, Ohio). *In: International Instrumentation Symposium, 23rd, Las Vegas, Nev., May 1-5, 1977, Proceedings.* (A78-17351 05-35) Pittsburgh, Pa., Instrument Society of America, 1977, p. 451-459. Contract No. NAS3-18021.

In order to understand the propagation of broadband sound from a device such as a jet engine, it is necessary to make fluctuating pressure measurements in the ducted airstream. However, in a flowing duct, fluctuating pressure energy can be due to both turbulence and sound travelling in the duct. By using the principal that sound waves and turbulent flow pressure perturbations travel at different velocities, a probe has been developed that provides the data necessary to separate the energy due to sound from that due to turbulence. A mini-computer based FFT analysis of the probe measurements provides the overall level of the broadband sound in the duct as well as the spectral distribution of the sound energy. (Author)

A78-23893 * Optimal controls for an advanced turbofan engine. G. L. Slater (Cincinnati, University, Cincinnati, Ohio). *In: Joint Automatic Control Conference, San Francisco, Calif., June 22-24, 1977, Proceedings. Volume 2.* (A78-23851 08-63) New York, Institute of Electrical and Electronics Engineers, Inc., 1977, p. 1038-1043. 10 refs. Contract No. NAS3-18021.

Linear optimal control theory is applied to the control synthesis of a high bypass ratio, variable pitch, turbofan engine. The basic control philosophy is to use only a low order dynamic model of the plant coupled with the concept of integral-output states so as to maintain control simplicity yet guarantee integral control of thrust, turbine temperature and other important engine outputs. Linear simulation results indicate that the control system developed provides rapid control of small thrust perturbations and quickly eliminates the effect of unmodelled thrust and temperature disturbances. Large thrust accelerations are obtained in about one half second while the control maintains negligible overshoot in temperature and stall margins. (Author)

A78-23518 * # Failure detection and correction for turbofan engines. R. C. Corley (General Electric Co., Group Engineering Div., Cincinnati, Ohio) and H. A. Spang, III (GE Research and Development Center, Schenectady, N.Y.). *AIChE, ASME, IEEE, ISA, and SME, Joint Automatic Control Conference, San Francisco, Calif., June 22-24, 1977, Paper.* 7 p. Contract No. NAS3-18021.

In this paper, a failure detection and correction strategy for turbofan engines is discussed. This strategy allows continuing control of the engines in the event of a sensor failure. An extended Kalman filter is used to provide the best estimate of the state of the engine based on currently available sensor outputs. Should a sensor failure occur the control is based on the best estimate rather than the sensor output. The extended Kalman filter consists of essentially two parts, a nonlinear model of the engine and up-date logic which causes the model to track the actual engine. Details on the model and up-date logic are presented. To allow implementation, approximations are made to the feedback gain matrix which result in a single feedback matrix which is suitable for use over the entire flight envelope. The effect of these approximations on stability and response is discussed. Results from a detailed nonlinear simulation indicate that good control can be maintained even under multiple failures. (Author)

A78-24902 * # Effects of film injection on performance of a cooled turbine. J. D. McDonel and J. E. Eiswerth (General Electric Co., Aircraft Engine Group, Evendale, Ohio). *NATO, AGARD, Propulsion and Energetics Panel Meeting, 50th, Middle East Technical University, Ankara, Turkey, Sept. 19-23, 1977, Paper.* 10 p. Contract No. NAS3-16732.

Some of the most dramatic increases in the performance of turbojet and turbofan aircraft engines have been obtained as a result of increased thermodynamic cycle temperatures made possible by the use of film cooling techniques. The realization of the potential performance gains, however, is only possible if the quantity of cooling air and the aerodynamic mixing losses resulting from the injection of coolant in the form of film on the flowpath surfaces are minimized. Such a minimization requires a more complete understanding of the relationship between cooling and aerodynamics. A review is conducted of tests which have been conducted to determine the effects of coolant injection on turbine performance. The results obtained in the tests are compared with an analytical technique developed for predicting coolant injection effects. Particular attention is given to the effects of turbine cooling on overall cycle thermodynamic efficiency, taking into account incremental changes in turbine thermodynamic efficiency for various incremental changes in coolant flow rate. G.R.

A78-45097 * # Fuel consumption improvement in current transport engines. R. W. Hines (United Technologies Corp., Pratt and Whitney Aircraft Group, East Hartford, Conn.) and J. A. Ziemianski (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Joint Propulsion Conference, 14th, Las Vegas, Nev., July 25-27, 1978, AIAA Paper 78-930.* 7 p. 7 refs. Contracts No. NAS3-20630; No. NAS3-20632.

A review is conducted of improvements which can be made with respect to the fuel consumption of current engines and new production versions of current engines. A description is presented of an engine diagnostics program which has the objective to identify and quantify the causes and sources of performance deterioration in the JT9D turbofan engine and to develop basic data which will be applied to minimize performance degradation of current and future engines. General areas where performance losses occur are examined, taking into account seals, blades and vanes, and cases. Potential performance improvement concepts are related to improved component aerodynamics, improved flowpath sealing, blade tip clearance control, improved turbine cooling effectiveness, improved turbine materials and coatings, duct and nozzle aerodynamic refinements, nacelle aerodynamic refinements, forced exhaust mixers, advanced nacelle materials, and advanced fuel control. G.R.

08 AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots

N78-27137*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

REAL TIME DIGITAL PROPULSION SYSTEM SIMULATION FOR MANNED FLIGHT SIMULATORS

James R. Mihaloew and Clint E. Hart 1978 45 p refs Presented at the 14th Propulsion Conf., Las Vegas, Nev., 25-27 Jul. 1978; sponsored by AIAA and the Soc. of Automotive Engr.

(NASA-TM-78958; E-9710) Avail: NTIS HC A03/MF A01 CSCL 01C

A real time digital simulation of a STOL propulsion system was developed which generates significant dynamics and internal variables needed to evaluate system performance and aircraft interactions using manned flight simulators. The simulation ran at a real-to-execution time ratio of 8.8. The model was used in a piloted NASA flight simulator program to evaluate the simulation technique and the propulsion system digital control. The simulation is described and results shown. Limited results of the flight simulation program are also presented. Author

09 RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

For related information see also *14 Ground Support Systems and Facilities (Space).*

N78-13077*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMBUSTOR FLUCTUATING PRESSURE MEASUREMENTS IN-ENGINE AND IN A COMPONENT TEST FACILITY: A PRELIMINARY COMPARISON

Meyer Reshotko and Allen Karchmer 1977 19 p refs Presented at 94th Meeting of the Acoust. Soc. Am., Miami Beach, Fla., 13-16 Dec. 1977

(NASA-TM-73845; E-9432) Avail: NTIS HC A02/MF A01 CSCL 14B

In a program to investigate combustor noise, measurements were made with a YF-102 engine of combustor internal fluctuating pressure and far field noise. The relationship of far field noise to engine internal measurement was ascertained. The relationships between combustor internal measurements obtained in an engine and those obtained in a component test facility were established by using a YF-102 combustor, instrumented identically with that used in the engine tests. The combustor was operated in a component test facility over a range of conditions encompassing engine operation. A comparison of the directly measured spectra at corresponding locations in the two tests showed significant differences. The results of two point signal analyses within each combustor, were similar for both tests, indicating that the internal dynamics of the combustor as an acoustic source are preserved in a component test facility. Author

N78-15069*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE ERDA/LeRC PHOTOVOLTAIC SYSTEMS TEST FACILITY

Americo F. Forestieri Sep. 1977 12 p refs Presented at 1977 Photovoltaics Solar Energy Conf., Comm. of the European Communities, Luxembourg, 27-30 Sep. 1977

(Contract E(49-26)-1022)

(NASA-TM-73787; ERDA/NASA-1022/77/19) Avail: NTIS HC A02/MF A01 CSCL 14B

A test facility was designed, and built to provide a place where photovoltaic systems may be assembled and electrically configured, to evaluate system performance and characteristics. The facility consists of a solar cell array of an initial 10-kW peak power rating, test hardware for several alternate methods of power conditioning, a variety of loads, an electrical energy storage system, and an instrumentation and data acquisition system. Author

A78-45095* # Real time digital propulsion system simulation for manned flight simulators. J. R. Mihaloew and C. E. Hart (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Joint Propulsion Conference, 14th, Las Vegas, Nev., July 25-27, 1978, AIAA Paper 78-927.* 44 p. 7 refs.

The QCSEE (Quiet, Clean Short-haul Experimental Engine) Program was initiated by NASA to develop and demonstrate propulsion system technology for an advanced commercial STOL aircraft. One of the specific technical objectives was to provide technology for digital electronic control of future commercial engines. An element of this technology development was to evaluate the digital control in a simulated flight environment. In this connection a simulation program was initiated to evaluate the QCSEE UTW (Under-the-Wing) digital control system over a range of conditions encountered in typical airport operations. The goal of the simulation effort was to derive a real time digital propulsion simulation which could be integrated into a multiengine aircraft simulation. A summary is provided of the accomplishments which have been made in this program. G.R.

12 ASTRONAUTICS (GENERAL)

For extraterrestrial exploration see *91 Lunar and Planetary Exploration.*

N78-10129*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PROCEEDINGS OF THE SPACECRAFT CHARGING TECHNOLOGY CONFERENCE Interim Report
C. P. Pike, ed. and R. R. Lovell, ed. 24 Feb. 1977 885 p refs Conf. held at Colorado, 27-29 Oct. 1976; Sponsored by NASA and AFGL
(AF Proj. 7661)
(NASA-TM-X-73537; AFGL-TR-77-0051; AFSG-364) Avail: NTIS HC A99/MF A01 CSCL 22B

Over 50 papers from the spacecraft charging conference are included on subjects such as: (1) geosynchronous plasma environment, (2) spacecraft modeling, (3) spacecraft materials characterization, (4) spacecraft materials development, and (5) satellite design and test. For individual titles, see N78-10130 through N78-10182.

N78-10135*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY REPORT ON THE CTS TRANSIENT EVENT COUNTER PERFORMANCE THROUGH THE 1976 SPRING ECLIPSE SEASON c18
N. John Stevens, Robert R. Lovell, and Vernon W. Klinect *In its* Proc. of the Spacecraft Charging Technol. Conf. 24 Feb. 1977 p 81-105 refs (For availability see N78-10129 01-12)
Avail: NTIS HC A99/MF A01 CSCL 22A

The transient event counter is described, defining its operational characteristics, and presenting the preliminary results obtained through the first 90 days of operation including the Spring 1976 eclipse season. The results show that the CTS was charged to the point where discharges have occurred. The discharge induced transients have not caused any anomalous events in spacecraft operation. The data indicate that discharges can occur at any time during the day without preference to any local time quadrant. The number of discharges occurring in the 1 sec sample interval are greater than anticipated. Author

N78-10136*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ACTIVE CONTROL OF SPACECRAFT CHARGING ON ATS-5 AND ATS-6 c15
Carolyn K. Purvis, Robert O. Bartlett (NASA. Goddard Space Flight Center), and Sherman E. DeForest (California Univ., La Jolla) *In its* Proc. of the Spacecraft Charging Technol. Conf. 24 Feb. 1977 p 107-120 refs (For availability see N78-10129 01-12)
Avail: NTIS HC A99/MF A01 CSCL 22B

Effects on spacecraft ground potential of active emission of charged particles are being investigated through experiments using the ATS-5 and ATS-6 spacecraft. Each spacecraft is equipped with ion engine neutralizers which emit low energy charged particles. Despite great differences in design between the two spacecraft, they attain similar potentials in similar environments. Therefore, effects on spacecraft potential of neutralizer operations can be used to compare the effects of operating the two different neutralizers (hot wire filament and plasma bridge). The neutralizers on both spacecraft were operated in eclipse. Results of these operations are presented and spacecraft responses compared.
Author

N78-10156*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE LEWIS RESEARCH CENTER GEOMAGNETIC SUBSTORM SIMULATION FACILITY c14
Frank D. Berkopec, N. John Stevens, and John C. Sturman *In its* Proc. of the Spacecraft Charging Technol. Conf. 24 Feb. 1977 p 423-430 refs (For availability see N78-10129 01-12)
Avail: NTIS HC A99/MF A01 CSCL 14B

A simulation facility was established to determine the response of typical spacecraft materials to the geomagnetic substorm environment and to evaluate instrumentation that will be used to monitor spacecraft system response to this environment. Space environment conditions simulated include the thermal-vacuum conditions of space, solar simulation, geomagnetic substorm electron fluxes and energies, and the low energy plasma environment. Measurements for spacecraft material tests include sample currents, sample surface potentials, and the cumulative number of discharges. Discharge transients are measured by means of current probes and oscilloscopes and are verified by a photomultiplier. Details of this facility and typical operating procedures are presented.
Author

N78-10158*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TESTING OF TYPICAL SPACECRAFT MATERIALS IN A SIMULATED SUBSTORM ENVIRONMENT c18
N. John Stevens, Frank D. Berkopec, John V. Staskus, Richard A. Blech, and Steven J. Narciso *In its* Proc. of the Spacecraft Charging Technol. Conf. 24 Feb. 1977 p 431-457 refs (For availability see N78-10129 01-12)
Avail: NTIS HC A99/MF A01 CSCL 11G

The test specimens were spacecraft paints, silvered Teflon, thermal blankets, and solar array segments. The samples, ranging in size from 300 to 1000 sq cm were exposed to monoenergetic electron energies from 2 to 20 keV at a current density of 1 NA/sq cm. The samples generally behaved as capacitors with strong voltage gradient at their edges. The charging characteristics of the silvered Teflon, Kapton, and solar cell covers were controlled by the secondary emission characteristics. Insulators that did not discharge were the spacecraft paints and the quartz fiber cloth thermal blanket sample. All other samples did experience discharges when the surface voltage reached -8 to -16kV. The discharges were photographed. The breakdown voltage for each sample was determined and the average energy lost in the discharge was computed.
Author

N78-10157*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CHARGING CHARACTERISTICS OF MATERIALS: COMPARISON OF EXPERIMENTAL RESULTS WITH SIMPLE ANALYTICAL MODELS c28
Carolyn K. Purvis, N. John Stevens, and Jon C. Oglebay *In its* Proc. of the Spacecraft Charging Technol. Conf. 24 Feb. 1977 p 453-436 refs (For availability see N78-10129 01-12)
Avail: NTIS HC A99/MF A01 CSCL 11G

A one-dimensional model for charging of samples is used in conjunction with experimental data taken to develop material charging characteristics for silvered Teflon. These characteristics are then used in a one dimensional model for charging in space to examine expected response. Relative charging rates as well as relative charging levels for silvered Teflon and metal are discussed.
Author

N78-10173*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PROVISIONAL SPECIFICATION FOR SATELLITE TIME IN A GEOMAGNETIC ENVIRONMENT c13
N. John Stevens, Robert R. Lovell, and Carolyn K. Purvis *In its* Proc. of the Spacecraft Charging Technol. Conf. 24 Feb. 1977 p 735-744 refs (For availability see N78-10129 01-12)
Avail: NTIS HC A99/MF A01 CSCL 22B

Satellites in geosynchronous orbit were experiencing operational anomalies. These anomalies are believed to be due to the environment charging the spacecraft surfaces to a point where discharges occur. In designing future satellites for long term operation at geosynchronous altitude, it is important that designers have a specification that will give the total time per year, the particle flux density and particle energies that their satellites can be expected to encounter in these substorm environmental conditions. The limited data currently available on the environmental conditions are used to generate the provisional specification given in this report.
Author

N78-10174*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DEVELOPMENT OF ENVIRONMENTAL CHARGING EFFECT MONITORS FOR OPERATIONAL SATELLITES c15
N. John Stevens, John C. Sturman, and Frank D. Berkopec *In its* Proc. of the Spacecraft Charging Technol. Conf. 24 Feb. 1977 p 745-751 refs (For availability see N78-10129 01-12)
Avail: NTIS HC A99/MF A01 CSCL 22B

Design details and design goals are given of an instrumentation package to monitor the effects of the environmental charging of spacecraft surfaces on the systems of operational spacecraft. Author

N78-10175*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
VIKING AND STP P78-2 ELECTROSTATIC CHARGING DESIGNS AND TESTING c15
R. O. Lewis, Jr. *In its* Proc. of the Spacecraft Charging Technol Conf. 24 Feb. 1977 p 753-772 Lakewood, Colo. (For availability see N78-10129 01-12)
Avail: NTIS HC A99/MF A01 CSCL 22B

The design provisions of the Viking and the P78-2 (SCATHA) vehicles and a mathematical analysis of the effect of arcing on typical interface circuits are given. Results of verification testing of the analysis are presented as well as vehicle testing for tolerance to arcing. Author

N78-16076*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
INTERACTION OF LARGE, HIGH POWER SYSTEMS WITH OPERATIONAL ORBIT CHARGED PARTICLE ENVIRONMENTS
Carolyn K. Purvis, N. John Stevens, and Frank D. Berkopec 1977 19 p refs Presented at the Meeting on Long Range Planning for the Ind. Phase of Space Exploration, San Francisco, 18-20 Oct. 1977. Sponsored by the Am. Astronautical Soc.
(NASA-TM-73867; E-9459) Avail: NTIS HC A02/MF A01 CSCL 22A

A potentially hazardous spacecraft environment interaction is discussed. The interaction of large high voltage systems with low energy (less than 50 eV) plasmas which can result in loss of power and/or arching was examined. The impact of this class of interactions where the ambient operation is most severe at low orbits where the ambient plasmas are densest. Results of experimental work and predictions of simple analytical models were presented and their implications for design of space systems were reviewed. Author

N78-27142*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
INVESTIGATION OF MEANS FOR PERTURBING THE FLOW FIELD IN A SUPERSONIC WIND TUNNEL
Gary L. Cole and Warren R. Hingst Jun. 1978 30 p refs
(NASA-TM-78954; E-9703) Avail: NTIS HC A03/MF A01 CSCL 14B

The development status of a device for generating atmospheric-type turbulences in supersonic inlet testing is summarized. Elaborated are desired aerodynamic and actuation capabilities of the device, and the techniques that were considered and their drawbacks. G.G.

N78-27143*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
DESIGN OF AN AIR EJECTOR FOR BOUNDARY-LAYER BLEED OF AN ACOUSTICALLY TREATED TURBOFAN ENGINE INLET DURING GROUND TESTING
Edward G. Stakolich Jun. 1978 21 p refs
(NASA TM-78917; E-9655) Avail: NTIS HC A02/MF A01 CSCL 14B

An air ejector was designed and built to remove the boundary-layer air from the inlet a turbofan engine during an acoustic ground test program. This report describes: (1) how the ejector was sized; (2) how the ejector performed; and (3) the performance of a scale model ejector built and tested to verify the design. With proper acoustic insulation, the ejector was effective in reducing boundary layer thickness in the inlet of the turbofan engine while obtaining the desired acoustic test conditions. Author

N78-10180*# Systems Science and Software, La Jolla, Calif. Plasma Physics Group.
DYNAMIC MODELING OF SPACECRAFT IN A COLLISIONLESS PLASMA c15
Ira Katz, Donald E. Parks, Sheng Wang, and Andrew Wilson *In* NASA. Lewis Res. Center Proc. of the Spacecraft Charging Technol. Conf. 24 Feb. 1977 p 319-330 refs (For availability see N78-10129 01-12)
(Contracts NAS3-20119; DNA001-76-C-0121)
Avail: NTIS HC A99/MF A01 CSCL 22B

A new computational model is described which can simulate the charging of complex geometrical objects in three dimensions. Two sample calculations are presented. In the first problem, the capacitance to infinity of a complex object similar to a satellite with solar array paddles is calculated. The second problem concerns the dynamical charging of a conducting cube partially covered with a thin dielectric film. In this calculation, the photoemission results in differential charging of the object. Author

N78-14063*# General Dynamics/Convair, San Diego, Calif.
CONCEPTUAL DESIGN FOR SPACELAB TWO-PHASE FLOW EXPERIMENTS
R. D. Bradshaw and C. D. King Dec. 1977 88 p refs
(Contract NAS3-20389)
(NASA-CR-135327; CASD-NAS-77-025) Avail: NTIS HC A05/MF A01 CSCL 22A

KC-135 aircraft tests confirmed the gravity sensitivity of two phase flow correlations. The prime component of the apparatus is a 1.5 cm dia by 90 cm fused quartz tube test section selected for visual observation. The water-cabin air system with water recycle was a clear choice for a flow regime pressure drop test since it was used satisfactorily on KC-135 tests. Freon-11 with either overboard dump or with liquid-recycle will be used for the heat transfer test. The two experiments use common hardware. The experimental plan covers 120 data points in six hours with mass velocities from 10 to 640 kg/sec-sq m and qualities 0.01 to 0.64. The apparatus with pump, separator, storage tank and controls is mounted in a double spacelab rack. Supporting hardware, procedures, measured variables and program costs are defined. Author

N78-20150*# Kentucky Univ., Lexington. Boiling and Phase Change Lab.
CONCEPTUAL DESIGN FOR SPACELAB POOL BOILING EXPERIMENT
John H. Lienhard and Robert E. Peck Mar. 1978 71 p refs
(Contract NAS3-20397)
(NASA-CR-135378; UKY-TR106-78-ME15) Avail: NTIS HC A04/MF A01 CSCL 22A

A pool boiling heat transfer experiment to be incorporated with a larger two-phase flow experiment on Spacelab was designed to confirm (or alter) the results of earth-normal gravity experiments which indicate that the hydrodynamic peak and minimum pool boiling heat fluxes vanish at very low gravity. Twelve small sealed test cells containing water, methanol or Freon 113 and cylindrical heaters of various sizes are to be built. Each cell will be subjected to one or more 45 sec tests in which the surface heat flux on the heaters is increased linearly until the surface temperature reaches a limiting value of 500 C. The entire boiling process will be photographed in slow-motion. Boiling curves will be constructed from thermocouple and electric input data, for comparison with the motion picture records. The conduct of the experiment will require no more than a few hours of operator time. Author

N78-25105*# Business and Technological Systems, Inc Seabrook, Md.

SEP ENCKE-87 AND HALLEY RENDEZVOUS STUDIES AND IMPROVED S/C MODEL IMPLEMENTATION IN HILTOP Final Report

J. L. Horsewood and F. I. Mann Feb. 1978 29 p refs (Contract NAS3-20950)

(NASA-CR-135414; BTS-TR-78-55-Pt-1) Avail: NTIS HC A03/MF A01 CSCL 22A

Studies were conducted to determine the performance requirements for projected state-of-the-art SEP spacecrafts boosted by the Shuttle/IUS to perform a rendezvous with the comet Halley and a rendezvous with the comet Encke during its 1977 apparition. The spacecraft model of the standard HILTOP computer program was assumed. Numerical and graphical results summarizing the studies are presented. Author

N78-25106*# Business and Technological Systems, Inc., Seabrook, Md.

HELIOCENTRIC INTERPLANETARY LOW THRUST TRAJECTORY OPTIMIZATION PROGRAM. SUPPLEMENT 1, PART 2 Final Report

F. I. Mann and J. L. Horsewood Feb. 1978 103 p refs (Contract NAS3-20950)

(NASA-CR-135414-App. BTS-TR-78-54-Suppl-1-Pt-2) Avail: NTIS HC A06/MF A01 CSCL 22A

The improvements made to the HILTOP electric propulsion trajectory computer program are described. A more realistic propulsion system model was implemented in which various thrust subsystem efficiencies and specific impulse are modeled as variable functions of power available to the propulsion system. The number of operating thrusters are staged, and the beam voltage is selected from a set of five (or less) constant voltages, based upon the application of variational calculus. The constant beam voltages may be optimized individually or collectively. The propulsion system logic is activated by a single program input key in such a manner as to preserve the HILTOP logic. An analysis describing these features, a complete description of program input quantities, and sample cases of computer output illustrating the program capabilities are presented. Author

13 ASTRODYNAMICS

Includes powered and free-flight trajectories; and orbit and launching dynamics.

A78-32756 * # **12-cm magneto-electrostatic containment argon/xenon ion source development.** W. D. Ramsey (Xerox Electro-Optical Systems, Pasadena, Calif.). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft fur Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-681.* 9 p. 8 refs. Contract No. NAS3-20393.

The original 12 cm hexagonal magneto-electrostatic containment (MESC) discharge chamber described by Moore in 1968 has been optimized for argon and xenon operation. Argon mass utilization efficiencies of 65 to 77 percent were achieved at keeper plus-main discharge energy consumptions of 244 to 422 eV/ion respectively. Xenon performance of 85 to 96 percent mass utilization were realized at 203 to 350 eV/ion. The paper discusses the optimization process and test results. (Author)

14 GROUND SUPPORT SYSTEMS AND FACILITIES (SPACE)

Includes launch complexes, research and production facilities; ground support equipment, e.g., mobile transporters, and simulators.

For related information see also *09 Research and Support Facilities (Air)*.

A78-37431 * # **A mission profile life test facility.** E. James (Xerox Electro-Optical Systems, Pasadena, Calif.), R. Vetrone, and R. Bechtel (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft fur Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-671.* 10 p. Contract No. NAS3-20389.

A test facility is being prepared for a 16,000 hour mission profile life test of multiple electric propulsion thrust subsystems. The facility will be capable of simultaneously operating three 2.7 kW, 30 cm mercury ion thrusters and their power processing. The facility will permit conduction of a program of long-term tests to document thruster characteristics as a function of time and operating point to allow prediction of thruster performance for any mission profile. The thruster will be tested in a 7m by 10m vacuum chamber. Each thruster will be installed in a separate lock chamber so that it can be extended into, or extracted from the main chamber without violating the vacuum integrity of the other thruster. The thrusters will exhaust into a 3m by 5m frozen mercury target. The target and an array of cryopanels to collect sputtered target material will be liquid nitrogen chilled. Power processor units will be tested in an adjacent 1.5m by 2m vacuum chamber and will be temperature controlled by simulated heat pipes. (Author)

A78-37441 * # **Economics of ion propulsion for large space systems.** T. D. Masek, J. W. Ward (Hughes Research Laboratories, Malibu, Calif.), and V. K. Rawlin (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft fur Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-698.* 19 p. Contract No. NAS3-20101.

This study of advanced electrostatic ion thrusters for space propulsion was initiated to determine the suitability of the baseline 30-cm thruster for future missions and to identify other thruster concepts that would better satisfy mission requirements. The general scope of the study was to review mission requirements, select thruster designs to meet these requirements, assess the associated thruster technology requirements and recommend short- and long-term technology directions that would support future thruster needs. Preliminary design concepts for several advanced thrusters were developed to assess the potential practical difficulties of a new design. This study produced useful general methodologies for assessing both planetary and earth orbit missions. For planetary missions, the assessment is in terms of payload performance as a function of propulsion system technology level. For earth orbit missions, the assessment is made on the basis of cost (cost sensitivity to propulsion system technology level). (Author)

15 LAUNCH VEHICLES AND SPACE VEHICLES

Includes boosters; manned orbital laboratories; reusable vehicles; and space stations.

N78-13187*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CTS (HERMES): UNITED STATES EXPERIMENTS AND OPERATIONS SUMMARY
Patrick L Donoughe and Henry R Hunczak 1977 27 p refs Presented at Symp on Hermes (Communications Technol Satellite), its Performance and Applications, Ottawa, 29 Nov - 1 Dec 1977, sponsored by Royal Soc of Canada, Canadian Dept of Communications and NASA
(NASA-TM-73830) Avail NTIS HC A03/MF A01 CSCL 22A

The Communications Technology Satellite, launched in January 1976 and embodying the highest power transmitter in a communications satellite was considered As a joint program between the U S and Canada, close coordination of the two countries was necessitated since the management and control of experiments were done in real time Criteria used by NASA for acceptance of the United States experiments are noted and acceptance procedures are discussed The category for each accepted experiment is given The modus operandi employed for the U S experiments in the areas of management, coordination liaison, and real time operation are described Some of the highlights associated with satellite utilization are given Author

N78-17127*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio
PURGING OF A TANK-MOUNTED MULTILAYER INSULATION SYSTEM BY GAS DIFFUSION
Irving E Sumner Jan 1978 59 p refs
(NASA TP 1127 E-9286) Avail NTIS HC A04/MF A01 CSCL 22B

The investigation was conducted on a multilayer insulation (MLI) system mounted on a spherical liquid hydrogen propellant tank The MLI consisted of two blankets of insulation each containing 15 double aluminized Mylar radiation shields separated by double silk net spacers The gaseous nitrogen initially contained within the MLI system and vacuum chamber was purged with gaseous helium introduced both underneath the MLI and into the vacuum chamber The MLI panels were assumed to be purged primarily by means of gas diffusion Overall test results indicated that nitrogen concentrations well below 1 percent could be achieved everywhere within the MLI system Typical times to achieve 1 percent nitrogen concentration within the MLI panels ranged from 69 minutes at the top of the tank to 158 minutes at the bottom of the tank Four space hold thermal performance tests indicated no significant thermal degradation of the MLI system had occurred due to the purge tests conducted The final measured heat input attributed to the MLI was 7 23 watts as compared to 7 18 watts for the initial baseline thermal performance test Author

N78-21186*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THE PLASMA INTERACTION EXPERIMENT (PIX) DESCRIPTION AND TEST PROGRAM
Louis R Ignaczak Fred A Haley Edward J Domino David H Culp and Francis J Shaker 1978 20 p Presented at the 13th Intern Elec Propulsion Conf San Diego, Calif 25-27 Apr 1978 cosponsored by AIAA and DGLR
(NASA TM 78863 E-9594) Avail NTIS HC A02/MF A01 CSCL 22A

The plasma interaction experiment (PIX) is a battery powered preprogrammed auxiliary payload on the LANDSAT C launch This experiment is part of a larger program to investigate space plasma interactions with spacecraft surfaces and components The varying plasma densities encountered during available telemetry coverage periods are deemed sufficient to determine first order interactions between the space plasma environment and the biased experimental surfaces The specific objectives of the PIX flight experiment are to measure the plasma coupling current and the negative voltage breakdown characteristics of a solar array segment and a gold plated steel disk Measurements will be made over a range of surface voltages up to plus or minus kilovolt The orbital environment will provide a range of plasma densities The experimental surfaces will be voltage biased in a preprogrammed step sequence to optimize the data returned for each plasma region and for the available telemetry coverage Author

N78-21188*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
COMPARISON OF REUSABLE INSULATION SYSTEMS FOR CRYOGENICALLY-TANKED EARTH-BASED SPACE VEHICLES
Irving E Sumner and James R Barber 1978 21 p refs Presented at 2d Thermophys and Heat Transfer Conf, Palo Alto, Calif, 24-26 May 1978, cosponsored by AIAA and ASME
(NASA-TM-73668, E-9192) Avail NTIS HC A02/MF A01 CSCL 22B

Three reusable insulation systems concepts were developed for use with cryogenic tanks of earth-based space vehicles Two concepts utilized double-goldized Kapton (DGK) or double-aluminized Mylar (DAM) multilayer insulation (MLI), while the third utilized a hollow-glass-microsphere, loadbearing insulation (LBI) Thermal performance measurements were made under space-hold (vacuum) conditions for insulating warm boundary temperatures of approximately 291 K The resulting effective thermal conductivity was approximately 0 00008 W/m-K (W - weight,Kg m - measured, K - temperature) for the MLI systems (liquid hydrogen test results) and 0 00054 W/m-K for the LBI system (liquid nitrogen test results corrected to liquid hydrogen temperature) Author

N78-28188*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PRELIMINARY CONCEPTS, SPECIFICATIONS, AND REQUIREMENTS FOR A ZERO-GRAVITY COMBUSTION FACILITY FOR SPACELAB
Richard L DeWitt Jun 1978 51 p refs
(NASA-TM-78910, E-9645) Avail NTIS HC A04/MF A01 CSCL 22B

The preliminary concepts, specifications, and requirements of a reusable zero gravity combustion facility (0-GCF) for use by experimenters aboard the spacelab payload of the space transportation system (STS) orbiter are described The facility will be amenable to any mission of the STS orbiter in which a spacelab habitable segment and pallet segment are integral and for which orbital mission plans specify induced accelerations of 0 0001 g or less for sufficiently long periods so as not to impact experiment performance Author

N78-15144*# Georgia Inst of Tech Atlanta Engineering Experiment Station
MILLIMETER WAVE SATELLITE CONCEPTS, VOLUME 1
Neil B Nilsen L D Holland, R E Thomas, R W Wallace, and J G Gallagher Sep 1977 238 p refs
(Contract NAS3-20110)
(NASA-CR-135227, GT-A1855-Vol-1) Avail NTIS HC A11/MF A01 CSCL 22B

The identification of technologies necessary for development of millimeter spectrum communication satellites was examined from a system point of view Development of methodology based on the technical requirements of potential services that might be assigned to millimeter wave bands for identifying the viable and appropriate technologies for future NASA millimeter research and development programs and testing of this methodology with selected user applications and services were the goals of the program The entire communications network both ground and space subsystems was studied Cost weight and performance models for the subsystems conceptual design for point-to-point and broadcast communications satellites and analytic relationships between subsystem parameters and an overall link performance

are discussed along with baseline conceptual systems, sensitivity studies, model adjustment analyses, identification of critical technologies and their risks, and brief research and development program scenarios for the technologies judged to be moderate or extensive risks. Identification of technologies for millimeter satellite communication systems, and assessment of the relative risks of these technologies, was accomplished through subsystem modeling and link optimization for both point-to-point and broadcast applications. Author

N78-31141*# Dayton Univ., Ohio. Research Inst.
CONTINUATION OF THE COMPENDIUM OF APPLICATIONS TECHNOLOGY SATELLITE AND COMMUNICATIONS TECHNOLOGY SATELLITE USER EXPERIMENTS 1967-1977. VOLUME 1 Final Report
Nicholas A. Engler, John F. Nash, and Jerry D. Strange May 1978 203 p refs
(Contract NAS3-20392)
(NASA-CR-135416-Vol-1; UDR-TR-78-67-Vol-1) Avail: NTIS HC A10/MF A01 CSCL 22A

User experiments conducted utilizing the Applications Technology Satellites (ATS) 1, 3, 5, and 6 and the Communications Technology Satellite are summarized. The experiments are grouped by type of service offered. For example: education, health services, and data transmission. Particular emphasis is given to summarizing and evaluating user attitudes toward the ATS program. J.M.S.

N78-31142*# Dayton Univ., Ohio. Research Inst.
CONTINUATION OF THE COMPENDIUM OF APPLICATIONS TECHNOLOGY SATELLITE AND COMMUNICATIONS TECHNOLOGY SATELLITE USER EXPERIMENTS 1967-1977. VOLUME 2 Final Report
Nicholas A. Engler, John F. Nash, and Jerry D. Strange May 1978 455 p refs
(Contract NAS3-20392)
(NASA-CR-135416-Vol-2; UDR-TR-78-67-Vol-2) Avail: NTIS HC A20/MF A01 CSCL 22A

Approximately 453 reports, papers, and articles catalogued into an information retrieval system, covering communications experiments and demonstrations conducted utilizing the Communications Technology Satellite and the Applications Technology Satellites 1, 3, 5, and 6 are listed. J.M.S.

N78-31143*# Raytheon Co., Wayland, Mass. Microwave and Power Tube Div
DESIGN, FABRICATION AND TESTING OF A CFA FOR USE IN THE SOLAR POWER SATELLITE Final Report
William C. Brown Aug 1978 152 p refs
(Contract NAS3-20374)
(NASA-CR-159410, PT-5228) Avail: NTIS HC A08/MF A01 CSCL 22B

A crossed field amplifier was designed to meet the performance objectives of high signal to noise ratio, an efficiency of 85%, a CW microwave power output of 5-8 kW, and a frequency of 2450 MHz. The signal to noise ratio achieved was better than 60 db/MHz in a 2000 MHz band centered on the carrier. High circuit efficiency of 97% and a sharp knee on voltage current characteristic were achieved. The basic problem of maintaining good transfer of heat to the external radiator while providing for adequate connections to input and output was solved. Maximum efficiency achieved was 70.6% and gain and power level were below objectives. An investigation of causes of reduced performance indicated the poor field pattern in the cathode anode interaction area of the tube was a major cause. S.S.

17 SPACECRAFT COMMUNICATIONS, COMMAND AND TRACKING

Includes telemetry; space communications networks; astronavigation; and radio blackout.

For related information see also *04 Aircraft Communications and Navigation* and *32 Communications.*

N78-28169*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CARRIER-INTERFERENCE RATIOS FOR FREQUENCY SHARING BETWEEN FREQUENCY-MODULATED AMPLITUDE-MODULATED-VESTIGIAL-SIDEBAND TELEVISION SYSTEMS

Scott P. Barnes and Edward F. Miller Aug. 1978 29 p refs (NASA-TP-1264; E-9478) Avail: NTIS HC A03/MF A01 CSCL 17B

For just perceptible interference, an FM television signal interfering with another FM television signal must have an average signal power that is 26 to 37 db less than the wanted signal power. For an AM-VSB television signal interfering with an FM television signal, the AM-VSB television's sync peak average power must be 18 to 31 db below the FM television signal's average power. Also, when an FM television signal interferes with an AM-VSB signal, the average signal power of the FM signal should be 56 to 59 db below the sync peak average power of the AM-VSB television signal. The range of power ratios occur as a result of different TV scenes used in the tests and different FM-signal frequency deviations used. All tests were performed using 525 line, system M, color-television signals.

G.G.

N78-28137*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THERMAL CHARACTERISTICS OF THE 12-GIGAHERTZ, 200-WATT OUTPUT STAGE TUBE FOR THE COMMUNICATIONS TECHNOLOGY SATELLITE

Arthur N. Curren Oct. 1978 39 p refs (NASA-TP-1344; E-9560) Avail: NTIS HC A03/MF A01 CSCL 17B

A description of the methods used to measure component temperatures and heat-rejection rates in a simulated space environment on output stage tubes (OST's) developed for the Communications Technology Satellite is presented along with summaries of experimentally determined values. The OST's were operated over the entire anticipated operating drive range, from the dc beam (zero drive) condition to the 6-db overdrive condition. The baseplate temperature was varied from -10 to 58 C with emphasis placed on the testing done at 45 C, the normal anticipated operating temperature. The heat-rejection rate of the OST baseplate ranged from 7.6 W at the dc beam condition to 184.5 W at the 6-db overdrive condition, the heat-rejection rate of the multistage depressed collector (MDC) cover ranged from 192.2 to 155.9 W for the same conditions. The maximum OST temperature measured on the MDC cover was 227 C during a dc beam test. The minimum temperature measured, also on the MDC cover, was -67.5 C at the end of an extended simulated eclipse test period. No effects were observed on the OST thermal characteristics due to vibration testing or temperature-reversal cycle testing.

Author

18 SPACECRAFT DESIGN, TESTING AND PERFORMANCE

Includes spacecraft thermal and environmental control; and attitude control.

For life support systems see *54 Man/System Technology and Life Support.* For related information see also *05 Aircraft Design, Testing and Performance* and *39 Structural Mechanics.*

N78-21188*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CHARGING OF FLEXIBLE SOLAR ARRAY SUBSTRATES IN KILOVOLT ELECTRON BEAMS
John V. Staskus and Steven J. Narciso Mar. 1978 32 p refs (NASA-TM-73865; E-9455) Avail: NTIS HC A03/MF A01 CSCL 10A

A series of survey tests were conducted to evaluate samples of flexible solar arrays. The samples used woven carbon fibers and/or coatings to increase the surface conductivity of the KAPTON substrate and thereby reduce surface charging. Four different samples were evaluated by exposing them to monoenergetic electron beams of 2 to 20 KeV at a current density of 1 nA sq cm. Simulated eclipse tests were also conducted. The results were as expected; the more continuous the conductive pattern, the lower the surface charging. Author

A78-19567 * NASCAP, a three-dimensional Charging Analyzer Program for complex spacecraft. I. Katz, D. E. Parks, M. J. Mandell, J. M. Harvey, S. S. Wang (Systems Science and Software, La Jolla, Calif.), and J. C. Roche (NASA, Lewis Research Center, Cleveland, Ohio). *(Institute of Electrical and Electronics Engineers, Annual Conference on Nuclear and Space Radiation Effects, 14th, Williamsburg, Va., July 12-15, 1977.) IEEE Transactions on Nuclear Science*, vol. NS-24, Dec. 1977, p. 2276-2280.

A computer code, NASCAP (NASA Charging Analyzer Program), has been developed by Systems, Science and Software under contract to NASA-LeRC to simulate the charging of a complex spacecraft in geosynchronous orbit. The capabilities of the NASCAP code include a fully three-dimensional solution of Poisson's equation about an object having considerable geometrical and material complexity, particle tracking, shadowing in sunlight, calculation of secondary emission, backscatter and photoemission, and graphical output. A model calculation shows how the NASCAP code may be used to improve our understanding of the spacecraft-plasma interaction. (Author)

A78-33220 * = NASA Charging Analyzer Program - A computer tool that can evaluate electrostatic contamination. N. J. Stevens, J. C. Roche (NASA, Lewis Research Center, Cleveland, Ohio), and M. J. Mandell (Systems, Science and Software, La Jolla, Calif.). *U.S. Air Force and NASA, International Spacecraft Contamination Conference, Colorado Springs, Colo., Mar. 7-9, 1978, Paper.* 13 p. 17 refs.

The data from the ATS 5 and 6 Auroral Particles Experiments have shown that the environment at geosynchronous orbit can charge spacecraft surfaces to appreciable negative values. Such surface charges could have undesirable effects on satellite equipment and the data obtained in satellite experiments. A computer program, the NASA Charging Analyzer Program (NASCAP), has, in this connection, been developed to determine the surface charging of spacecraft when encountering geomagnetic substorm conditions. Once a model of a spacecraft has been developed in the NASCAP code, the surface charging can be computed for any environmental input flux. On the basis of the obtained information regarding the surface charging, charged particle trajectories can be computed to determine if it is possible for a particle to return to a satellite surface. It is pointed out that the computer runs conducted with the NASCAP code represent the first attempts to use a self-consistent program to study the behavior of spacecraft surfaces experiencing a geomagnetic substorm condition. G.R.

A78-35590 * # Evaluation of commercially-available spacecraft-type heat pipes. W. B. Kaufman and L. K. Tower (NASA, Lewis Research Center, Cleveland, Ohio). In: International Heat Pipe Conference, 3rd, Palo Alto, Calif., May 22-24, 1978, Technical Papers. (A78-35576 14-34) New York, American Institute of Aeronautics and Astronautics, Inc., 1978, p. 88-95. 5 refs. (AIAA 78-397)

As part of an effort to develop reliable, cost effective spacecraft thermal control heat pipes, Lewis Research Center of NASA is conducting life tests on 30 commercially-available heat pipes in 10 groups of different design and material combinations. Materials are aluminum and stainless steel, and working fluids are methanol and ammonia. The formation of noncondensible gas is observed for times exceeding 11,000 hours. The heat transport capacities of the pipes are also determined. Considerable gas is found in two groups of methanol pipes; one group shows no gas. One group of ammonia pipes has no observable gas. Another group has much gas. Manufacturers' processing schedules are examined for differences explaining the presence of gas. Heat transport capacity is found to be severely reduced in some pipes containing gas. (Author)

A78-36004 * # Comparison of reusable insulation systems for cryogenically-tanked earth-based space vehicles. I. E. Sumner and J. R. Barber (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers, Thermophysics and Heat Transfer Conference, 2nd, Palo Alto, Calif., May 24-26, 1978, AIAA Paper 78-877.* 15 p. 8 refs.

Three reusable insulation systems concepts have been developed for use with cryogenic tanks of earth-based space vehicles. Two concepts utilized double-goldized Kapton (DGK) or double-aluminized Mylar (DAM) multilayer insulation (MLI), while the third utilized a hollow-glass-microsphere, load-bearing insulation (LBI). All three insulation systems have recently undergone experimental testing and evaluation under NASA-sponsored programs. Thermal performance measurements were made under space-hold (vacuum) conditions for insulation warm boundary temperatures of approximately 291 K. The resulting effective thermal conductivity was approximately .00008 W/m-K for the MLI systems (liquid hydrogen test results) and .00054 W/m-K for the LBI system (liquid nitrogen test results corrected to liquid hydrogen temperature). The DGK MLI system experienced a maximum thermal degradation of 38 percent, the DAM MLI system 14 percent, and the LBI system 6.7 percent due to repeated thermal cycling representing typical space flight conditions. Repeated exposure of the DAM MLI system to a high humidity environment for periods as long as 8 weeks provided a maximum degradation of only 24 percent. (Author)

A78-36719 * Interaction of large, high power systems with operational orbit charged particle environments. C. K. Purvis, N. J. Stevens, and F. D. Berkopec (NASA, Lewis Research Center, Cleveland, Ohio). In: The industrialization of space; Proceedings of the Twenty-third Annual Meeting, San Francisco, Calif., October 18-20, 1977. Part 1. (A78-36701 15-12) San Diego, Calif., American Astronautical Society; Univelt, Inc., 1978, p. 429-446. 18 refs. (AAS 77-243)

Concepts are presently being advanced for space systems to be used for such activities as manufacturing, earth observations, scientific exploration, power generation and human habitation, in locations ranging from low earth orbit (300-500 km) to geosynchronous orbit and beyond. Many of these systems concepts envision large structures and high power levels, and consequently higher operating voltages than have been used in space to date. The potential impact of interactions of space systems with their operational orbit charged particle environments on the systems' performance must be accounted for in the design process. A potentially hazardous spacecraft-environment interaction is discussed, namely the interaction of large high voltage systems with low energy (less than 50 eV) plasmas which can result in loss of power, and/or arcing. The impact of this class of interactions on system operation is most severe at low orbits where the ambient plasmas are densest. Results of experimental work and predictions of simple analytical models are presented and their implications for design of space systems are discussed. (Author)

A78-43560 * # Effect of vibration on retention characteristics of screen acquisition systems. J. R. Tegart (Martin Marietta Aerospace, Denver, Colo.) and J. C. Aydelott (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Joint Propulsion Conference, 14th, Las Vegas, Nev., July 25-27, 1978, AIAA Paper 78-1030.* 12 p. 8 refs. Contract No. NAS3-20097.

The design of surface tension propellant acquisition systems using fine-mesh screen must take into account all factors that influence the liquid pressure differentials within the system. One of those factors is spacecraft vibration. Analytical models to predict the effects of vibration have been developed. A test program to verify the analytical models and to allow a comparative evaluation of the parameters influencing the response to vibration was performed. Screen specimens were tested under conditions simulating the operation of an acquisition system, considering the effects of such parameters as screen orientation and configuration, screen support method, screen mesh, liquid flow and liquid properties. An analytical model, based on empirical coefficients, was most successful in predicting the effects of vibration. (Author)

A78-14991 * # ADDJUST - An automated system for steering Centaur launch vehicles in measured winds. D. C. Swanson (General Dynamics Corp., Convair Div., San Diego, Calif.). In: Conference on Aerospace and Aeronautical Meteorology, 7th, and Symposium on Remote Sensing from Satellites, Melbourne, Fla., November 16-19, 1976, Preprints. (A78-14952 03-47) Boston, Mass., American Meteorological Society, 1977, p. 210-213. Contract No. NAS3-13514.

ADDJUST (Automatic Determination and Dissemination of Just-Updated Steering Terms) is an automated computer and communication system designed to provide Atlas/Centaur and Titan/Centaur launch vehicles with booster-phase steering data on launch day. Wind soundings are first obtained, from which a smoothed wind velocity vs altitude relationship is established. Design for conditions at the end of the boost phase with initial pitch and yaw maneuvers, followed by zero total angle of attack through the filtered wind establishes the required vehicle attitude as a function of altitude. Polynomial coefficients for pitch and yaw attitude vs altitude are determined and are transmitted for validation and loading into the Centaur airborne computer. The system has enabled 14 consecutive launches without a flight wind delay. V.P.

A78-36005 * # An ultralightweight, evacuated, load-bearing, high-performance insulation system. R. T. Parmley and G. R. Cunnington, Jr. (Lockheed Research Laboratories, Palo Alto, Calif.). *American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers, Thermophysics and Heat Transfer Conference, 2nd, Palo Alto, Calif., May 24-26, 1978, AIAA Paper 78-878.* 6 p. 19 refs. Contract No. NAS3-17817.

A new hollow-glass microsphere insulation and a flexible stainless steel vacuum jacket were demonstrated on a flight-weight cryogenic test tank, 1.17 m in diameter. The weight of the system is three times lighter than the most advanced vacuum-jacketed design demonstrated to date, a free-standing honeycomb hard shell with a multilayer insulation system (for a Space Tug application). Design characteristics of the flexible vacuum jacket are presented along with a model describing the insulation thermal performance as a function of boundary temperatures and emittance, compressive load on the insulation and insulation gas pressure. Test data are compared with model predictions and with prior flat-plate calorimeter test results. Potential applications for this insulation system or a derivative of this system include the cryogenic Space Tug, the Single-Stage-to-Orbit Space Shuttle, LH2 fueled subsonic and hypersonic aircraft, and LNG applications. (Author)

19 SPACECRAFT INSTRUMENTATION

For related information see also *06 Aircraft Instrumentation* and *35 Instrumentation and Photography*.

N78-17148*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESIGN AND FABRICATION OF A LOW-SPECIFIC-WEIGHT PARABOLIC DISH SOLAR CONCENTRATOR
Carl W. Richter, Arthur G. Birchenough, Gerald A. Marquis, and Thaddeus S. Mroz Jan. 1978 18 p refs
(NASA-TP-1152; E-9339) Avail: NTIS HC A02/MF A01 CSCL 10A

A segmented design and fabrication and assembly techniques were developed for a 1.8 m (6 ft) diameter parabolic concentrator for space application. This design and these techniques were adaptable to a low cost, mass-produced concentrator. Minimal machining was required. Concentrator segments of formed magnesium were used. The concentrator weighed only 1.6 kg sq m (0.32 lbm/sq ft). Author

A78-19566 * **Summary of the CTS Transient Event Counter data after one year of operation.** N. J. Stevens, V. W. Klinect (NASA, Lewis Research Center, Cleveland, Ohio), and J. V. Gore (NASA, Lewis Research Center, Cleveland, Ohio; Department of Communications, Communications Research Centre, Ottawa, Canada). *(Institute of Electrical and Electronics Engineers, Annual Conference on Nuclear and Space Radiation Effects, 14th, Williamsburg, Va., July 12-15, 1977.) IEEE Transactions on Nuclear Science*, vol. NS-24, Dec. 1977, p. 2270-2275. 16 refs.

The environmental charging of satellite surfaces during geomagnetic substorms is the apparent cause of a significant number of anomalous events occurring on geosynchronous satellites since the early 1970's. Electromagnetic pulses produced in connection with the differential charging of insulators can couple into the spacecraft harness and cause electronic switching anomalies. An investigation conducted to determine the response of the spacecraft surfaces to substorm particle fluxes makes use of a harness transient detector. The harness transient detector, called the Transient Event Counter (TEC) was built and integrated into the Canadian-American Communications Technology Satellite (CTS). A description of the TEC and its operational characteristics is given and the obtained data are discussed. The data show that the satellite surfaces appear to be charged to the point that discharges occur and that the discharge-induced transients couple into the wire harnesses. G.R.

20 SPACECRAFT PROPULSION AND POWER

Includes main propulsion systems and components, e.g., rocket engines; and spacecraft auxiliary power sources.

For related information see also *07 Aircraft Propulsion and Power, 28 Propellants and Fuels,* and *44 Energy Production and Conversion.*

N78-13124*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HYDROGEN FILM COOLING OF A SMALL HYDROGEN-OXYGEN THRUST CHAMBER AND ITS EFFECT ON EROSION RATES OF VARIOUS ABLATIVE MATERIALS

Ned Hannum, William E. Roberts, and Louis M. Russell Dec. 1977 27 p refs

(NASA-TP-1098; E-8909) Avail: NTIS HC A03/MF A01 CSCL 21H

An experimental investigation was conducted to determine what arrangement of film-coolant-injection orifices should be used to decrease the erosion rates of small, high temperature, high pressure ablative thrust chambers without incurring a large penalty in combustion performance. All of the film cooling was supplied through holes in a ring between the outer row of injector elements and the chamber wall. The best arrangement, which had twice the number of holes as there were outer row injection elements, was also the simplest. The performance penalties, presented as a reduction in characteristic exhaust velocity efficiency, were 0.8 and 2.8 percentage points for the 10 and 20 percent cooling flows, respectively. The best film-coolant injector was then used to obtain erosion rates for 19 ablative materials. The throat erosion rate was reduced by a factor of 2.5 with a 10 percent coolant flow. Only the more expensive silica phenolic materials had low enough erosion rates to be considered for use in the nozzle throat. However, some of the cheaper materials might qualify for use in other areas of small nozzles with large throat diameters where the higher erosion rates are more acceptable. Author

N78-16089*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

LIQUID ROCKET LINES, BELLOWS, FLEXIBLE HOSES, AND FILTERS NASA Space Vehicle Design Criteria (Chemical Propulsion)

Apr 1977 186 p refs Prepared by Rocketdyne, Canoga Park, Calif.

(NASA-SP-8123) Avail: NTIS HC A09/MF A01 CSCL 21H

Fluid-flow components in a liquid propellant rocket engine and the rocket vehicle which it propels are interconnected by lines, bellows, and flexible hoses. Elements involved in the successful design of these components are identified and current technologies pertaining to these elements are reviewed, assessed, and summarized to provide a technology base for a checklist of rules to be followed by project managers in guiding a design or assessing its adequacy. Recommended procedures for satisfying each of the design criteria are included. A.R.H.

N78-20251*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STATUS OF SERT II SPACECRAFT AND ION THRUSTERS, 1978

W. R. Kerslake and L. R. Ignaczak 1978 10 p refs Presented at the 13th Intern. Elec. Propulsion Conf., San Diego, Calif., 25-27 Apr. 1978; sponsored in part by AIAA and DGLR

(NASA-TM-78827; E-9531) Avail: NTIS HC A02/MF A01 CSCL 21C

The historical record of the SERT 2 spacecraft and ion thruster systems for 8 years since the February 1970 launch is reviewed. The original SERT 2 mission, one year duration, was planned with the spacecraft in a continuous sunlight orbit to provide continuous solar power. An extended mission, using intermittent power available from an earth shadowed orbit was performed during the past 5 years while waiting for the orbit to change again to continuous sunlight in early 1979. Continuous thruster testing is planned in 1979. Both spacecraft and ion thruster systems are near-fully functional when the solar array is illuminated. Thruster system 2 is fully operational. Thruster system 1 continues to demonstrate relight capability, but the high-voltage-grid short remains. Author

N78-21202*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EVOLUTION OF THE 1-mlb MERCURY ION THRUSTER SUBSYSTEM

W. R. Kerslake and B. A. Banks 1978 25 p refs Presented at the 13th Intern. Elec. Propulsion Conf., San Diego, Calif., 25-27 Apr. 1978; cosponsored by AIAA and DGLR

(NASA-TM-73733; E-9278) Avail: NTIS HC A02/MF A01 CSCL 21C

The developmental history, performance, and major lifetests of each component of the present 1-mlb (4.5 mN) thruster system are traced over the past 10 years. The 1-mlb thruster subsystem consists of an 8 cm diameter ion thruster mounted on 2 axis gimbals, a mercury propellant tank, a power electronics unit, a controller/digital interface unit, and necessary electrical harnesses plus propellant tankage and feed lines. Author

N78-21203*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

PULSE IGNITION CHARACTERIZATION OF MERCURY ION THRUSTER HOLLOW CATHODE USING AN IMPROVED PULSE IGNITOR

E. G. Wintucky and R. P. Gruber 1978 20 p refs Presented at the 13th Intern. Elec. Propulsion Conf., San Diego, Calif., 25-27 Apr. 1978; cosponsored by AIAA and DGLR

(NASA-TM-78858; E-9592) Avail: NTIS HC A02/MF A01 CSCL 21C

An investigation of the high voltage pulse ignition characteristics of the 8 cm mercury ion thruster neutralizer cathode identified a low rate of voltage rise and long pulse duration as desirable factors for reliable cathode starting. Cathode starting breakdown voltages were measured over a range of mercury flow rates and tip heater powers for pulses with five different rates of voltage rise. Breakdown voltage requirements for the fastest rising pulse (2.5 to 3.0 kV/micro sec) were substantially higher (2 kV or more) than for the slowest rising pulse (0.3 to 0.5 kV/micro sec) for the same starting conditions. Also described is an improved, low impedance pulse ignitor circuit which reduces power losses and eliminates problems with control and packaging associated with earlier designs. Author

N78-21204*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PLANNED FLIGHT TEST OF A MERCURY ION AUXILIARY PROPULSION SYSTEM. 1: OBJECTIVES, SYSTEMS DESCRIPTIONS, AND MISSION OPERATIONS

John C. Power 1978 46 p refs Presented at the 13th Intern. Elec. Propulsion Conf., San Diego, Calif., 25-27 Apr. 1978; cosponsored by AIAA and DGLR

(NASA-TM-78859; E-9589) Avail: NTIS HC A03/MF A01 CSCL 21C

A planned flight test of an 8 cm diameter, electron-bombardment mercury ion thruster system is described. The primary objective of the test is to flight qualify the 5 mN (1 mlb.) thruster system for auxiliary propulsion applications. A seven year north-south stationkeeping mission was selected as the basis for the flight test operating profile. The flight test, which will employ two thruster systems, will also generate thruster system space performance data, measure thruster-spacecraft interactions, and demonstrate thruster operation in a number of operating modes. The flight test is designated as SAMSO-601 and will be flown aboard the shuttle-launched Air Force space test program P80-1 satellite in 1981. The spacecraft will be 3-axis stabilized in its final 740 km circular orbit, which will have an inclination of approximately greater than 73 degrees. The spacecraft design lifetime is three years. Author

N78-21205*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF FACILITY BACKGROUND GASES ON INTERNAL EROSION OF THE 30-cm Hg ION THRUSTER
Vincent K. Rawlin and Maris A. Mantenieks 1978 31 p refs Presented at the 13th Intern. Elec. Propulsion Conf., San Diego, Calif., 25-27 Apr. 1978; sponsored by AIAA and DGLR
(NASA-TM-73803; E-9584; AIAA-78-665) Avail: NTIS HC A03/MF A01 CSCL 21C

Sputtering erosion of the upstream side of the molybdenum screen grid by discharge chamber ions in mercury bombardment thrusters was considered. Data which revealed that the screen grid erosion was very sensitive to the partial pressure of certain background gases in the space simulation vacuum facility were presented along with results of tests conducted to evaluate this effect. It is shown from estimates of the screen grid erosion in space that adequate lifetime for proposed missions exists.
Author

N78-21206*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A REVIEW OF ELECTRON BOMBARDMENT THRUSTER SYSTEMS/SPACECRAFT FIELD AND PARTICLE INTERFACES
David C. Byers 1978 36 p refs Presented at the 13th Intern. Elec. Propulsion Conf., San Diego, Calif., 25-27 Apr. 1978; sponsored by AIAA and DGLR
(NASA-TM-78850; E-9571) Avail: NTIS HC A03/MF A01 CSCL 21C

Information on the field and particle interfaces of electron bombardment ion thruster systems was summarized. Major areas discussed were the nonpropellant particles, neutral propellant, ion beam, low energy plasma, and fields. Spacecraft functions and subsystems reviewed were solar arrays, thermal control systems, optical sensors, communications, science, structures and materials, and potential control.
Author

N78-21207*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DIAGNOSTIC EVALUATIONS OF A BEAM-SHIELDED 8-cm MERCURY ION THRUSTER
S. Nakanishi 1978 25 p refs Presented at the 13th Intern. Elec. Propulsion Conf., San Diego, Calif., 25-27 Apr. 1978; sponsored by AIAA and DGLR
(NASA-TM-78855; E-9581) Avail: NTIS HC A02/MF A01 CSCL 21C

An engineering model thruster fitted with a remotely actuated graphite fiber polyimide composite beam shield was tested in a 3- by 6.5-meter vacuum facility for in situ assessment of beam shield effects on thruster performance. Accelerator drain current neutralizer floating potential and ion beam floating potential increased slightly when the shield was moved into position. A target exposed to the low density regions of the ion beam was used to map the boundaries of energetic fringe ions capable of sputtering. The particle efflux was evaluated by measurement of film deposits on cold, heated, bare, and enclosed glass slides.
Author

N78-21208*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE 5200 CYCLE TEST OF AN 8-cm DIAMETER Hg ION THRUSTER
M. A. Mantenieks and E. G. Wintucky 1978 27 p refs Presented at the 13th Intern. Elec. Propulsion Conf., San Diego, Calif., 25-27 Apr. 1978; sponsored by AIAA and DGLR
(NASA-TM-78860; E-9590) Avail: NTIS HC A03/MF A01 CSCL 21C

An accelerated cycle test was conducted in which an 8-cm Engineering Model Thruster (EMT) prototype successfully completed 5200 on-off cycles and a total of more than 1300 hours of thruster operation at a 4.5 mN thrust level. Cathode tip heater powers required for starting and keeper voltages remained well within acceptable limits. The discharge chamber utilization and electrical efficiency were nearly constant over the duration of the test. It was concluded that on-off cyclic operation by itself does not appreciably degrade starting capability or performance of the 8-cm EMT.
Author

N78-21209*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PLANNED FLIGHT TEST OF A MERCURY ION AUXILIARY PROPULSION SYSTEM. PART 2: INTEGRATION WITH HOST SPACECRAFT
Rodney M. Knight 1978 16 p refs Presented at the 13th Intern. Elec. Propulsion Conf., San Diego, Calif., 25-27 Apr. 1978; sponsored by AIAA and DGLR
(NASA-TM-78869; E-9599) Avail: NTIS HC A02/MF A01 CSCL 21C

The objectives of the flight test and a description on how those objectives are in support of an overall program goal of attaining user application were described. The approach to accomplishment was presented as it applies to integrating the propulsion system with the host spacecraft. A number of known interface design considerations which affect the propulsion system and the spacecraft were discussed. Analogies were drawn comparing the relationship of the organizations involved with this flight test with those anticipated for future operational missions. The paper also expanded upon objectives, system description, mission operations, and measurement of plume effects.
Author

N78-21211*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LIQUID ROCKET ENGINE SELF-COOLED COMBUSTION CHAMBERS Space Vehicle Design Criteria
Sep. 1977 130 p refs
(NASA-SP-8124) Avail: NTIS HC A07/MF A01 CSCL 21H

Self-cooled combustion chambers are chambers in which the chamber wall temperature is controlled by methods other than fluid flow within the chamber wall supplied from an external source. In such chambers, adiabatic wall temperature may be controlled by use of upstream fluid components such as the injector or a film-coolant ring, or by internal flow of self-contained materials; e.g. pyrolysis gas flow in charring ablators, and the flow of infiltrated liquid metals in porous matrices. Five types of self-cooled chambers are considered in this monograph. The name identifying the chamber is indicative of the method (mechanism) by which the chamber is cooled, as follows: ablative; radiation cooled; internally regenerative (Interegen); heat sink; adiabatic wall. Except for the Interegen and heat sink concepts, each chamber type is discussed separately. A separate and final section of the monograph deals with heat transfer to the chamber wall and treats Stanton number evaluation, film cooling, and film-coolant injection techniques, since these subjects are common to all chamber types. Techniques for analysis of gas film cooling and liquid film cooling are presented.
Author

N78-22148*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CLOSED LOOP SOLAR ARRAY-ION THRUSTER SYSTEM WITH POWER CONTROL CIRCUITRY Patent Application
Robert P. Gruber, inventor (to NASA) Filed 29 Mar. 1978 20 p
(NASA-Case-LEW-12780-1; US-Patent-Appl-SN-891370) Avail: NTIS HC A02/MF A01 CSCL 21C

A solar array-ion thruster system is described which includes a power control circuit that permits use of the thruster itself in operating the solar array at the maximum power point. The power control circuit, connected between the solar array and the ion thruster and receiving voltage and current signals from the former, multiplies the voltage and current signals together to produce a power signal which is differentiated with respect to time. The differentiator output is detected by a zero crossing detector and, after suitable shaping, the detector output is

phase compared with a clock in a phase demodulator. An integrator receives no output from the phase demodulator when the operating point is at the maximum power point, but is driven toward the maximum power point for non-optimum operation. A ramp generator provides minor variations in the beam current reference signal produced by the integrator in order to obtain the first derivative of power. NASA

N78-23142*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A MECHANICAL THERMAL AND ELECTRICAL PACKAGING DESIGN FOR A PROTOTYPE POWER MANAGEMENT AND CONTROL SYSTEM FOR THE 30 cm MERCURY ION THRUSTER

G. Richard Sharp, Louis Gedeon, Jon C. Oglebay, Francis S. Shaker, and Clifford E. Siegert 1978 31 p refs Presented at the 13th Intern. Elec. Propulsion Conf., San Diego, Calif., 25-27 Apr. 1978; sponsored by AIAA and DGLR

(NASA-TM-78882; E-9593) Avail: NTIS HC A03/MF A01 CSCL 21C

A prototype electric power management and thruster control system for a 30 cm ion thruster is described. The system meets all of the requirements necessary to operate a thruster in a fully automatic mode. Power input to the system can vary over a full two to one dynamic range (200 to 400 V) for the solar array or other power source. The power management and control system is designed to protect the thruster, the flight system and itself from arcs and is fully compatible with standard spacecraft electronics. The system is easily integrated into flight systems which can operate over a thermal environment ranging from 0.3 to 5 AU. The complete power management and control system measures 45.7 cm (18 in.) x 15.2 cm (6 in.) x 114.8 cm (45.2 in.) and weighs 36.2 kg (79.7 lb). At full power the overall efficiency of the system is estimated to be 87.4 percent. Three systems are currently being built and a full schedule of environmental and electrical testing is planned. Author

N78-23143*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A 30-cm MERCURY ION THRUSTER PERFORMANCE WITH A 1 kW CAPACITOR-DIODE VOLTAGE MULTIPLIER BEAM SUPPLY

F. F. Terdan and W. T. Harrigill, Jr. 27 Apr. 1978 17 p refs Presented at the 13th Intern. Elec. Propulsion Conf., San Diego, Calif., 25-27 Apr. 1978; sponsored by AIAA and DGLR

(NASA-TM-78864; E-9555; AIAA-Paper-78-686) Avail: NTIS HC A02/MF A01 CSCL 21C

A 1 kW solar array and capacitor-diode voltage multiplier converter (S/A-CDVM) was successfully integrated with a 30 cm diameter mercury ion thruster system to provide ion beam power. Measurements were made to compare steady state and transient response performance of a conventional bridge converter with the S/A-CDVM converter used for the ion beam supply. The ability to recover from screen to accelerator arcs and promptly re-establish stable thruster performance was demonstrated. Solar array transient response to thruster arcing was measured. Author

N78-23144*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SENSITIVITY OF 30-cm MERCURY BOMBARDMENT ION THRUSTER CHARACTERISTICS TO ACCELERATOR GRID DESIGN

V. K. Rawlin 1978 29 p refs Presented at the 13th Intern. Elec. Propulsion Conf., San Diego, Calif., 25-27 Apr. 1978; sponsored by AIAA and DGLR

(NASA-TM-78861; E-9597; AIAA-Paper-78-668) Avail: NTIS HC A03/MF A01 CSCL 21C

The design of ion optics for bombardment thrusters strongly influences overall performance and lifetime. The operation of a 30 cm thruster with accelerator grid open area fractions ranging from 43 to 24 percent, was evaluated and compared with experimental and theoretical results. Ion optics properties measured included the beam current extraction capability, the minimum accelerator grid voltage to prevent backstreaming, ion beamlet diameter as a function of radial position on the grid and accelerator grid hole diameter, and the high energy, high angle ion beam edge location. Discharge chamber properties evaluated were propellant utilization efficiency, minimum discharge power per beam amp, and minimum discharge voltage. Author

N78-28173*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INVESTIGATION OF THE EFFECT OF CERAMIC COATINGS ON ROCKET THRUST CHAMBER LIFE

R. J. Quentmeyer, H. J. Kasper, and J. M. Kazaroff 1978 26 p refs Presented at the 14th Propulsion Conf., Las Vegas, Nev., 25-27 Jul. 1978; sponsored by AIAA and the Soc. of Automotive Engr.

(NASA-TM-78892; E-9630; AIAA-Paper-78-1034) Avail: NTIS HC A03/MF A01 CSCL 21H

Cylindrical rocket thrust chamber cylinders were coated with a 0.203 mm (0.008 in.) layer of zirconium oxide using a process that employed electrodeposition of metal to a spray coated mandrel. The cylinders were cyclically tested using hydrogen oxygen propellants at a nominal chamber pressure of 4.14 MN/sq m (600 psia) to show the effect of the coating on life. Both cylinders failed prematurely due to causes unrelated to the coatings. Post destructive analysis showed no cooling passage wall deformation. Where erosion of the coating occurred, the coating thickness stabilized at 0.061 mm (0.0024 in.) within 80 cycles and remained well adhered throughout the tests. Author

N78-27170*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STATUS OF THE NASA-LEWIS RESEARCH CENTER SPACECRAFT CHARGING INVESTIGATION

N. John Stevens, Frank D. Berkopec, and Carolyn K. Purvis 1978 25 p refs Presented at the Spacecraft Electromagnetic Compatibility Seminar, Noordwijk, The Netherlands, 24-26 May 1978; sponsored by the European Space Research and Technology Centre (ESTEC)

(NASA-TM-78938; E-9682) Avail: NTIS HC A02/MF A01 CSCL 22B

The technology necessary to control the absolute and differential charging of spacecraft surfaces is detailed for developing ground simulation facilities, characterizing the charging and discharging characteristics of spacecraft materials, deriving analytical modelling tools and issuing design guideline documents. Facilities were developed and testing of various materials was completed. Comparisons between experimental results, space results and predictions from models were made. Harness transient monitors were flown on satellites. G.G.

N78-27174*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE OF A THERMIONIC CONVERTER MODULE UTILIZING EMITTER AND COLLECTOR HEAT PIPES

Erich Kroeger, James Morris, Gabor Miskolczy (Thermo Electron Corp.), David P. Lieb (Thermo Electron Corp.), and Douglass B. Goodale (Thermo Electron Corp.) Jun 1978 38 p refs (Contract NAS3-20270)

(NASA-TM-78941; E-9705) Avail: NTIS HC A03/MF A01 CSCL 10A

A thermionic converter module simulating a configuration for an out-of-core thermionic nuclear reactor was designed, fabricated, and tested. The module consists of three cylindrical thermionic converters. The tungsten emitter of the converter is heated by a tungsten, lithium heat pipe. The emitter heat pipes are immersed in a furnace, insulated by MULTI-FOIL thermal insulation, and heated by tungsten radiation filaments. The performance of each thermionic converter was characterized before assembly into the module. Dynamic voltage, current curves were taken using a 60 Hz sweep and computerized data acquisition over a range of emitter, collector, and cesium-reservoir temperatures. An output power of 215 W was observed at an emitter temperature of 1750 K and a collector temperature of 855 K for a two diode module. With a three diode module, an output power of 270 W was observed at an average emitter temperature of 1800 K and a Collector temperature of 875 K. J.M.S.

N78-31183*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LIQUID ROCKET ENGINE AXIAL-FLOW TURBOPUMPS
Space Vehicle Design Criteria (Chemical Propulsion)
D. D. Scheer, M. C. Huppert (Rocketdyne), F. Viteri (Aerojet Liquid Rocket Co.), J. Farquhar (Aerojet Liquid Rocket Co.), and Russell B. Keller, Jr., ed. Apr. 1978 127 p. refs
(NASA-SP-8125) Avail: NTIS HC A07/MF A01 CSCL 21H

The axial pump is considered in terms of the total turbopump assembly. Stage hydrodynamic design, pump rotor assembly, pump materials for liquid hydrogen applications, and safety factors as utilized in state of the art pumps are among the topics discussed. Axial pump applications are included.
J.M.S.

A78-32734 * # **Planned flight test of a mercury ion auxiliary propulsion system. I - Objectives, systems descriptions, and mission operations.** J. L. Power (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft für Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-647-I.* 45 p. 22 refs.

A planned flight test of an 8-cm diameter, electron-bombardment mercury ion thruster system is described. The primary objective of the test is to flight qualify the 5 mN thruster system for auxiliary propulsion applications. A seven year north-south station-keeping mission was selected as the basis for the flight test operating profile. The flight test, which will employ two thruster systems, will also generate thruster system space performance data, measure thruster-spacecraft interactions, and demonstrate thruster operation in a number of operating modes. The flight test is designated as SAMSO-601 and will be flown aboard the Shuttle-launched Air Force Space Test Program P80-1 satellite in 1981. The spacecraft will be 3-axis stabilized in its final 740 km circular orbit, which will have an inclination of at least 73 degrees. The spacecraft design lifetime is three years. (Author)

A78-32735 * # **Planned flight test of a mercury ion auxiliary propulsion system. II - Integration with host spacecraft.** R. M. Knight (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft für Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-647-II.* 15 p. 5 refs.

This is part II of a three-part paper describing the approved flight test of a mercury ion auxiliary propulsion system. The objectives of the flight test are summarized with reference to user application. The approach to accomplishment is presented as it applies to integrating the propulsion system with the host spacecraft, USAF's STP P80-1. A number of known interface design considerations which affect the propulsion system and the spacecraft are discussed. Finally, analogies are drawn comparing the relationship of the organizations involved with this flight test with those anticipated for future operational missions. Attention is given to the viewpoint of the project office. (Author)

A78-32736 * # **5200 cycle of an 8-cm diameter Hg ion thruster.** M. A. Mantenieks and E. G. Wintucky (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft für Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-649.* 26 p. 12 refs.

An accelerated cycle test was conducted in which an 8-cm Engineering Model Thruster (EMT) prototype successfully completed 5200 on-off cycles and a total of more than 1300 hours of thruster operation at a 4.5 mN thrust level. Cathode tip heater powers required for starting and keeper voltages remained well within acceptable limits. The discharge chamber utilization and electrical efficiency were nearly constant over the duration of the test. It is concluded that on-off cyclic operation by itself does not appreciably degrade starting capability or performance of the 8-cm EMT.
(Author)

A78-32743 * # **Status of SERT II spacecraft and ion thrusters - 1978.** W. R. Kerslake and L. R. Ignaczak (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft für Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-662.* 7 p. 6 refs.

The historical record of the SERT II spacecraft and ion thruster systems for 8 years since the February 1970 launch is reviewed. The original SERT II mission, one year duration, was planned with the spacecraft in a continuous sunlight orbit to provide continuous solar power. An extended mission, using intermittent power available from an earth shadowed orbit has been performed during the past 5 years while waiting for the orbit to change again to continuous sunlight in early 1979. Continuous thruster testing is planned in 1979. Both spacecraft and ion thruster systems are near-fully functional when the solar array is illuminated. Thruster system 2 is fully operational. Thruster system 1 continues to demonstrate relight capability, but the high-voltage-grid short remains. (Author)

A78-32745 * # **Effect of facility background gases on internal erosion of the 30-cm Hg ion thruster.** V. K. Rawlin and M. A. Mantenieks (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft für Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-665.* 30 p. 26 refs.

One life limiting phenomenon of mercury bombardment thrusters is sputtering erosion of the upstream side of the molybdenum screen grid by discharge chamber ions. Data were obtained which revealed that the screen grid erosion was very sensitive to the partial pressure of certain background gases in the space simulation vacuum facility. The results of tests conducted to evaluate this effect are presented. An estimate of the screen grid erosion in space was made which showed that adequate lifetime for proposed missions exists. (Author)

A78-32747 * # **Sensitivity of 30-cm mercury bombardment ion thruster characteristics to accelerator grid design.** V. K. Rawlin (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft für Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-668.* 28 p. 20 refs.

The design of ion optics for bombardment thrusters strongly influences overall performance and lifetime. The operation of a 30-cm thruster with accelerator grid open area fractions ranging from 43 to 24 percent, was evaluated and compared with previously published experimental and theoretical results. Ion optics properties measured included the beam current extraction capability, the minimum accelerator grid voltage to prevent backstreaming, ion beamlet diameter as a function of radial position on the grid and accelerator grid hole diameter, and the high energy, high angle ion beam edge location. Discharge chamber properties evaluated were propellant utilization efficiency, minimum discharge power per beam amp, and minimum discharge voltage. (Author)

A78-32750 * # **Investigation of high voltage spacecraft system interactions with plasma environments.** N. J. Stevens, F. D. Berkopec, C. K. Purvis, N. Grier, and J. Staskus (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft für Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-672.* 14 p. 29 refs.

The exposure of high voltage spacecraft systems to the charged particle environment of space can produce interactions that will influence system operation. An experimental investigation of these interactions has been undertaken for insulator and conductor test surfaces biased up to plus or minus 1 kV in a simulated low earth orbit charged particle environment. It has been found that these interactions are controlled by the insulator surfaces surrounding the

biased conductors. For positive applied voltages the electron current collection can be enhanced by the insulators. For negative applied voltages the insulator surface confines the voltage to the conductor region; this can cause arcing. Understanding these interactions and the technology to control their impact on system operation is essential to the design of solar cell arrays for ion drive propulsion applications that use direct drive power processing. (Author)

A78-32752 * # The Plasma Interaction Experiment /PIX/ Description and flight qualification test program. L. R. Ignaczak, F. A. Haley, E. J. Domino, D. H. Culp, and F. J. Shaker (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft für Luft- und Raumfahrt. International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-674.* 19 p.

The Plasma Interaction Experiment (PIX) is a battery powered preprogrammed auxiliary payload on the Landsat-C launch. This experiment is part of a larger program to investigate space plasma interactions with spacecraft surfaces and components. The varying plasma densities encountered during available telemetry coverage periods are deemed sufficient to determine first order interactions between the space plasma environment and the biased experimental surfaces. The specific objectives of the PIX flight experiment are to measure the plasma coupling current and the negative voltage breakdown characteristics of a solar array segment and a gold plated steel disk. Measurements will be made over a range of surface voltages up to plus or minus 1 kilovolt. The orbital environment will provide a range of plasma densities. The experimental surfaces will be voltage-biased in a preprogrammed step sequence to optimize the data returned for each plasma region and for the available telemetry coverage. (Author)

A78-32754 * # A review of electron bombardment thruster systems/spacecraft field and particle interfaces. D. C. Byers (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft für Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-677.* 35 p. 76 refs.

This paper collates and summarizes information on the field and particle interfaces of electron bombardment ion thruster systems. Major areas discussed are the propellant particles, neutral propellant, ion beam, low energy plasma, and fields. Spacecraft functions and subsystems reviewed are solar arrays, thermal control systems, optical sensors, communications, science, structures and materials, and potential control. An appendix is included to facilitate identification of specific interaction areas. (Author)

A78-32759 * # A mechanical, thermal and electrical packaging design for a prototype power management and control system for the 30 cm mercury ion thruster. G. R. Sharp, L. Gadeon, J. C. Oglebay, F. S. Shaker, and C. E. Siegert (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft für Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-585.* 31 p. 12 refs.

A prototype Electric Power Management and Thruster Control System for a 30 cm ion thruster has been built and is ready to support a first mission application. The system meets all of the requirements necessary to operate a thruster in a fully automatic mode. Power input to the system can vary over a full two to one dynamic range (200 to 400 V) for the solar array or other power source. The Power Management and Control system is designed to protect the thruster, the flight system and itself from arcs and is fully compatible with standard spacecraft electronics. The system is designed to be easily integrated into flight systems which can operate over a thermal environment ranging from 0.3 to 5 AU. The complete Power Management and Control system measures 45.7 cm x 15.2 cm x 114.8 cm and weighs 36.2 kg. At full power the overall efficiency of the system is estimated to be 87.4 percent. Three systems are currently being built and a full schedule of environmental and electrical testing is planned. (Author)

A78-32760 * # 30-cm mercury ion thruster performance with a 1 kW capacitor-diode voltage multiplier beam supply. F. S. Terdan and W. T. Harrigill, Jr. (NASA, Lewis Research Center Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft für Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-686.* 16 p. 19 refs.

A 1 kW Solar Array and Capacitor-Diode Voltage Multiplier Converter (S/A-CDVM) has been successfully integrated with a 30 cm-diameter mercury ion thruster system to provide ion beam power. Measurements were made to compare steady state and transient response performance of a conventional bridge converter with the S/A-CDVM converter used for the ion beam supply. The ability to recover from screen to accelerator arcs and promptly re-establish stable thruster performance was demonstrated. Solar array transient response to thruster arcing was also measured. (Author)

A78-32768 * # Diagnostic evaluations of a beam-shielded 8-cm mercury ion thruster. S. Nakanishi (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft für Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-702.* 24 p. 8 refs.

An engineering model thruster fitted with a remotely actuated graphite fiber polyimide composite beam shield was tested in a 3- by 6.5-meter vacuum facility for in-situ assessment of beam shield effects on thruster performance. Accelerator drain current neutralizer floating potential and ion beam floating potential increased slightly when the shield was moved into position. A target exposed to the low density regions of the ion beam was used to map the boundaries of energetic fringe ions capable of sputtering. The particle efflux was evaluated by measurement of film deposits on cold, heated, bare, and enclosed glass slides. (Author)

A78-32773 * # Pulse ignition characterization of mercury ion thruster hollow cathode using an improved pulse ignitor. E. G. Wintucky and R. P. Gruber (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft für Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-709.* 19 p. 12 refs.

An investigation of the high voltage pulse ignition characteristics of the 8-cm mercury ion thruster neutralizer cathode identified a low rate of voltage rise and long pulse duration as desirable factors for reliable cathode starting. Cathode starting breakdown voltages were measured over a range of mercury flow rates and tip heater powers for pulses with five different rates of voltage rise. Breakdown voltage requirements for the fastest rising pulse (2.5 to 3.0 kV/microsec) were substantially higher (2 kV or more) than for the slowest rising pulse (0.3 to 0.5 kV/microsec) for the same starting conditions. The paper also describes an improved, low impedance pulse ignitor circuit which reduces power losses and eliminates problems with control and packaging associated with earlier designs. (Author)

A78-32776 * # Evolution of the 1-mlb mercury ion thruster subsystem. W. R. Kerslake and B. A. Banks (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft für Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-711B.* 24 p. 30 refs.

A general description and review of the auxiliary Electric

Propulsion program, which led to the present 1-mlb (4.5 mN) thruster system, is presented. The developmental history, performance, and major lifetests of each component of the system are traced over the past 10 years. Major components include the 8-cm diameter ion thruster, the power processor, and the propellant reservoir and distribution system. (Author)

A78-40828 * # Comment on 'Heat-pipe reactors for space power applications'. R. E. English (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Energy*, vol. 2, May-June 1978, p. 191, 192. Authors' Reply, p. 192.

N78-10288*# Hughes Research Labs., Malibu, Calif. Ion Physics Dept.
EXTENDED PERFORMANCE SOLAR ELECTRIC PROPULSION THRUST SYSTEM STUDY. VOLUME 1: EXECUTIVE SUMMARY Final Report
R. L. Poeschel and E. I. Hawthorne. Sep. 1977. 108 p. refs.
(Contract NAS3-20395)
(NASA-CR-135281) Avail: NTIS HC A06/MF A01 CSCL 21C

Several thrust system design concepts were evaluated and compared using the specifications of the most advanced 30 cm engineering model thruster as the technology base. The extensions in thruster performance required for the Halley's comet mission were defined and alternative thrust system concepts were designed. Confirmation testing and analyses of thruster and power-processing components were performed, and the feasibility of satisfying extended performance requirements was verified. A baseline design was selected from the alternatives considered, and the design analysis and documentation were refined. A program development plan was formulated that outlines the work structure considered necessary for developing, qualifying, and fabricating the flight hardware for the baseline thrust system within the time frame of a project to rendezvous with Halley's comet. An assessment was made of the costs and risks associated with a baseline thrust system as provided to the mission project under this plan. Critical procurements and interfaces were identified and defined. Results are presented. Author

N78-11192*# Hughes Research Labs., Malibu, Calif.
EXTENDED PERFORMANCE SOLAR ELECTRIC PROPULSION THRUST SYSTEM STUDY. VOLUME 1: EXECUTIVE SUMMARY Final Report, 14 Feb. - 29 Aug. 1977
R. L. Poeschel, E. I. Hawthorne, Y. C. Weissman, M. Frisman, G. C. Benson, R. J. McGrath, R. M. Martinelli, T. L. Unsenberdt, and J. R. Beattie. Sep. 1977. 110 p. refs. Prepared in cooperation with Hughes Space and Communications Group, Los Angeles.
(Contract NAS3-20395)
(NASA-CR-135281) Avail: NTIS HC A06/MF A01 CSCL 21C

Several ion thrust system design concepts were evaluated and compared using the specifications of the most advanced 30 cm engineering model thruster as the technology base. Emphasis was placed on relatively high-power missions (60 to 100 kW) such as a Halley's comet rendezvous. The extensions in thruster performance required for the Halley's comet mission were defined and alternative thrust system concepts were designed in sufficient detail for comparing mass, efficiency, reliability, structure, and thermal characteristics. Confirmation testing and analysis of thruster and power processing components were performed. A baseline design was selected from the alternatives considered, and the design analysis and documentation were refined. The baseline thrust system design features modular construction, conventional power processing, and a concentrator solar array concept and is designed to interface with the Space Shuttle. A development plan was formulated that outlines the work structure considered necessary for developing the flight hardware for the baseline thrust system of a mission to rendezvous with Halley's comet during December 1985. Author

N78-12149*# TRW Defense and Space Systems Group, Redondo Beach, Calif.
ION BEAM PLUME AND EFFLUX CHARACTERIZATION FLIGHT EXPERIMENT STUDY Final Report, 1 Jan. - 1 Dec. 1977
J. M. Sellen, Jr., S. Zafran, A. Cola, G. Rosek, and G. K. Komatsu. 1 Dec. 1977. 166 p. refs.
(Contract NAS3-20287)
(NASA-CR-135275) Avail: NTIS HC A08/MF A01 CSCL 21C

A flight experiment and flight experiment package for a shuttle-borne flight test of an 8-cm mercury ion thruster was designed to obtain charged particle and neutral particle material transport data that cannot be obtained in conventional ground based laboratory testing facilities. By the use of both ground and space testing of ion thrusters, the flight worthiness of these ion thrusters, for other spacecraft applications, may be demonstrated. The flight experiment definition for the ion thruster initially defined a broadly ranging series of flight experiments and flight test sensors. From this larger test series and sensor list, an initial flight test configuration was selected with measurements on charged particle material transport, condensable neutral material transport, thruster material erosion, ion beam neutralization, and ion thrust beam/space plasma electrical equilibration. These measurement areas may all be examined for a seven day shuttle sortie mission and for available test time in the 50 - 100 hour period. Author

N78-13122*# Systems Science and Software, La Jolla, Calif.
SOLAR ELECTRIC PROPULSION THRUSTER INTERACTIONS WITH SOLAR ARRAYS Contractor Report, Jul. 1976 - Jul. 1977
Donald E. Parks and Ira Katz. Aug. 1977. 258 p. refs.
(Contract NAS3-20119)
(NASA-CR-135257, SSS-R-78-3420) Avail: NTIS HC A12/MF A01 CSCL 21C

The effect of interactions of spacecraft-generated and naturally occurring plasmas with high voltage solar array components on an advanced solar electric propulsion system proposed for the Halley's Comet rendezvous mission was investigated. The spacecraft-generated plasma consists of mercury ions and neutralizing electrons resulting from the operation of ion thrusters (the charge-exchange plasma) and associated hollow cathode neutralizers. Quantitative results are given for the parasitic currents and power coupled into solar arrays with voltage fixed as a function of position on the array. Author

N78-13123*# Colorado State Univ., Fort Collins. Dept. of Mechanical Engineering.
CHARGE-EXCHANGE PLASMA GENERATED BY AN ION THRUSTER Annual Report, 1 Nov. 1976 - 31 Dec. 1977
Harold R. Kaufman. Dec. 1977. 41 p. refs.
(Grant NsG 3038)
(NASA-CR-135318) Avail: NTIS HC A03/MF A01 CSCL 21C

The charge exchange plasma generated by an ion thruster was investigated experimentally using both 5 cm and 15 cm thrusters. Results are shown for wide ranges of radial distance from the thruster and angle from the beam direction. Considerations of test environment as well as distance from the thruster indicate that a valid simulation of a thruster on a spacecraft was obtained. A calculation procedure and a sample calculation of charge exchange plasma density and saturation electron current density are included. Author

N78-13187*# Colorado State Univ., Fort Collins. Dept. of Mechanical Engineering.
MERCURY ION THRUSTER RESEARCH, 1977 Annual Report, 1 Dec. 1976 - 1 Dec. 1977
Paul J. Wilbur. Dec. 1977. 163 p. refs.
(Grant NGR 06-002-112)
(NASA-CR-135317) Avail: NTIS HC A08/MF A01 CSCL 21C

The measured ion beam divergence characteristics of two and three-grid multiaperture accelerator systems are presented.

The effects of perveance geometry net-to-total accelerating voltage discharge voltage and propellant are examined The applicability of a model describing doubly-charged ion densities in mercury thrusters is demonstrated for an 8-cm diameter thruster The results of detailed Langmuir probing of the interior of an operating cathode are given and used to determine the ionization fraction as a function of position upstream of the cathode orifice A mathematical model of discharge chamber electron diffusion and collection processes is presented along with scaling laws useful in estimating performance of large diameter and/or high specific impulse thrusters A model describing the production of ionized molecular nitrogen in ion thrusters is included Author

N78-18169*# TRW Defense and Space Systems Group, Redondo Beach, Calif

ION ENGINE AUXILIARY PROPULSION APPLICATIONS AND INTEGRATION STUDY

S Zafran ed 7 Jul 1977 280 p refs

(Contract NAS3-20113)

(NASA-CR-135312 TRW-29989-6013-RU-001 Avail NTIS HC A13/MF A01 CSCL 21C

The benefits derived from application of the 8 cm mercury electron bombardment ion thruster were assessed Two specific spacecraft missions were studied A thruster was tested to provide additional needed information on its efflux characteristics and interactive effects A Users Manual was then prepared describing how to integrate the thruster for auxiliary propulsion on geosynchronous satellites By incorporating ion engines on an advanced communications mission the weight available for added payload increases by about 82 kg (181 lb) for a 100 kg (2200 lb) satellite which otherwise uses electrothermal hydrazine Ion engines can be integrated into a high performance propulsion module that is compatible with the multimission modular spacecraft and can be used for both geosynchronous and low earth orbit applications The low disturbance torques introduced by the ion engines permit accurate spacecraft pointing with the payload in operation during thrusting periods The feasibility of using the thruster's neutralizer assembly for neutralization of differentially charged spacecraft surfaces at geosynchronous altitude was demonstrated during the testing program Author

N78-18080*# Hughes Research Labs, Malibu, Calif

EXTENDED PERFORMANCE SOLAR ELECTRIC PROPULSION THRUST SYSTEM STUDY VOLUME 4 THRUSTER TECHNOLOGY EVALUATION Final Report, 14 Feb - 29 Aug. 1977

R L Poeschel, E I Hawthorne, V J Weisman, M Friedman, G C Benson, R J McGrath, R M Martinelli, T L Unsenberut and J R Beattie Sep 1977 110 p refs Prepared in cooperation with Hughes Space and Communications Group, Los Angeles

(Contract NAS3-20395)

(NASA-CR-135281) Avail NTIS HC A06/MF A01 CSCL 21C

Several thrust system design concepts were evaluated and compared using the specifications of the most advanced 30 cm engineering model thruster as the technology base Emphasis was placed on relatively high power missions 60 to 100 kW such as a Halley's comet rendezvous The extensions in thruster performance required for the Halley's comet mission were defined and alternative thrust system concepts were designed in sufficient detail for comparing mass efficiency reliability structure and thermal characteristics Confirmation testing and analysis of thruster and power processing components were performed and the feasibility of satisfying extended performance requirements was verified A baseline design was selected from the alternatives considered and the design analysis and documentation were refined The baseline thrust system design features modular construction, compatible power processing and a concentrator solar array concept and is designed to interface with the Space Shuttle Author

N78-18168*# Hughes Research Labs., Malibu, Calif Ion Physics Dept. Staff

EXTENDED PERFORMANCE SOLAR ELECTRIC PROPULSION THRUST SYSTEM STUDY. VOLUME 5: CAPACITOR-DIODE VOLTAGE MULTIPLIER: TECHNOLOGY EVALUATION Final Report

R M Martinelli Sep 1977 74 p

(Contract NAS3-20395)

(NASA-CR-135281-Vol-5) Avail NTIS HC A04/MF A01 CSCL 21C

A 1-kW capacitor-diode voltage multiplier (CDVM) was designed, fabricated and tested to demonstrate the power of feasibility of high power CDVM's and to verify the analytical techniques that had been used to predict the performance characteristics of a 6-kw CDVM High efficiency (98.2%), a low ratio of component weight to power (0.55 kg/kW), and low output ripple voltage (less than 1%, peak to peak) were obtained during the operation of a 1-kW CDVM versus input line, load current, and load fault conditions Author

N78-18169*# Hughes Research Labs., Malibu, Calif

EXTENDED PERFORMANCE SOLAR ELECTRIC PROPULSION THRUST SYSTEM STUDY. VOLUME 3: TRADEOFF STUDIES OF ALTERNATE THRUST SYSTEM CONFIGURATIONS Final Report, 14 Feb. - 29 Aug. 1977

E I Hawthorne Dec 1977 157 p refs

(Contract NAS3-20395)

(NASA-CR-135281-Vol-3) Avail NTIS HC A08/MF A01 CSCL 21C

Several thrust system design concepts were evaluated and compared using the specifications of the most advanced 30 cm engineering model thruster as the technology base Emphasis was placed on relatively high power missions The extensions in thruster performance required for the Halley's comet mission were defined and alternative thrust system concepts were designed in sufficient detail for comparing mass, efficiency, reliability, structure and thermal characteristics Confirmation testing and analysis of thruster and power-processing components were performed A baseline design was selected from the alternatives considered and the design analysis and documentation were refined A program development plan was formulated that outlines the work structure considered necessary for developing, qualifying, and fabricating the flight hardware for the baseline thrust system within the time frame of a project to rendezvous with Halley's comet An assessment was made of the costs and risks associated with a baseline thrust system as provided to the mission project under the plan Critical procurements and interfaces were identified and defined Author

N78-19198*# Colorado State Univ., Fort Collins Dept. of Mechanical Engineering

INERT GAS THRUSTERS Annual Report, 1 Aug. 1976 - 30 Jul. 1977

Harold R Kaufman Jul 1977 78 p refs

(Grant NsG 3011)

(NASA-CR-135228) Avail NTIS HC A05/MF A01 CSCL 21C

Inert gases particularly argon and xenon are of interest as possible alternatives to the usual electric thruster propellants of mercury and cesium Hollow cathode data were obtained for a wide range of operating conditions Some test conditions gave plasma coupling voltages at or below the sputtering threshold, hence should permit long operating lifetimes All observations of hollow cathode operation were consistent with a single theory of operation in which a significant amount of the total electron emission is from localized areas within the orifice The mode of emission is also supported by scanning electron microscope photographs that indicate local temperatures at or near the melting temperature of the tungsten tip Experimental hollow cathode performance was correlated for two orifice diameters three inert gas propellants, and a range of flow rates for each propellant The basic theory for the production of doubly ionized argon and xenon was completed Experimental measurements of the doubly ionized fraction agree with theory within about plus or minus 20 percent High voltage isolators were studied for the propellant feed line The breakdown voltage per segment ranged from 300 to over 500 V with argon Author

N78-19280*# TRW Defense and Space Systems Group, Redondo Beach, Calif

ELECTRIC PROTOTYPE POWER PROCESSOR FOR A 30CM ION THRUSTER Final Report, 1 Apr. 1976 - 1 Mar. 1977

J J Biess, L Y Inouye, and A D Schoenfeld Mar 1977 104 p

(Contract NAS3-19730)

(NASA-CR-135287 TRW-28014-6001-TU-00) Avail NTIS HC A06/MF A01 CSCL 21C

An electrical prototype power processor unit was designed, fabricated and tested with a 30 cm mercury ion engine for primary space propulsion The power processor unit used the thyristor series resonant inverter as the basic power stage for the high power beam and discharge supplies A transistorized series resonant inverter processed the remaining power for the low power outputs The power processor included a digital interface unit to process all input commands and internal telemetry signals so that electric propulsion systems could be operated with a central computer system The electrical prototype unit included design improvement in the power components such as thyristors transistors, filters and resonant capacitors, and power transformers and inductors in order to reduce component weight, to minimize losses, and to control the component temperature rise A design analysis for the electrical prototype is also presented on the component weight, losses, part count and reliability estimate The electrical prototype was tested in a thermal vacuum environment Integration tests were performed with a 30 cm ion engine and demonstrated operational compatibility Electromagnetic interference data was also recorded on the design to provide information for spacecraft integration Author

N78-20280*# TRW Defense and Space Systems Group, Redondo Beach, Calif Power Conversion Electronics Dept

EXTENDED PERFORMANCE ELECTRIC PROPULSION POWER PROCESSOR DESIGN STUDY. VOLUME 1: EXECUTIVE SUMMARY Final Report, 1 May - 25 Oct. 1977

J J Biess, L Y Inouye, and A D Schoenfeld Nov. 1977 83 p

(Contract NAS3-20403)

(NASA-CR-135357 TRW-31526-000-Vol-1) Avail NTIS HC A05/MF A01 CSCL 21C

Several power processor design concepts were evaluated and compared Emphasis was placed on a 30cm ion thruster power processor with a beam supply rating of 2.2kW to 10kW Extensions in power processor performance were defined and were designed in sufficient detail to determine efficiency, component weight, part count, reliability, and thermal control Preliminary electrical design, mechanical design, and thermal analysis were performed on a 6kW power transformer for the beam supply Bi-Mod mechanical, structural, and thermal control configurations were evaluated for the power processor, and preliminary estimates of mechanical weight were determined A program development plan was formulated that outlines the work breakdown structure for the development, qualification and fabrication of the power processor flight hardware. Author

N78-22148*# Texas A&I Univ., Kingsville

INVESTIGATION OF THE BURNING CONFIGURATION OF A COAXIAL INJECTOR IN A COMBUSTION CHAMBER

J OHara Feb 1978 26 p refs

(Grant NsG-3112)

(NASA-CR-135383) Avail NTIS HC A03/MF A01 CSCL 21H

An analytical investigation was made into the stability of the burning configuration of a single coaxial injector surrounded by similar injectors The stability criteria was based on an average pressure difference along the boundaries of the adjacent stream tubes as calculated using Spaulding's numerical method The results indicate qualitatively that there is a tendency for the injectors to have different burning configurations It is believed that the configuration achieved is random however once the burning configuration is established, it is believed to persist.

N78-24279*# Rocketdyne, Canoga Park, Calif

PREBURNER OF STAGED COMBUSTION ROCKET ENGINE Final Report, Jul. 1976 - Dec. 1977

M C Yost Feb 1978 280 p refs

(Contract NAS3-19713)

(NASA-CR-135358, RI/RD78-114) Avail NTIS HC A13/MF A01 CSCL 21H

A regeneratively cooled LOX/hydrogen staged combustion assembly system with a 400:1 expansion area ratio nozzle utilizing an 89,000 Newton (20,000 pound) thrust regeneratively cooled thrust chamber and 175:1 tubular nozzle was analyzed, assembled and tested The components for this assembly include two spark/torch oxygen-hydrogen igniters, two servo-controlled LOX valves, a preburner injector, a preburner combustor, a main propellant injector, a regeneratively cooled combustion chamber, a regeneratively cooled tubular nozzle with an expansion area ratio of 175:1, an uncooled heavy-wall steel nozzle with an expansion area ratio of 400:1, and interconnecting ducting The analytical effort was performed to optimize the thermal and structural characteristics of each of the new components and the ducting, and to reverify the capabilities of the previously fabricated components The testing effort provided a demonstration of the preburner/combustor chamber operation, chamber combustion efficiency and stability, and chamber and nozzle heat transfer Author

N78-24280*# Hughes Research Labs., Malibu, Calif Ion Physics Dept

THE 30-CM ION THRUSTER POWER PROCESSOR Final Report

B G Herron and D J Hopper Apr 1978 77 p refs

(Contract NAS3-17223)

(NASA-CR-135401) Avail NTIS HC A05/MF A01 CSCL 21C

A power processor unit for powering and controlling the 30 cm Mercury Electron-Bombardment Ion Thruster was designed, fabricated, and tested The unit uses a unique and highly efficient transistor bridge inverter power stage in its implementation The system operated from a 200 to 400 V dc input power bus, provides 12 independently controllable and closely regulated dc power outputs and has an overall power conditioning capacity of 3.5 kW Protective circuitry was incorporated as an integral part of the design to assure failure-free operation during transient and steady state load faults The implemented unit demonstrated an electrical efficiency between 91.5 and 91.9 at its nominal rated load over the 200 to 400 V dc input bus range Author

N78-25127*# Rocketdyne, Canoga Park, Calif Advanced and Propulsion Engineering Units

ADVANCED SPACE ENGINE POWERHEAD BREADBOARD ASSEMBLY SYSTEM STUDY Final Report, Dec. 1976 - Jun. 1977

R G Campbell Mar 1978 170 p refs

(Contract NAS3-20386)

(NASA-CR-135232, RI/RD77-192) Avail NTIS HC A08/MF A01 CSCL 21H

The objective of this study was to establish a preliminary design of a Powerhead Breadboard Assembly (PBA) for an 88,964 Newton (20,000 pound) thrust oxygen/hydrogen staged combustion cycle engine for use in orbital transfer vehicle propulsion Existing turbopump, preburner and thrust chamber components were integrated with interconnecting ducting, a heat exchanger and a control system to complete the PBA design Cycle studies were conducted to define starting transients and steady state balances for the completed design Specifications were developed for all valve applications and the conditions required for the control system integration with the facility for system test were defined Author

A78-32751 * Spacecraft-generated plasma interaction with high voltage solar array. D. E. Parks and I. Katz (Systems, Science and Software, La Jolla, Calif.). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft fur Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-673.* 9 p. 11 refs. Contract No. NAS3-20119.

Calculations are made of the effect of interactions of spacecraft-generated plasmas and high voltage solar array components on an advanced Solar Electric Propulsion system. The plasma consists of mercury ions and electrons resulting from the operation of ion thrusters and associated hollow cathode neutralizers. Because large areas of the solar array are at high potential and not completely insulated from the surrounding plasma, the array can, under some conditions, collect excessive electron currents. Results are given for the parasitic currents collected by the solar arrays and means for reducing these currents are considered. (Author)

A78-32753 * Ion beam plume and efflux measurements of an 8-cm mercury ion thruster. G. K. Komatsu, J. M. Sellen, Jr., and S. Zafran (TRW Defense and Space Systems Group, Redondo Beach, Calif.). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft fur Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-676.* 9 p. Contract No. NAS3-20113.

Measurements of the ion beam plume and efflux constituents of an 8-cm mercury ion thruster have been carried out in the TRW 5 x 10 foot testing chamber. Charged components (ion beam plume) were measured with an array of movable position Faraday cups and retarding potential analyzers yielding both current density and particle energy determination. Neutral components (ion beam efflux) were determined with a movable position ionization gauge. Measurements of the ion beam plume were performed for a thruster both with and without a sputter shield. Analysis of data in terms of normalized effluxes has been carried out and has been applied to an example calculation of efflux compatibility with a communications spacecraft. (Author)

A78-37430 * Extended performance solar electric propulsion thrust system design. J. E. Cake (NASA, Lewis Research Center, Cleveland, Ohio), E. I. Hawthorne (Hughes Aircraft Co., Space and Communications Group, Los Angeles, Calif.), and R. L. Poeschel (Hughes Research Laboratories, Malibu, Calif.). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft fur Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-643.* 14 p. 19 refs. Contract No. NAS3-20395.

A thrust system design has been established for an extended performance technology, 6.4 kW, 4800 sec specific impulse ion thruster. The configuration is comprised of ten thrusters configured with a power management and control subsystem in a modular thrust system design. The system design approach is an adaptation of that previously established for the baseline technology 2.7 kW, 3000 sec specific impulse ion thruster. The power management and control subsystem design includes a combination of individual electronics for each thruster and a set of electronics with redundancy that are common to all thrusters. The thermal dissipation from all electronics is removed with a common heat pipe/radiator assembly. (Author)

A78-37434 * Engineering Model 8-cm Thruster System. B. G. Herron (Hughes Aircraft Co., Technology Div., El Segundo, Calif.), J. Hyman, Jr., D. J. Hopper, W. S. Williamson, C. R. Dulgeroff, and C. R. Collett (Hughes Research Laboratories, Malibu, Calif.). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft fur Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-646.* 11 p. 8 refs. Contracts No. NAS3-18917; No. NAS3-21023.

Development of an Engineering Model 8-cm Mercury Ion Thruster System for Satellite Control has been successfully completed. This system operates at a specific impulse in excess of 2800 sec, produces a thrust of 5 mN with a total input power of 165 W; it has a dry mass of 16.6 kg and a mercury-propellant-reservoir capacity of 8.75 kg. This paper summarizes the development work, the system characteristics and performance, and the testing undertaken to verify the design. (Author)

A78-37436 * Extended-performance thruster technology evaluation. J. R. Beattie, R. L. Poeschel (Hughes Research Laboratories, Malibu, Calif.), and R. T. Bechtel (NASA, Lewis Research Center, Solar Electric Propulsion Office, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft fur Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-666.* 14 p. 15 refs. Contract No. NAS3-20395.

Two 30-cm ion thruster technology areas are investigated in support of the extended-performance thruster operation required for the Halley's comet rendezvous mission. These areas include an evaluation of the thruster performance and lifetime characteristics at increased specific impulse and power levels, and the design and evaluation of a high-voltage propellant electrical isolator. Experimental results are presented indicating that all elements of the thruster design function well at the higher specific impulse and power levels. It is shown that the only thruster modifications required for extended-performance operation are a respacing of the ion optics assembly and a redesign of the propellant isolators. Experimental results obtained from three isolator designs are presented, and it is concluded that the design and development of a high-voltage isolator is possible using existing technology. (Author)

A78-37439 * Electrical Prototype Power Processor for the 30-cm Mercury electric propulsion engine. J. J. Biess (TRW Defense and Space Systems Group, Redondo Beach, Calif.) and R. J. Frye (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft fur Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-684.* 9 p. 9 refs. Contracts No. NAS3-19730; No. NAS3-20403.

An Electrical Prototpye Power Processor has been designed to the latest electrical and performance requirements for a flight-type 30-cm ion engine and includes all the necessary power, command, telemetry and control interfaces for a typical electric propulsion subsystem. The power processor was configured into seven separate mechanical modules that would allow subassembly fabrication, test and integration into a complete power processor unit assembly. The conceptual mechanical packaging of the electrical prototype power processor unit demonstrated the relative location of power, high voltage and control electronic components to minimize electrical interactions and to provide adequate thermal control in a vacuum environment. Thermal control was accomplished with a heat pipe simulator attached to the base of the modules. (Author)

23 CHEMISTRY AND MATERIALS (GENERAL)

Includes biochemistry and organic chemistry.

N78-22167*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IN SITU SELF CROSS-LINKING OF POLYVINYL ALCOHOL BATTERY SEPARATORS Patent Application
Warren H. Philipp, L. C. Hsu, and D. W. Sheibley, inventors (to NASA) Filed 19 Apr. 1978 13 p
(NASA-Case-LEW-12972-1, US-Patent-Appl-SN-897829) Avail: NTIS HC A02/MF A01 CSCL 07C

The method disclosed is used to produce a polyvinyl alcohol sheet material wherein the polyvinyl alcohol is substantially free of 1,2 diol units, and has an acetal self cross-linked structure wherein the acetal content is determined by the 1,2 diol content in the sheet material prior to cross-linking. The sheet material product exhibits high conductivity and oxidation resistance, as well as minimal distortion of the prefabricated polyvinyl alcohol sheet material. NASA

N78-26172*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
ION PROPULSION FOR SPACECRAFT
W. R. Kerslake et al. 1977 27 p refs
(NASA-TM-79502) Avail: NTIS HC A03/MF A01 CSCL 21C

The theory of the ion thruster propulsion system is discussed along with the Space Electric Rocket Test 1 and 2. The use of electric propulsion for stationkeeping and attitude control function, of geosynchronous satellites is described, and a comparison of thruster systems is presented. F.O.S.

N78-26177*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
THE FRICTION AND WEAR PROPERTIES OF SPUTTERED HARD REFRACTORY COMPOUNDS
William A. Brainard Aug. 1978 17 p refs. Proposed for presentation at the 2d Intern. Conf. on Solid Lubrication, Denver, 14-18 Aug. 1978, sponsored by the Am. Soc. of Lub. Engr.
(NASA-TM-78895, E-9368) Avail: NTIS HC A02/MF A01 CSCL 11D

Several refractory silicide, boride, and carbide coatings were examined. The coatings were applied to type 440C steel surfaces by radio-frequency sputtering. The friction and wear properties of the coatings were found to be related to stoichiometry and impurity content of the bulk coating as well as the degree of interfacial adherence between coating and substrate. Bulk coating stoichiometry could to a large extent be controlled by the application of a negative bias voltage during deposition. Adherence was promoted by the formation of an oxidized layer at the interface. Deliberate preoxidizing of the 440C produced enhanced adherence for many compounds which are related to the formation of a mixed oxide transition region. Author

N78-26178*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FRICTION AND WEAR OF CARBON-GRAPHITE MATERIALS FOR HIGH-ENERGY BRAKES
Robert C. Bill Aug. 1978 21 p refs. Proposed for presentation at the 2d Intern. Conf. on Solid Lubrication, Denver, 14-18 Aug. 1978, sponsored by the Am. Soc. of Lubrication Engr.
(NASA-TM-78903, AVRADCOM-TR-78-27(PL), E-8259-1) Avail: NTIS HC A02/MF A01 CSCL 11D

Caliper type brake simulation experiments were conducted on seven different carbon graphite materials formulations against a steel disk material and against a carbon graphite disk material. The effects of binder level, boron carbide (B4C) additions, SiC additions, graphite fiber additions, and graphite cloth reinforcement on friction and wear behavior were investigated. Reductions in binder level, additions of B4C, and additions of SiC each resulted in increased wear. The wear rate was not affected by the addition of graphite fibers. Transition to severe wear and high friction was observed in the case of graphite-cloth-reinforced carbon sliding against a disk of similar composition. The transition was related to the disruption of a continuous graphite shear film that must form on the sliding surfaces if low wear is to occur. B.B.

A78-24910*# Progress in advanced high temperature turbine materials, coatings, and technology. J. C. Freche and G. M. Ault (NASA, Lewis Research Center, Cleveland, Ohio). *NATO, AGARD, Propulsion and Energetics Panel Meeting, 50th, Middle East Technical University, Ankara, Turkey, Sept. 19-23, 1977, Paper.* 43 p. 89 refs.

Several NASA-sponsored benefit-cost studies have shown that very substantial benefits can be obtained by increasing material capability for aircraft gas turbines. Prealloyed powder processing holds promise for providing superalloys with increased strength for turbine disk applications. The developement of advanced powder metallurgy disk alloys must be based on a design of optimum processing and heat treating procedures. Materials considered for high temperature application include oxide dispersion strengthened (ODS) alloys, directionally solidified superalloys, ceramics, directionally solidified eutectics, materials combining the high strength of a gamma prime strengthened alloy with the elevated temperature strength of an ODS, and composites. Attention is also given to the use of high pressure turbine seals, approaches for promoting environmental protection, and turbine cooling technology. G.R.

N78-16094*# Gelles (S. H.) Associates, Columbus, Ohio
MATERIALS SCIENCE EXPERIMENTS IN SPACE Final Report
S. H. Gelles, B. C. Giessen, M. E. Glicksman, J. L. Margrave, H. Markovitz, A. S. Nowick, J. D. Verhoeven, and A. F. Witt Jan. 1978 84 p refs
(Contract NAS3-20049)
(NASA-CR-2842) Avail: NTIS HC A05/MF A01 CSCL 22A

The criteria for the selection of the experimental areas and individual experiments were that the experiment or area must make a meaningful contribution to the field of material science and that the space environment was either an absolute requirement for the successful execution of the experiment or that the experiment can be more economically or more conveniently performed in space. A number of experimental areas and individual experiments were recommended for further consideration as space experiments. Areas not considered to be fruitful and others needing additional analysis in order to determine their suitability for conduct in space are also listed. Recommendations were made concerning the manner in which these materials science experiments are carried out and the related studies that should be pursued. Author

24 COMPOSITE MATERIALS

Includes laminates.

N78-10217*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
CONSOLIDATION OF SILICON NITRIDE WITHOUT ADDITIVES
Paul F Sikora and Hun C Yeh 1977 13 p refs Presented at Fall Meeting of the Am. Ceramic Soc., San Francisco, 31 Oct - 3 Nov 1976
(NASA-TM-73693, E-9229) Avail NTIS HC A02/MF A01 CSCL 11D

The feasibility of producing a sound, dense Si3N4 body without additives was explored, using conventional gas hot isostatic pressing techniques and an uncommon hydraulic hot isostatic pressing technique These two techniques produce much higher pressure 275-413 MN/m sq (40,000 - 60,000 psi) than hot-pressing techniques Evaluation was based on density measurement, microscopic examination, both optical and electron and X-ray diffraction analysis The results are summarized as follows (1) Si3N4 can be densified to high density, greater than 95% of theoretical, without additions (2) The higher density Si3N4 specimens appear to be associated with a greater amount of alpha to beta transformation (3) Under high pressure, the alpha to beta transformation can occur at a temperature as low as 1150 C (4) Grain deformation and subsequent recrystallization and grain refinement result from hot isostatic pressing of Si3N4 Author

N78-13136*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EFFECT OF DISCONTINUITIES AS A MEANS TO ALLEVIATE THERMAL EXPANSION MISMATCH DAMAGE IN LAMINAR COMPOSITES
Charles A Hoffman Nov 1977 17 p refs
(NASA-TM-73739 E-9259) Avail NTIS HC A02/MF A01 CSCL 11D

An investigation of Nichrome/tungsten laminar composites showed that intentionally introduced discontinuities, such as perforations through or grooves on the surface of the matrix laminae improved thermal expansion mismatch damage resistance It was found that specimens having smooth matrix laminate surfaces were virtually destroyed by delamination in 21 or fewer fast cool cycles in which they were water quenched from 981 C Specimens having interior matrix laminae with discontinuities and relatively thin nondiscontinuous surface matrix laminae resisted 50 similar cycles without evident delamination damage Author

N78-13137*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FRACTURE SURFACE CHARACTERISTICS OF OFF-AXIS COMPOSITES
J H Sinclair and C C Chamis 1977 23 p refs Presented at 14th Ann. Meeting of the Soc. of Engr. Sci., Inc Bethlehem, Pa 14-16 Nov 1977
(NASA TM 73700 E-9085-2) Avail NTIS HC A02/MF A01 CSCL 11D

The fracture surface characteristics of off axis high modulus graphite fiber epoxy composite specimens were studied using a scanning electron microscope (SEM) The specimens were subjected to tensile loading at various angles (0 deg 90 deg) to the fiber direction SEM photomicrographs of the fractured surfaces revealed three different load angle regions with distinct fracture characteristics Based on these revelations criteria were established which can be used to characterize fracture surfaces with respect to a predominant single stress fracture mode Author

N78-13138*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
MECHANICAL BEHAVIOR AND FRACTURE CHARACTERISTICS OF OFF-AXIS FIBER COMPOSITES. 1: EXPERIMENTAL INVESTIGATION
John H. Sinclair and Christos C. Chamis Dec 1977 36 p refs
(NASA-TP-1081, E-9085) Avail NTIS HC A03/MF A01 CSCL 11D

The mechanical behavior, fracture surfaces, and fracture modes of unidirectional high-modulus graphite-fiber/epoxy composites subjected to off-axis tensile loads were investigated experimentally The investigation included the generation of stress-strain-to-fracture data and scanning electron microscope studies of the fractured surfaces The results led to the identification of fracture modes and distinct fracture surface characteristics for off axis tensile loading The results also led to the formulation of criteria for identifying and characterizing these fracture modes and their associated fracture surfaces The results presented and discussed herein were used in the theoretical investigation and comparisons described in Part 2 These results should also provide a good foundation for identifying, characterizing, and quantifying fracture modes in both off-axis and angle-plied laminates. Author

N78-13088*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio
MECHANICAL BEHAVIOR AND FRACTURE CHARACTERISTICS OF OFF-AXIS FIBER COMPOSITES. 2: THEORY AND COMPARISONS
Christos C Chamis and John H Sinclair Jan 1978 29 p refs
(NASA-TP-1082 E-9269) Avail NTIS HC A03/MF A01 CSCL 11D

The mechanical behavior and stresses inducing fracture modes of unidirectional high-modulus graphite-fiber epoxy composites subjected to off-axis tensile loads were investigated theoretically The investigation included the use of composite mechanics combined-stress failure criteria, and finite-element stress analysis The results are compared with experimental data and led to the formulation of criteria and convenient plotting procedures for identifying, characterizing, and quantifying these fracture modes Author

N78-17152*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio
ADHESIVE COHESIVE STRENGTH OF A ZrO2.1-2 w % Y2O3 NiCrAlY THERMAL BARRIER COATING
Stanley R Levine 1978 26 p refs Proposed for presentation at the 80th Ann Meeting of the Am Ceramic Soc Detroit M 11 May 1978
(NASA-TM-73792 E-9359) Avail NTIS HC A03/MF A01 CSCL 11D

The room temperature adhesive cohesive strength of a 0.05 cm thick ZrO2 12w oY2O3 0.013 cm thick NiCrAlY thermal barrier coating system (TBC) was investigated The weakest link was the oxide NiCrAlY interface region with a strength of 6.2 MN sq m The fracture was about half cohesive oxide failure half oxide NiCrAlY adhesive failure and 1 percent cohesive NiCrAlY failure The TBC failed in a similar manner in 950 C tensile and compression tests The oxide stripped from the TBC had a cohesive strength of 24.6 MN sq m The NiCrAlY had a cohesive strength of 25.1 MN sq m The NiCrAlY and oxide failed primarily at interparticle boundaries Author

N78-17153*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio
THE EFFECTS OF ECCENTRICITIES ON THE FRACTURE OF OFF-AXIS FIBER COMPOSITES
C C Chamis and J H Sinclair 1978 17 p refs Presented at the 33rd Ann. Conf. of the Soc. of the Plastics Ind. Reinforced Plastics Composites Inst Washington, D C 7-10 Feb 1978
(NASA-TM-73826 E-9269-1) Avail NTIS HC A02/MF A01 CSCL 11D

Finite element analyses were performed to investigate theoret

ically the effects of in-plane and out-of-plane eccentricities, bending or twisting, and thickness nonuniformity on the axial stress and strain variations across the width of off-axis specimens. The results are compared with measured data and are also used to assess the effects of these eccentricities on the fracture stress of off-axis fiber composites. Guidelines for detecting and minimizing the presence of eccentricities are described. Author

N78-17154*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
MECHANICAL AND PHYSICAL PROPERTIES OF MODERN BORON FIBERS
James A. DiCarlo. 1978. 20 p. refs. Proposed for presentation at the 2d Intern. Conf. on Composite Mater., Toronto, 16-20 Apr. 1978, sponsored by the Met. Soc. of AIME
(NASA-TM-73882, E-9494) Avail: NTIS HC A02/MF A01 CSCL 11D

The results of accurate measurements of the modern boron fiber's Young's modulus, flexural modulus, shear modulus, and Poisson's ratio are reported. Physical property data concerning fiber density, thermal expansion, and resistance obtained during the course of the mechanical studies are also given. Author

N78-17155*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THERMAL ENVIRONMENT EFFECTS ON STRENGTH AND IMPACT PROPERTIES OF BORON-ALUMINUM COMPOSITES
H. H. Grimes, R. A. Lad, and J. E. Marsel (Cleveland State Univ., Ohio). 1977. 20 p. refs. Proposed for presentation at the 2d Intern. Conf. on Composite Materials, Toronto, Canada, 16-20 Apr. 1978, sponsored by the Am. Inst. of Mining, Met. and Petrol. Engrs.
(NASA-TM-73885, E-9498) Avail: NTIS HC A02/MF A01 CSCL 11D

Thermal effects on fracture strength and impact energy were studied in 50 volume percent unidirectional composites of 143 and 203 micron boron fibers in 6061 and 1100 aluminum matrices. For 6061 matrix composites strength was maintained to approximately 400 C in the cyclic tests and higher than 400 C in the static tests. For the 1100 matrix composites strength degradation appeared near 260 C after cycling and higher than 260 C in static heating. This composite strength degradation is explained by a fiber degradation mechanism resulting from a boron-aluminum interface reaction. The impact energy absorption degraded significantly only above 400 C for both matrix alloys. Thus, while impact loss for the 6061 composite correlates with the fiber strength loss, other energy absorption processes appear to extend the impact resistance of the 1100 matrix composites to temperatures beyond where its strength is degraded. Interrupted impact tests on as-received and thermally cycled composites define the range of load over which the fibers break in the impact event. Author

N78-19204*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
AXIAL RESIDUAL STRESSES IN BORON FIBERS
Donald H. Behrendt. 1978. 19 p. refs. Presented at 2d Intern. Conf. on Composite Materials, Toronto, Canada, 16-20 Apr. 1978
(NASA-TM-73894) Avail: NTIS HC A02/MF A01 CSCL 11D

The axial residual stress distribution as a function of radius was determined from the fiber surface to the core including the average residual stress in the core. Such measurements on boron on tungsten (B/W) fibers, show that the residual stresses for 102, 142, 203, and 365 micron diameter fibers were similar, being compressive at the surface and changing monotonically to a region of tensile within the boron. At approximately 25 percent of the original radius, the stress reaches a maximum tensile stress of about 860 mn/sq m and then decreases to a compressive stress near the tungsten boride core. Data were presented for 203 micron diameter B/W fibers that show annealing above 900 C reduces the residual stresses. A comparison between 102 micron diameter B/W and boron on carbon (b/C) shows that the residual stresses were similar in the outer regions of the fibers, but that large differences near and in the core were observed. The effects of these residual stresses on the fracture of boron fibers were discussed. Author

N78-19205*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
RESIDUAL STRESSES IN ANGLEPLIED LAMINATES AND THEIR EFFECTS ON LAMINATE BEHAVIOR
C. C. Chamis. 1978. 24 p. refs. Presented at the 2d Intern. Conf. on Composite Mater., Toronto, 16-23 Apr. 1978
(NASA-TM-78835) Avail: NTIS HC A02/MF A01 CSCL 11D

Evidence of the presence of lamination residual stresses in angleplied laminates were transply cracks and warpage of unsymmetric laminates which occur prior to application of any mechanical load. Lamination residual strains were measured using the embedded strain gage technique. These strains result from the temperature differences between cure and room temperature and vary linearly within this temperature range. Lamination residual stresses were usually present in angleplied fiber composites laminates; they were also present in unidirectional hybrids and superhybrids. For specific applications, the magnitudes of lamination residual stresses were determined and evaluated relative to the anticipated applied stresses. Particular attention was given to cyclic thermal loadings in applications where the thermal cycling takes place over a wide temperature range. Author

N78-20254*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
MEASUREMENT OF THE TIME-TEMPERATURE DEPENDENT DYNAMIC MECHANICAL PROPERTIES OF BORON/ALUMINUM COMPOSITES
J. A. DiCarlo and J. E. Marsel (Cleveland State Univ.). 1978. 43 p. refs. Presented at the 5th Conf. on Composite Mater. Testing and Design, New Orleans, 20-23 Mar. 1978; sponsored by Am. Soc. for Testing and Mater.
(NASA-TM-78837, E-9548) Avail: NTIS HC A03/MF A01 CSCL 11D

A flexural vibration test and associated equipment were developed to accurately measure the low strain dynamic modulus and damping of composite materials from -200 C to over 500 C. The basic test method involves the forced vibration of composite bars at their resonant free-free flexural modes in a high vacuum cryostat furnace. The accuracy of these expressions and the flexural test was verified by dynamic moduli and damping capacity measurements on 50 fiber volume percent boron/aluminum (B/Al) composites vibrating near 2000 Hz. The phase results were summarized to permit predictions of the B/Al dynamic behavior as a function of frequency, temperature, and fiber volume fraction. Author

N78-20255*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CORRELATION OF FIBER COMPOSITE TENSILE STRENGTH WITH THE ULTRASONIC STRESS WAVE FACTOR
Alex Vary and Raymond F. Lark. 1978. 23 p. refs. Presented at the 1978 Spring Conf., New Orleans, 3-7 Apr. 1978; sponsored by Am. Soc. for Nondestructive Testing
(NASA-TM-78846, E-9564) Avail: NTIS HC A03/MF A01 CSCL 11D

An ultrasonic acoustic technique was used to indicate the strength variations of tensile specimens of a graphite epoxy composite. A stress wave factor was determined and its value was found to depend on variations of the fiber-resin bonding as well as fiber orientation. The fiber orientations studied were 0 deg (longitudinal), 10 deg (off axis), 90 deg (transverse), [0 deg ± or ± 45 deg/0 deg] symmetrical, and [± or ± 45 deg] symmetrical. The stress wave factor can indicate variations of the tensile and shear strengths of composite materials. The stress wave factor was also found to be sensitive to strength variations associated with microporosity and differences in fiber-resin ratio. Author

N78-21220*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IN SITU PLY STRENGTH: AN INITIAL ASSESSMENT
C. C. Chamis and T. L. Sullivan 1978 19 p refs Presented at the 5th Conf. on Composite Mater.: Testing and design, New Orleans, 20-22 Mar. 1978; sponsored by Am. Soc. for Testing and Mater.
(NASA-TM-73771; E-9238) Avail: NTIS HC A02/MF A01 CSCL 11D

The in situ ply strengths in several composites were calculated using laminate fracture data for appropriate low modulus, and high modulus fiber composites were used in conjunction with the least squares method. The laminate fracture data were obtained from tests on Modmor-I graphite/epoxy, AS-graphite/epoxy, boron/epoxy and E-glass/epoxy. The results show that the calculated in situ ply strengths can be considerably different from those measured in unidirectional composites, especially the transverse strengths and those in angleplied laminates with transply cracks. Author

N78-21221*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TITANIUM/BERYLLIUM LAMINATES: FABRICATION, MECHANICAL PROPERTIES, AND POTENTIAL AEROSPACE APPLICATIONS
C. C. Chamis and R. F. Lark May 1978 25 p refs Presented at the 23d Natl. SAMPE Symp. and Exhibition, Anaheim, Calif., 2-4 May 1978
(NASA-TM-73891; E-9508) Avail: NTIS HC A02/MF A01 CSCL 11D

The investigation indicated that structural laminates can be made which have: a modulus of elasticity comparable to steel, fracture strength comparable to the yield strength of titanium, density comparable to aluminum, impact resistance comparable to titanium, and little or no notch sensitivity. These laminates can have stiffness and weight advantages over other materials including advanced fiber composites, in some aerospace applications where buckling resistance, vibration frequencies, and weight considerations control the design. Author

N78-22163*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
METHOD FOR ALLEVIATING THERMAL STRESS DAMAGE IN LAMINATES Patent Application
C. A. Hoffman, J. W. Weeton, and N. W. Orth, inventors (to NASA) Filed 6 Apr. 1978 16 p
(NASA-Case-LEW-12493-1; US-Patent-Appl-SN-893857) Avail: NTIS HC A02/MF A01 CSCL 11D

According to the method of the invention discontinuities are positively introduced into the interface between layers so as to reduce the thermal stress produced by unequal expansion of the materials which make up the composite. Although a plurality of discrete elements could be used to form one of the layers and thus carry out this purpose, the discontinuities are preferably produced by simply drilling holes in the metallic matrix layer or by forming grooves in a grid pattern in this layer. The apparent novel feature of the invention is the use of geometrical considerations to introduce discontinuities in the matrix of a composite material. This provides for the control of stresses that would otherwise unbound the constituents, cause peeling of the outer layers, and cause the loss of strength properties of the composite when it is subjected to one or more thermal cycles. NASA

N78-24291*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THERMAL BARRIER COATINGS
S. J. Grisaffe, S. R. Levine, and J. S. Clark 1978 21 p refs Presented at the 23d Ann. Intern. Gas Turbine Conf., London, 9-13 Apr. 1978; sponsored by ASME
(NASA-TM-78848) Avail: NTIS HC A02/MF A01 CSCL 11D

Thermal barrier coatings offer gas turbines one way to reach fuel flexibility and improved efficiency. Test/analytical results are encouraging for this young technology. Author

N78-32191*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
EFFECTS OF MOISTURE PROFILES AND LAMINATE CONFIGURATION ON THE HYGRO STRESSES IN ADVANCED COMPOSITES
C. C. Chamis, J. H. Sinclair, and R. F. Lark 1978 16 p ref Presented at the 10th Natl. Tech. Conf., Kiamesha Lake, New York, 17-19 Oct. 1978 Sponsored by the Soc. for the Advan. of Mater. and Process Eng.
(NASA-TM-78978; E-9755) Avail: NTIS HC A02/MF A01 CSCL 11D

An integrated hygrothermo-mechanical theory was used to predict the effects of three moisture profiles on the ply hygro stresses in angleplied laminates. The moisture profiles were linear, parabolic and hyperbolic. Moisture content varied from 1 percent in the exposed ply to zero in the protected ply. The angleplied laminates were of two generic configurations. The results obtained are summarized graphically to illustrate the effects of both moisture profile and laminate configuration. The results indicate that ply transverse tensile hygro stresses may reach sufficiently high magnitudes to cause transply cracking. A.R.H.

N78-33140*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
ANALYSIS/DESIGN OF STRIP REINFORCED RANDOM COMPOSITES (STRIP HYBRIDS)
C. C. Chamis and J. H. Sinclair 1978 23 p refs To be presented at the Annual Meeting of ASME, San Francisco, Calif., 10-15 Dec. 1978
(NASA-TM-78985; E-9733) Avail: NTIS HC A02/MF A01 CSCL 11D

Advanced analysis methods and composite mechanics were applied to a strip-reinforced random composite square panel with fixed ends to illustrate the use of these methods for the a priori assessment of the composite panel when subjected to complex loading conditions. The panel was assumed to be of E-glass random composite. The strips were assumed to be of three advanced unidirectional composites to cover a range of low, intermediate, and high modulus stiffness. The panels were assumed to be subjected to complex loadings to assess their adequacy as load-carrying members in auto body, aircraft engine nacelle and windmill blade applications. The results show that strip hybrid panels can be several times more structurally efficient than the random composite base materials. Some of the results are presented in graphical form and procedures are described for use of these graphs as guides for preliminary design of strip hybrids. A.R.H.

N78-33150*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ACOUSTIC EMISSION TESTING OF COMPOSITE VESSELS UNDER SUSTAINED LOADING
R. F. Lark and P. E. Moorhead 1978 25 p refs Presented at the Symp. on Nondestructive Evaluation and Flaw Criticality for Composite Mater., Philadelphia 10-11 Oct. 1978 Sponsored by the Am. Soc. for Testing Mater.
(NASA-TM-78981; E-9759) Avail: NTIS HC A02/MF A01 CSCL 11D

Acoustic emissions (AE) generated from Kevlar 49/epoxy composite pressure vessels subjected to sustained load-to-failure tests were studied. Data from two different transducer locations on the vessels were compared. It was found that AE from vessel wall-mounted transducers showed a wide variance from those for identical vessels subjected to the same pressure loading. Emissions from boss-mounted transducers did, however, yield values that were relatively consistent. It appears that the signals from the boss-mounted transducers represent an integrated average of the emissions generated by fibers fracturing during the vessel tests. The AE from boss-mounted transducers were also independent of time for vessel failure. This suggests that a similar number of fiber fractures must occur prior to initiation of vessel failure. These studies indicate a potential for developing an AE test procedure for predicting the residual service life or integrity of composite vessels. A.R.H.

N78-33161*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ION BEAM SPUTTERING OF FLUOROPOLYMERS
J. S. Sovey 1978 15 p refs To be presented at the 25th Natl. Vacuum Symp., San Francisco, 28 Nov. 1978 - 1 Dec. 1978 Sponsored by the Am. Vacuum Soc.
(NASA-TM-79000; E-9784) Avail: NTIS HC A02/MF A01 CSCL 11D

Ion beam sputter processing rates as well as pertinent characteristics of etched targets and films are described. An argon ion beam source was used to sputter etch and deposit the fluoropolymers PTFE, FEP, and CTFE. Ion beam energy, current density, and target temperature were varied to examine effects on etch and deposition rates. The ion etched fluoropolymers yield cone or spire-like surface structures which vary depending upon the type of polymer, ion beam power density, etch time, and target temperature. Sputter target and film characteristics documented by spectral transmittance measurements. X-ray diffraction, ESCA, and SEM photomicrographs are included.
A.R.H.

A78-24892 * # **A Weibull characterization for tensile fracture of multicomponent brittle fibers.** R. G. Barrows (NASA, Lewis Research Center; U.S. Army, Air Mobility Research and Development Laboratory, Cleveland, Ohio). *Metallurgical Society of AIME, Fall Metals Conference, Chicago, Ill., Oct. 24-27, 1977, Paper.* 30 p. 25 refs.

Necessary to the development and understanding of brittle fiber reinforced composites is a means to statistically describe fiber strength and strain-to-failure behavior. A statistical characterization for multicomponent brittle fibers is presented. The method, which is an extension of usual Weibull distribution procedures, statistically considers the components making up a fiber (e.g., substrate, sheath, and surface) as separate entities and taken together as in a fiber. Tensile data for silicon carbide fiber and for an experimental carbon-boron alloy fiber are evaluated in terms of the proposed multicomponent Weibull characterization. (Author)

A78-24905 * # **An integrated theory for predicting the hydrothermomechanical response of advanced composite structural components.** C. C. Chamis, R. F. Lark, and J. H. Sinclair (NASA, Lewis Research Center, Cleveland, Ohio). *American Society for Testing and Materials, Technical Specialists Conference on Environmental Effects on Advanced Composite Materials, Dayton, Ohio, Sept. 29, 30, 1977, Paper.* 43 p. 18 refs.

A theory is developed for predicting the hydrothermomechanical response of advanced composite structural components. The combined hydrothermal effects on the mechanical properties of unidirectional composites loaded along the material axis and off-axis, and of angleplied laminates are also evaluated. The materials investigated consist of neat PR-288 epoxy matrix resin and an AS-type graphite fiber/PR-288 resin unidirectional composite. S.C.S.

A78-25191 * **Effect of processing parameters on autoclaved PMR polyimide composites.** R. D. Vannucci (NASA, Lewis Research Center, Cleveland, Ohio). In: Materials and processes - In service performance; Proceedings of the Ninth National Technical Conference, Atlanta, Ga., October 4-6, 1977. (A78-25176 09-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1977, p. 177-199.

A study was conducted to determine the effect of processing parameters on the processability and properties of autoclaved fiber reinforced PMR polyimide composites. Composites were fabricated from commercially available graphite fabric and glass fabric PMR polyimide prepreg materials. Process parameters investigated included degree of resin advancement, heating rate, and cure pressure. Composites were inspected for porosity by ultrasonic 'C' scan and photomicrographic examination. Processing characteristics for each set of process parameters and the effect of process parameters on composite mechanical properties at room temperature and 600 F are described. (Author)

A78-33201 * # **Residual stresses in angleplied laminates and their effects on laminate behavior.** C. C. Chamis (NASA, Lewis Research Center, Cleveland, Ohio). *Metallurgical Society of AIME, International Conference on Composite Materials, 2nd, Toronto, Canada, Apr. 16-20, 1978, Paper.* 23 p. 17 refs.

NASA Lewis Research Center research in the field of composite laminate residual stresses is reviewed and summarized. The origin of lamination residual stresses, evidence of their presence, experimental methods for measuring them, and theoretical methods for predicting them are described. Typical results are presented which show the magnitudes of residual stresses in various laminates including hybrids and superhybrids, and in other complex composite components. Results are also presented which show the effects of lamination residual stresses on laminate warpage and on laminate mechanical properties including fracture stresses. Finally, the major findings and conclusions derived therefrom are summarized. (Author)

A78-33203 * # **Predicted inlet gas temperatures for tungsten fiber reinforced superalloy turbine blades.** E. A. Winsa, L. J. Westfall, and D. W. Petrasek (NASA, Lewis Research Center, Cleveland, Ohio). *Metallurgical Society of AIME, International Conference on Composite Materials, 2nd, Toronto, Canada, Apr. 16-20, 1978, Paper.* 22 p. 23 refs.

Tungsten fiber-reinforced superalloy composite (TFRS) impingement-cooled turbine blade inlet gas temperatures were calculated taking into account material spanwise strength, thermal conductivity, material oxidation resistance, fiber-matrix interaction, and coolant flow. Measured values of TFRS thermal conductivities are presented. Calculations indicate that blades made of 30 volume percent fiber content TFRS having a 12,000 N-m/kg stress-to-density ratio while operating at 40 atm and a 0.06 coolant flow ratio could permit a turbine blade inlet gas temperature of over 1900 K. This is more than 150 K greater than similar superalloy blades. (Author)

A78-33204 * # **Thermal environment effects on strength and impact properties of boron-aluminum composites.** H. H. Grimes, R. A. Lad (NASA, Lewis Research Center, Cleveland, Ohio), and J. F. Maisel (Cleveland State University, Cleveland, Ohio). *Metallurgical Society of AIME, International Conference on Composite Materials, 2nd, Toronto, Canada, Apr. 16-20, 1978, Paper.* 19 p.

A systematic study was conducted regarding the degradation of fracture strength and impact energy in commercial B-Al composites in both static and cyclic thermal environments. The composites used in the study contained approximately 50 vol % boron fibers, unidirectionally aligned in either a 6061 Al or 1100 Al matrix. The tensile strengths of the composites after 3000 thermal cycles as a function of upper cycle temperature are presented in graphs. The temperature at which the strengths of 6061 Al matrix, B-Al composites were significantly degraded after 3000 cycles was noticeably higher than that for the 1100 Al matrix composites. Static heating at 420 C resulted in no significant strength degradation for the 6061 Al matrix composites. In the case of 1100 matrix composites, some degradation was observed at 420 C but markedly less than in the composites cycled to 420 C. G.R.

A78-33207 * # **Correlation of fiber composite tensile strength with the ultrasonic stress wave factor.** A. Vary and R. F. Lark (NASA, Lewis Research Center, Cleveland, Ohio). *American Society for Nondestructive Testing, Spring Conference, New Orleans, La., Apr. 3-7, 1978, Paper.* 22 p. 9 refs.

An ultrasonic-acoustic technique was used to indicate the strength variations of tensile specimens of a graphite-epoxy composite. A 'stress wave factor' was determined and its value was found to depend on variations of the fiber-resin bonding as well as fiber orientation. The fiber orientations studied were 0 deg (longitudinal), 10 deg (off axis), 90 deg (transverse), (0 deg/+ or - 45 deg 0) symmetrical, and (+ or - 45 deg) symmetrical. The stress wave factor can indicate variations of the tensile and shear strengths of composite materials. The stress wave factor was also found to be sensitive to strength variations associated with microporosity and differences in fiber-resin ratio. (Author)

A78-33209 * # Shear strength of metal - SiO2 contacts. S. V. Pepper (NASA, Lewis Research Center, Cleveland, Ohio). *American Physical Society, U.S. Navy, and ARPA, International Topical Conference on the Physics of SiO2 and Its Interfaces, Yorktown Heights, N.Y., Mar. 22-24, 1978, Paper.* 5 p. 11 refs.

The strength of the bond between metals and SiO2 is studied by measuring the static coefficient of friction of metals contacting alpha-quartz in ultrahigh vacuum. It was found that copper with either chemisorbed oxygen, nitrogen or sulphur exhibited higher contact strength on stoichiometric SiO2 than did clean copper. Since the surface density of states induced by these species on copper is similar, it appears that the strength of the interfacial bond can be related to the density of states on the metal surface. (Author)

A78-33210 * # Kinetics of imidization and crosslinking in PMR-polyimide resin. R. W. Lauver (NASA, Lewis Research Center, Cleveland, Ohio). *American Chemical Society, Central Regional Meeting, 9th, Charleston, W. Va., Oct. 12-14, 1977, Paper.* 23 p. 14 refs.

A78-33213 * # Principles of ESCA and applications to metal corrosion, coating and lubrication. D. R. Wheeler (NASA, Lewis Research Center, Cleveland, Ohio). *American Society for Metals Symposium on Modern Metallographic Techniques and Their Applications, Cleveland, Ohio, Apr. 10, 11, 1978, Paper.* 14 p. 10 refs.

The principles of ESCA (electron spectroscopy for chemical analysis) are described by comparison with other spectroscopic techniques. The advantages and disadvantages of ESCA as compared to other surface sensitive analytical techniques are evaluated. The use of ESCA is illustrated by actual applications to oxidation of steel and René 41, the chemistry of lubricant additives on steel, and the composition of sputter deposited hard coatings. Finally, a bibliography of material that is useful for further study of ESCA is presented and commented upon. (Author)

A78-33222 * # Measurement of the time-temperature dependent dynamic mechanical properties of boron/aluminum composites. J. A. DiCarlo (NASA, Lewis Research Center, Material Science Branch, Cleveland, Ohio) and J. E. Maisel (Cleveland State University, Cleveland, Ohio). *American Society for Testing and Materials, Conference on Composite Materials: Testing and Design, 5th, New Orleans, La., Mar. 20-23, 1978, Paper.* 42 p. 20 refs.

A relatively simple flexural vibration test is developed for accurate measurement of the low-strain dynamic modulus and damping capacity of B-Al composite bar specimens from -200 C to over 500 C. The specimens are prepared from 8-ply unidirectional panels containing 50 volume percent fibers composed of 203-micron commercial boron-on-tungsten fibers. The basic test technique consists of the forced flexural vibration of the composite bar specimens at their two lowest free-free symmetrical resonant modes in a high-vacuum cryostat furnace. Specimen damping is determined from oscilloscope photographs of the free decay obtained after simultaneously removing the resonant drive signal and grounding the vibration-drive electrode. The availability of time-temperature dynamic data coupled with the predictive accuracy of composite theory suggests a future potential for using such data in examining environmental effects on composite macrostructure and microstructure. S.D.

A78-33223 * # In situ ply strengths - An initial assessment. C. C. Chamis and T. L. Sullivan (NASA, Lewis Research Center, Cleveland, Ohio). *American Society for Testing and Materials, Conference on Composite Materials: Testing and Design, 5th, New Orleans, La., Mar. 20-23, 1978, Paper.* 18 p. 14 refs.

The in situ ply strengths in several composites were calculated using a computational procedure developed for this purpose. Laminate fracture data for appropriate low modulus and high modulus fiber composites were used in the laminate analysis in conjunction with the method of least squares. The laminate fracture data were obtained from tests on Modmor-I graphite/epoxy, AS-graphite/epoxy, boron/epoxy and E-glass/epoxy. The results obtained show that the calculated in situ ply strengths can be considerably different from those measured in unidirectional composites, especially the transverse strengths and those in angleplied laminates with transply cracks. (Author)

A78-33436 * Recent advances in lightweight, filament-wound composite pressure vessel technology. R. F. Lark (NASA, Lewis Research Center, Cleveland, Ohio). In: Composites in pressure vessels and piping; Proceedings of the Energy Technology Conference, Houston, Tex., September 18-23, 1977. (A78-33435 13-24) New York, American Society of Mechanical Engineers, 1977, p. 17-49. 8 refs.

A review of recent advances is presented for lightweight, high-performance composite pressure vessel technology that covers the areas of design concepts, fabrication procedures, applications, and performance of vessels subjected to single-cycle burst and cyclic fatigue loading. Filament-wound fiber/epoxy composite vessels were made from S-glass, graphite, and Kevlar 49 fibers and were equipped with both structural and nonstructural liners. Pressure vessel structural efficiencies were attained which represented weight savings, using different liners, of 40 to 60 percent over all-titanium pressure vessels. Significant findings in each area are summarized including data from current NASA-Lewis Research Center contractual and in-house programs. (Author)

A78-37686 * # The use of an ion-beam source to alter the surface morphology of biological implant materials. A. J. Weigand (NASA, Lewis Research Center, Cleveland, Ohio). *Society for Biomaterials, Conference, San Antonio, Tex., Apr. 29-May 2, 1978, Paper.* 27 p. 21 refs.

An electron-bombardment ion-thruster was used as a neutralized-ion-beam sputtering source to texture the surfaces of biological implant materials. The materials investigated included 316 stainless steel; titanium-6% aluminum, 4% vanadium; cobalt-20% chromium, 15% tungsten; cobalt-35% nickel, 20% chromium, 10% molybdenum; polytetrafluoroethylene; polyoxymethylene; silicone and polyurethane copolymer; 32%-carbon-impregnated polyolefin; segmented polyurethane; silicone rubber; and alumina. Scanning electron microscopy was used to determine surface morphology changes of all materials after ion-texturing. Electron spectroscopy for chemical analysis was used to determine the effects of ion-texturing on the surface chemical composition of some polymers. Liquid contact angle data were obtained for ion-textured and untextured polymer samples. Results of tensile and fatigue tests of ion-textured metal alloys are presented. Preliminary data of tissue response to ion-textured surfaces of some metals, polytetrafluoroethylene, alumina, and segmented polyurethane have been obtained. (Author)

A78-40310 * Effect of preload on the fatigue and static strength of composite laminates with defects. T. R. Porter (Boeing Aerospace Co., Seattle, Wash.) and G. T. Smith (NASA, Lewis Research Center, Cleveland, Ohio). In: Recent advances in engineering science, Proceedings of the Fourteenth Annual Meeting, Bethlehem, Pa., November 14-16, 1977. (A78-40301 17-31) Bethlehem, Pa., Lehigh University, 1977, p. 267-270.

The effect of a preload cycle on the structural performance of three graphite-epoxy composite laminates was studied. The layups studied were a laminate typical of general purpose structures (L1), a laminate representative of a filament wound tank (L2), and a laminate representative of turbomachine fan blades. The effects of three sizes of simulated initial defects were studied. The tests developed static strength data, fatigue to failure data, and residual static data after application of a predetermined number of fatigue cycles. For L1 specimens, there was a slight trend for the static

strength to be greater for preloaded specimens. After application of cyclic loading, however, the influence of preloading was insignificant. In L2 and L3 specimens there was no consistent difference in the static or fatigue results between preloaded and nonpreloaded specimens. P.T.H.

A78-50325 * # **Impetus of composite mechanics on test methods for fiber composites.** C. C. Chamis (NASA, Lewis Research Center, Cleveland, Ohio). *U.S.-USSR Seminar on Fracture of Composite Materials, Riga, Latvian SSR, Sept. 4-7, 1978, Paper.* 30 p. 14 refs.

Significant contributions of the three major areas of composite mechanics to the development of test methods are illustrated with selected examples. The areas of composite mechanics include composite micromechanics, composite macromechanics, and laminate theory. The examples can be considered to be representative of the contribution of composite mechanics to the development of composite test methods. The specific examples describe contributions such as criteria for selecting resin matrices for improved composite strength, the 10 deg off-axis tensile test, procedures for configuring hybrids, and the concept of 'reduced bending rigidities'. The pertinent composite mechanics equations associated with each contribution are given and supplemented by tabular and/or graphical data which illustrate the significance of the contribution. G.R.

N78-11197*# Massachusetts Inst. of Tech., Cambridge
ANALYSIS OF DELAMINATION IN UNIDIRECTIONAL AND CROSSPLIED FIBER COMPOSITES CONTAINING SURFACE CRACKS Interim Report
S. S. Wang and J. F. Mandell May 1977 35 p refs
(Grant NsG-3044)
(NASA-CR-135248) Avail: NTIS HC A03/MF A01 CSCL 11D

A two-dimensional hybrid stress finite element analysis is described which was used to study the local stress field around delamination cracks in composite materials. The analysis employs a crack tip singularity element which is embedded in a matrix interlayer between plies of the laminate. Results are given for a unidirectional graphite/epoxy laminate containing a delamination emanating from a surface crack through the outside ply. The results illustrate several aspects of delamination cracks: (1) the localization of the singular stress domain within the interlayer, (2) the local concentration of stress in the ply adjacent to the crack; (3) the nature of the transverse normal and interlaminar shear stress distributions; and (4) the relative magnitudes of K sub 1 and K sub 2 associated with the delamination. A simple example of the use of the analysis in predicting delamination crack growth is demonstrated for a glass/epoxy laminate. The comparisons with experimental data show good agreement. Author

N78-13134*# Westinghouse Electric Corp., Pittsburgh, Pa. Research and Development Center.
CHARACTERIZATION, SHAPING, AND JOINING OF SiC/SUPERALLOY SHEET FOR EXHAUST SYSTEM COMPONENTS Final Report
J. A. Cornie 20 Jul 1977 82 p refs
(Contract NAS3-19735)
(NASA-CR-135301; Rept-9D4-NASIC-R1) Avail: NTIS HC A05/MF A01 CSCL 11D

Hafnium carbide was shown to be virtually inert when in contact with silicon carbide and Waspaloy for at least 200 hr at 1093 C (2000 F). Extensive interaction was noted with other superalloys such as HA-188. A continuous CVD HfC deposition process was developed for deposition of up to 8 microns on .14 mm (.0056 in.) SiC tungsten core filament at rates as high as .6 m/min. The rate can be increased by increasing the length of the reactor and the output of the power supply used in resistive heating of the filament substrate. The strength of HfC coated filament varies with thickness in a Griffith-like manner. This strength reduction was greater for HfC coatings than for tungsten coatings, presumably because of the greater ductility of tungsten. Author

N78-14089*# General Electric Co., Cincinnati, Ohio.
IMPACT RESISTANT BORON/ALUMINUM COMPOSITES FOR LARGE FAN BLADES
T. L. Oller, C. T. Salemme, J. H. Bowden, G. S. Doble, and P. Melnyk Dec 1977 127 p ref
(Contract NAS3-19729)
(NASA-CR-135274; R77AEG667) Avail: NTIS HC A07/MF A01 CSCL 11D

Blade-like specimens were subjected to static ballistic impact testing to determine their relative FOD impact resistance levels. It was determined that a plus or minus 15 deg layup exhibited good impact resistance. The design of a large solid boron/aluminum fan blade was conducted based on the FOD test results. The CF6 fan blade was used as a baseline for these design studies. The solid boron/aluminum fan blade design was used to fabricate two blades. This effort enabled the assessment of the scale up of existing blade manufacturing details for the fabrication of a large B/Al fan blade. Existing CF6 fan blade tooling was modified for use in fabricating these blades. Author

N78-16103*# Cornell Univ., Ithaca, N. Y. Dept. of Theoretical and Applied Mechanics.
IMPACT ON MULTILAYERED COMPOSITE PLATES Final Report, Sep. 1976 - Dec. 1976
B. S. Kim and F. C. Moon Apr. 1977 121 p refs
(Grant NsG-3080)
(NASA-CR-135247) Avail: NTIS HC A06/MF A01 CSCL 11D

Stress wave propagation in a multilayer composite plate due to impact was examined by means of the anisotropic elasticity theory. The plate was modelled as a number of identical anisotropic layers and the approximate plate theory of Mindlin was then applied to each layer to obtain a set of difference-differential equations of motion. Dispersion relations for harmonic waves and correction factors were found. The governing equations were reduced to difference equations via integral transforms. With given impact boundary conditions these equations were solved for an arbitrary number of layers in the plate and the transient propagation of waves was calculated by means of a Fast Fourier Transform algorithm. The multilayered plate problem was extended to examine the effect of damping layers present between two elastic layers. A reduction of the interlaminar normal stress was significant when the thickness of damping layer was increased but the effect was mostly due to the softness of the damping layer. Finally, the problem of a composite plate with a crack on the interlaminar boundary was formulated. Author

N78-16131*# Fiber Science, Inc., Gardena, Calif.
COMPOSITE HUB/METAL BLADE COMPRESSOR ROTOR Contractor Report, Dec. 1974 - Oct. 1976
Sam Yao Jan. 1978 25 p
(Contract NAS3-18926)
(NASA-CR-135343) Avail: NTIS HC A02/MF A01 CSCL 11D

A low cost compressor rotor was designed and fabricated for a small jet engine. The rotor hub and blade keepers were compression molded with graphite epoxy. Each pair of metallic blades was held in the hub by a keeper. All keepers were locked in the hub with circumferential windings. Feasibility of fabrication was demonstrated in this program. Author

N78-20257*# General Dynamics/Convair, San Diego, Calif.
THERMAL PERFORMANCE OF A CUSTOMIZED MULTILAYER INSULATION (MLI). DESIGN AND FABRICATION OF TEST FACILITY HARDWARE Final Report
K. E. Leonhard 15 Aug 1975 67 p refs
(Contract NAS3-17756)
(NASA-CR-135051; CASC-NAS-75-006) Avail: NTIS HC A04/MF A01 CSCL 11D

The design, fabrication, and assembly of hardware for testing the performance of a customized multilayer insulation are discussed. System components described include the thermal payload simulator, the modified cryoshroud, and a tank back pressure control device designed to maintain a constant liquid

boiling point during the thermal evaluation of the multilayer insulation. The thermal payload simulator will provide a constant temperature surface in the range of 20.6 to 417K (37 to 750R) for the insulated tank to view. The cryoshroud was modified to establish a low temperature black body cavity while limiting liquid hydrogen usage to a minimum feasible rate. Author

N78-22164*# Norton Co., Worcester, Mass.
IMPROVED REACTION SINTERED SILICON NITRIDE Final Report
H. R. Baumgartner Mar. 1978 83 p refs
(Contract NAS3-19723)
(NASA-CR-135291) Avail: NTIS HC A05/MF A01 CSCL 11D

Processing treatments were applied to as-nitrided reaction sintered silicon nitride (RSSN) with the purpose of improving strength after processing to above 350 MN/m2 and improving strength after oxidation exposure. The experimental approaches are divided into three broad classifications: sintering of surface-applied powders; impregnation of solution followed by further thermal processing; and infiltration of molten silicon and subsequent carburization or nitridation of the silicon. The impregnation of RSSN with solutions of aluminum nitrate and zirconyl chloride, followed by heating at 1400-1500 C in a nitrogen atmosphere containing silicon monoxide, improved RSSN strength and oxidation resistance. The room temperature bend strength of RSSN was increased nearly fifty percent above the untreated strength with mean absolute strengths up to 420 MN/m2. Strengths of treated samples that were measured after a 12 hour oxidation exposure in air were up to 90 percent of the original as-nitrided strength, as compared to retained strengths in the range of 35 to 60 percent for untreated RSSN after the same oxidation exposure. Author

N78-25132*# TRW Equipment Labs., Cleveland, Ohio
FIBER REINFORCED PMR POLYIMIDE COMPOSITES Final Report, 28 Jun. 1976 - 31 Oct 1977
P. J. Cavano and W. E. Winters 15 May 1978 103 p refs (Contract NAS3-20366)
(NASA-CR-135377; TRW-ER-7884F) Avail: NTIS HC A06/MF A01 CSCL 11D

Commercially obtained PMR-15 polyimide prepregs with S-glass and graphite fiber reinforcements were evaluated along with in-house prepared glass and graphite cloth PMR 2 materials. A novel autoclave approach was conceived and used to demonstrate that both the PMR systems respond to 1.4 MPa (200 psi) autoclave pressures to produce void free composites equivalent to die molded laminates. Isothermal gravimetric analysis and subsequent mechanical property tests indicated that the PMR 2 system was significantly superior in thermo-oxidative stability and that S-glass reinforcements may contribute to the accelerated degradation of composites at 316 C (600 F) when compared to graphite fiber reinforced composites. Fully reversed bending fatigue experiments were conducted with a type of fixture unused for organic matrix composites. These studies indicated that the graphite fiber composites were clearly superior in fatigue resistance to the glass fiber reinforced material and that PMR matrix composite systems yield performance of the same order as composite materials employing other families of matrices. Author

A78-16903 * Evaluation of low cost/high temperature fiber and blanket insulation. E. L. Strauss (Martin Marietta Aerospace, Denver, Colo.). In: Diversity - Technology explosion; Proceedings of the Twenty-second National Symposium and Exhibition, San Diego, Calif., April 26-28, 1977. (A78-16870 04-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1977, p. 466-485. 8 refs. Contract No. NAS3-18900.

Twelve fiber materials comprising water-felted fiber cakes and blanket insulation were subjected to furnace exposures at 1000, 1200, 1400, and 1600 C for up to 500 hours to establish the time-temperature limits below which these insulation materials can withstand repeated thermal cycles without detrimental shrinkage, thermal conductivity increase, or physical changes. Test samples were inspected periodically during the exposure cycles and weight loss and dimensional shrinkage were measured. Density, fiber crystallography, and thermal conductivity were measured after exposure and properties were compared with those of unexposed controls. (Author)

A78-26683 * Evaluation of flawed composite structure under static and cyclic loading. T. R. Porter (Boeing Aerospace Co., Seattle, Wash.). In: Fatigue of filamentary composite materials; Proceedings of the Symposium, Denver, Colo., November 15, 16, 1976. (A78-26873 10-24) Philadelphia, Pa., American Society for Testing and Materials, 1977, p. 152-170. Contract No. NAS3-19709.

This paper presents the results of a program investigating the effects of initial defects on the fatigue and fracture response of composite laminates. The structural laminates investigated were a typical angle-ply laminate, a polar/hoop-wound pressure vessel laminate, and a typical engine fan blade laminate. Defects investigated were full- and half-penetration circular holes, full- and half-penetration slits, and countersink holes. Results are presented showing the effects of the defect size and type on the static fracture strength, fatigue performance, and residual static strength. The results of inspection procedures are shown, describing the effect of cyclic and static loadings on damage propagation in composite laminates. The data in this study were used to define proof test levels as a qualification procedure in composite structure subjected to cyclic loading. (Author)

25 INORGANIC AND PHYSICAL CHEMISTRY

Includes chemical analysis, e.g., chromatography; combustion theory; electrochemistry; and photochemistry.

For related information see also *77 Thermodynamics and Statistical Physics.*

N78-10224* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FUEL COMBUSTOR Patent

Cecil J. Marek, inventor (to NASA) Issued 4 Oct. 1977 5 p Filed 31 Mar. 1976 Supersedes N76-20215 (14 - 11, p 1358)

(NASA-Case-LEW-12137-1; US-Patent-4,052,144; US-Patent-Appl-SN-672210; US-Patent-Class-431-352; US-Patent-Class-431-158; US-Patent-Class-60-39.51R; US-Patent-165-105) Avail: US Patent Office CSCL 21B

A fuel combustor comprises a chamber with air and fuel inlets and a combination gas outlet. The fuel is supplied to a vaporization zone and fuel and air are mixed in a pair of mixing chambers, each exemplified by a swirl can. The resultant mixture is directed into a combustion zone within the combustor. Heat pipes are arranged with one end portion substantially in the combustion zone and the other end in the vaporization zone of its appropriate mixing chamber. Some of the heat of combustion is thus carried back upstream into the swirl cans, to vaporize the fuel as it enters the vaporization zone in the swirl can, thereby improving vaporization and fuel mixing.

Official Gazette of the U.S. Patent Office

N78-12167*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF TRICHLOROFLUOROMETHANE AND MOLECULAR CHLORINE ON OZONE FORMATION BY SIMULATED SOLAR RADIATION

David A. Bittker and Edgar L. Wong Nov. 1977 22 p refs (NASA-TP-1093; E-9078) Avail: NTIS HC A02/MF A01 CSCL 04A

Mixtures of air with either Cl2 or CFCl3 were photolyzed in a reaction chamber by simulated solar radiation. Ozone formation was temporarily inhibited by Cl2 and permanently inhibited by CFCl3. A chemical mechanism including gas phase and wall reactions is proposed to explain these results. The CFCl3 is assumed to be adsorbed on the chamber walls and to poison the sites for Cl destruction. Author

N78-13157*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FORMATION OF Na2SO4 AND K2SO4 IN FLAMES DOPED WITH SULFUR AND ALKALI CHLORIDES AND CARBONATES

George C. Fryburg, Robert A. Miller, Carl A. Stearns, and Fred J. Kohl 1977 19 p refs Presented at Symp. on High Temp. Metal Halide Chem., Atlanta, 9-14 Oct. 1977; sponsored by Electrochem. Soc.

(NASA-TM-73794) Avail: NTIS HC A02/MF A01 CSCL 21B

High pressure, free-jet expansion, mass spectrometric sampling was used to identify directly and to measure reaction products formed in doped methane-oxygen flames. Flames were doped with SO2 or CH3SH and sodium or potassium chlorides or carbonates. Gaseous NA2SO4 or K2SO4 molecules were formed in residence times on the order of msec for each combination of dopants used. Composition profiles of combustion products were measured and compared with equilibrium thermodynamic calculations of product composition. Author

N78-13158*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

VOLATILE PRODUCTS FROM THE INTERACTION OF KCl(g) WITH Cr2O3 AND LaCrO3 IN OXIDIZING ENVIRONMENTS

Fred J. Kohl, Robert A. Miller, Carl A. Stearns, George C. Fryburg, and John G. Dillard 1977 15 p refs Presented at Symp. on High Temp. Metal Halide Chem., Atlanta, 9-14 Oct. 1977; sponsored by Electrochem. Soc.

(NASA-TM-73795) Avail: NTIS HC A02/MF A01 CSCL 07D

Cooled target collection techniques and high pressure mass spectrometric sampling were used to measure the relative rates of oxidative vaporization and to identify the volatile products emanating from samples of chromia and Mg-doped lanthanum chromite. The materials were exposed to partial pressures of KCl with and without H2O in one atmosphere of slowly flowing oxygen at elevated temperatures. Chromia and fresh samples of lanthanum chromite exhibited enhanced rates of oxidative vaporization upon exposure to these reactants. Mass spectrometric identification showed that the enhancements resulted from the heterogeneous formation of complex molecules of the type KCl sub 1,2,3 CrO3 and KOH sub 1,2 CrO3. Lanthanum chromite that had undergone prolonged oxidative vaporization exhibited no enhanced oxidation upon exposure to the reactants. Author

N78-13159*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INTERACTION OF NaCl(g) AND HCl(g) WITH CONDENSED Na2SO4

Carl A. Stearns, Fred J. Kohl, George C. Fryburg, and Robert A. Miller 1977 21 p refs Presented at Symp. on High Temp. Metal Halide Chem., Atlanta, Ga., 9-14 Oct. 1977; sponsored by Electrochemical Soc.

(NASA-TM-73796) Avail: NTIS HC A02/MF A01 CSCL 07D

The interaction of Na2SO4(l) with NaCl(g), HCl(g), and H2O(g) was studied in atmospheric pressure flowing air and oxygen at Na2SO4(l) temperatures of 900 and 1000 C. Thermomicrogravimetric and high pressure mass spectrometric sampling techniques were used. Experimental results establish that previously reported enhanced rates of weight loss of Na2SO4(l) in the presence of NaCl(g) are due to the reaction: Na2SO4(c) + 2HCl(g) = 2NaCl(g) + SO2(g) + H2O(g) + 1/2O2(g) being driven to the right in flowing gas systems. The HCl(g) is the product of hydrolysis of NaCl caused by small but significant amounts of H2O(g) present in the system. Thermochemical calculations are used to show that even with sub-ppm levels of H2O(g) present, significant quantities of HCl(g) are produced. Author

N78-15211*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE FLUORINATION OF COBALT AND ZINC

Patricia Marie ODonnell Jul. 1976 111 p refs

(NASA-TM-X-73478; E-C233) Avail: NTIS HC A06/MF A01 CSCL 07D

The reaction of cobalt and zinc with gaseous fluorine was studied. Both temperature and pressure were variables, ranging from 298 to 773 K and 50 to 625 torr. Both reactions were described by the parabolic rate law. The reaction was both temperature and pressure dependent. In the zinc reaction the vaporization rate of zinc above 573 K complicated the kinetics. The cobalt reaction was complex due to the formation of two fluorides. Parabolic rate constants were calculated and from the temperature dependence of the reaction a heat of reaction of 2.8 kcal-mole superscript -1 for zinc and 4.8 kcal-mole superscript -1 for cobalt in the low temperature range was estimated. A theoretical analysis indicated the most probable mechanism for both reactions is cation diffusion through cation vacancies. Comparisons with reported oxidation kinetics were given. Author

N78-17172*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
RELEASE OF DISSOLVED NITROGEN FROM WATER DURING DEPRESSURIZATION
R. J. Simoneau 1978 20 p refs To be Presented at the 14th Ann. Meeting of the Southeastern Seminar on Thermal Sci., Raleigh, N. C., 6-7 Apr. 1978
(NASA-TM-73822, E-1411-1) Avail: NTIS HC A02/MF A01 CSCL 07D

Experiments were run to study depressurization of water containing various concentrations of dissolved nitrogen gas, the primary case being room temperature water saturated with nitrogen at 4 MPa. In a static depressurization experiment, water with very high nitrogen content was depressurized at rates from 0.09 to 0.50 MPa per second and photographed with high speed movies. The pictures showed that the bubble population at a given pressure increased strongly with decreasing depressurization rate. Flow experiments were performed in an axisymmetric converging-diverging nozzle and in a two-dimensional converging nozzle with glass sidewalls. Depressurization gradients were roughly 500 to 1200 MPa per second. Both nozzles exhibited choked flow behavior even at nitrogen concentration levels as low as 4 percent of saturated. The flow rates were independent of concentration level and could be computed as incompressible water flow based on the difference between stagnation and throat pressures; however, the throat pressures were significantly different between the two nozzles. Author

N78-19237*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DEFINITION AND EFFECT OF CHEMICAL PROPERTIES OF SURFACES IN FRICTION, WEAR, AND LUBRICATION
Donald H. Buckley 1978 40 p refs Proposed for Presentation at the Intern. Conf. on Tribology, Cambridge, Mass., 19-23 June 1978; sponsored by ONR, AROD, ARPA, and MIT
(NASA-TM-73806) Avail: NTIS HC A03/MF A01 CSCL 07D

Chemical properties relative to their role in adhesion, friction, wear and lubrication discussed in this paper will include: (1) adsorption, both physical and chemical; (2) orientation of the solid as well as the lubricant; (3) surface energy; (4) surface segregation; (5) surface versus bulk metallurgical effects; (6) electronic nature of the surface; and (7) bonding mechanisms. Author

N78-20281*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF NITRIC OXIDE ON PHOTOCHEMICAL OZONE FORMATION IN MIXTURES OF AIR WITH MOLECULAR CHLORINE AND WITH TRICHLOROFLUOROMETHANE
David A. Bittker and Edgar L. Wong Apr. 1978 25 p refs
(NASA-TP-1192, E-9297) Avail: NTIS HC A02/MF A01 CSCL 07D

Ozone formation in a reaction chamber at room temperature and atmospheric pressure was studied for the photolysis of mixtures of NO with either Cl2 or CFCl3 in air. Both Cl2 + NO and CFCl3 + NO in air strongly inhibited O3 formation during the entire 3 to 4 hour reaction. A chemical mechanism that explains the results was presented. An important part of this mechanism was the formation and destruction of chlorine nitrate. Computations were performed with this same mechanism for CFCl3-NO-air mixtures at stratospheric temperatures, pressures, and concentrations. Results showed large reductions in steady-state O3 concentrations in these mixtures as compared with pure air. Author

N78-25148* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
APPARATUS FOR EXTRACTION AND SEPARATION OF A PREFERENTIALLY PHOTO-DISSOCIATED MOLECULAR ISOTOPE INTO POSITIVE AND NEGATIVE IONS BY MEANS OF AN ELECTRIC FIELD Patent
Horst E. Wilhelm, inventor (to NASA) (Colo. State Univ., Ft. Collins) Issued 18 Apr. 1978 5 p Sponsored by NASA
(NASA-Case-LEW-12465-1; US-Patent-4,085,332; US-Patent-Appl-SN-692413; US-Patent-Class-250-528; US-Patent-Class-55-2; US-Patent-Class-55-100; US-Patent-Class-55-101; US-Patent-Class-250-531; US-Patent-Class-250-423P) Avail: US Patent Office CSCL 07D

Molecules of one and the same isotope were preferentially photodissociated by a laser and an ultraviolet source, or by multiphoton absorption of laser radiation. The resultant ions were confined with a magnetic field, moved in opposite directions by an electric field, extracted from the photodissociation region by means of screening and accelerating grids, and collected in ducts. Official Gazette of the U.S. Patent Office

N78-25149*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FORMULATED PLASTIC SEPARATORS FOR SOLUBLE ELECTRODE CELLS Patent Application
Dean W. Sheibley, inventor (to NASA) Filed 3 Nov. 1977 22 p
(NASA-Case-LEW-12358-2; US-Patent-Appl-SN-848428) Avail: NTIS HC A02/MF A01 CSCL 07D

Membranes comprising a hydrochloric acid-insoluble sheet of a mixture of a rubber and a powered ion transport material were designed for use in oxidation-reduction (REDOX) electrical accumulator cells. The sheet of thermoplastic rubber and an ion transport material, which may be in the form of a film on a flexible substrate such as asbestos or paper was made by dissolving the rubber in a solvent and mixing with the ion transport material which is 20-50 volume percent as compared with 80-50 volume percent rubber. Preferred ion transport materials include a salt or a chloride anion; a phosphonium, tertiary ammonium or quaternary ammonium cation; a metal oxide, and a silicate or boric acid. NASA

N78-26185*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
APPLICATION OF ESCA TO THE DETERMINATION OF STOICHIOMETRY IN SPUTTERED COATINGS AND INTERFACE REGIONS
Donald R. Wheeler Aug. 1978 15 p refs Proposed for presentation at the 2d Intern. Conf. on Solid Lubrication, Denver, 14-18 Aug. 1978; sponsored by the Am. Soc. of Lubrication Engr.
(NASA-TM-78896; E-9367) Avail: NTIS HC A02/MF A01 CSCL 07D

X-ray photoelectron spectroscopy was used to characterize radiofrequency sputter deposited films of several refractory compounds. Both the bulk film properties such as purity and stoichiometry and the character of the interfacial region between the film and substrate were examined. The materials were CrB2, MoS2, Mo2C, and Mo2B5 deposited on 440C steel. It was found that oxygen from the sputtering target was the primary impurity in all cases. Biasing improves the film purity. The effect of biasing on film stoichiometry is different for each compound. Comparison of the interfacial composition with friction data suggests that adhesion of these films is improved if a region of mixed film and iron oxides can be formed. Author

N78-27228* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TARGETS FOR PRODUCING HIGH PURITY I-123 Patent
James W. Blue, inventor (to NASA) Issued 9 May 1978 7 p Filed 4 Sep. 1973 Supersedes N74-10476 (12 - 1, p 0060) Continuation-in-part of abandoned US Patent Appl. SN-266927, filed 28 Jun. 1972, which is a continuation-in-part of US appl. SN-863280, filed 2 Oct. 1969; US Patent-3,694,313
(NASA-Case-LEW-10518-3; US-Patent-4,088,532; US-Patent-Appl-SN-394207; US-Patent-Class-176-11; US-Patent-Class-176-16; US-Patent-Class-250-400; US-Patent-Class-250-429; US-Patent-Class-250-492B; US-Patent-3,694,313; US-Patent-Appl-SN-266927; US-Patent-Appl-SN-863280) Avail: US Patent Office CSCL 07D

Tellurium powder in improved targets is bombarded with a cyclotron beam to produce Xe-123. Flowing gas streams carry

the Xe 123 through one cold trap which removes Xe-123 that subsequently decays to I-123. During this bombardment energy is deposited in the target material causing its temperature to rise. Some of the tellurium vaporizes and subsequently condenses on surfaces that are cooler than the vaporization temperature. Provision is made for the repeated bombardment of this condensed tellurium. Official Gazette of the U.S. Patent Office

A78-24887 * # Volatile products from the interaction of KCl(g) with Cr2O3 and LaCrO3 in oxidizing environments. F. J. Kohl, R. A. Miller, C. A. Stearns, G. C. Fryburg (NASA, Lewis Research Center, Cleveland, Ohio), and J. G. Dillard. *Electrochemical Society, Symposium on High Temperature Metal Halide Chemistry, Atlanta, Ga., Oct. 9-14, 1977, Paper.* 14 p. 9 refs.

Based on cooled target collection methods and high pressure mass spectrometer sampling, oxidative vaporization rates and emanating volatile products were evaluated for interactions of KCl(g) with Cr2O3 and LaCrO3 in oxidizing environments. It was found that: (1) increased rates of oxidative vaporization upon exposure to the reactants are exhibited by chromia and fresh lanthanum chromite samples, and (2) these increased rates result from the heterogeneous formation of complex molecules such as KCl sub 1,2,3CrO3 and KOH sub 1,2CrO3. No increased rates were observed for lanthanum chromite subjected to prolonged oxidative vaporization. S.C.S.

A78-24888 * # Interaction of NaCl/g/ and HCl/g/ with condensed Na2SO4. C. A. Stearns, F. J. Kohl, G. C. Fryburg, and R. A. Miller (NASA, Lewis Research Center, Cleveland, Ohio). *Electrochemical Society, Symposium on High Temperature Metal Halide Chemistry, Atlanta, Ga., Oct. 9-14, 1977, Paper.* 20 p. 17 refs.

Na2SO4(l)-NaCl(g) interactions were studied at a total pressure of one atmosphere of air or oxygen for various temperatures of Na2SO4(l) and for various partial pressures of NaCl(g) and H2O(g). Mass spectrometric sampling techniques were used to identify and monitor gas phase species. Continuous recording thermomicrogravimetric measurements were conducted to determine condensed phase weight change rates. Experimental measurements were supplemented with thermodynamic calculations. Numerous experiments were performed at sample temperatures of 900 and 1000 C with 300 ppm NaCl(g). In these experiments, the reproducibility of the Na2SO4 vaporization weight loss rate and initial weight gain upon addition of NaCl(g) were found to be satisfactory. It was found that the addition of NaCl(g) to air flowing over Na2SO4(l) at 900 and 1000 C enhances the rate of weight loss of the Na2SO4(l). This enhancement increases when H2O(g) is also added to the air flow. G.R.

A78-24889 * # Formation of Na2SO4 and K2SO4 in flames doped with sulfur and alkali chlorides and carbonates. G. C. Fryburg, R. A. Miller, C. A. Stearns, and F. J. Kohl (NASA, Lewis Research Center, Cleveland, Ohio). *Electrochemical Society, Symposium on High Temperature Metal Halide Chemistry, Atlanta, Ga., Oct. 9-14, 1977, Paper.* 18 p. 27 refs.

High pressure, free-jet expansion, mass spectrometric sampling was used to identify directly and to measure reaction products formed in doped methane-oxygen flames. Flames were doped with SO2 or CH3SH and sodium or potassium chlorides or carbonates. Gaseous Na2SO4 or K2SO4 molecules were formed in residence times on the order of 1 msec for each combination of dopants used. Composition profiles of combustion products were measured and compared with equilibrium thermodynamic calculations of product composition. (Author)

A78-31430 * X-ray photoelectron spectroscopic study of surface chemistry of dibenzyl disulfide on steel under mild and severe wear conditions. D. R. Wheeler (NASA, Lewis Research Center, Cleveland, Ohio). *Wear*, vol. 47, Apr. 1978, p. 243-264. 16 refs.

X-ray photoelectron spectroscopy was used to characterize the chemical composition of 304 stainless steel surfaces run in oil containing dibenzyl disulfide under both mild and severe wear conditions. In severe wear a sulfide was formed at the expense of the normal oxide. This was due to either chemical attack on the oxide or reaction with clean metal exposed by the wear process. In the mild wear scars there was no evidence of either sulfide or mercaptide. The oxide, however, was approximately twice as thick as the normal oxide on an unworn surface. The change in surface chemistry was primarily a function of wear rate rather than load. (Author)

A78-33221 * # Effluent characterization from a conical pressurized fluid bed. R. J. Priem, R. J. Rollbuhler, and R. W. Patch (NASA, Lewis Research Center, Cleveland, Ohio). *International Conference on Fluidized-Bed Combustion, 5th, Washington, D.C., Dec. 12-14, 1977, Paper.* 14 p. 10 refs.

An important factor regarding the use of a pressurized coal burning fluidized bed (PFB) providing gases for driving a gas turbine is the turbine blade lifetime. However, very little data are currently available to predict erosion and corrosion rates produced by the effluent from a PFB. To assess the potential of alloys developed for aeronautical applications to resist this environment it was decided to build a coal burning fluidized bed that could be employed to measure erosion and corrosion rates. Tests were conducted with a conical fluidized bed to obtain some degree of flotation through the top of the bed. A description is presented of the data obtained in the first 138 hours of testing to characterize the effluent from the bed under different test conditions. The considered tests had been made to determine the best operating conditions prior to using the bed for a determination of the erosion and corrosion rates of typical turbine blade materials. G.R.

A78-33224 * Release of dissolved nitrogen from water during depressurization. R. J. Simoneau (NASA, Lewis Research Center, Cleveland, Ohio). *Southeastern Seminar on Thermal Sciences, Annual Meeting, 14th, Raleigh, N.C., Apr. 6, 7, 1978, Paper.* 19 p. 7 refs.

Experiments were run to study depressurization of water containing various concentrations of dissolved nitrogen gas, the primary case being room temperature water saturated with nitrogen at 4 MPa. In a static depressurization experiment, water with very high nitrogen content was depressurized at rates from 0.09 to 0.50 MPa per second and photographed with high-speed movies. The pictures showed that the bubble population at a given pressure increased strongly with decreasing depressurization rate. Bubbles rarely appeared before the pressure reached half the initial pool pressure. Flow experiments were performed in an axisymmetric converging-diverging nozzle and in a two-dimensional converging nozzle with glass sidewalls. Depressurization gradients were roughly 500 to 1200 MPa per second. Both nozzles exhibited choked flow behavior even at nitrogen concentration levels as low as 4 percent of saturated. The flow rates were independent of concentration level and could be computed as incompressible water flow based on the difference between stagnation and throat pressures. However, the throat pressures were significantly different between the two nozzles. (Author)

26 METALLIC MATERIALS

Includes physical, chemical, and mechanical properties of metals, e.g., corrosion, and metallurgy.

N78-11230*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

SECONDARY-ELECTRON-EMISSION PROPERTIES OF CONDUCTING SURFACES WITH APPLICATION TO MULTISTAGE DEPRESSED COLLECTORS FOR MICROWAVE AMPLIFIERS

Ralph Forman Nov 1977 33 p refs

(NASA-TP-1097, E-9233) Avail: NTIS HC A03/MF A01 CSCL 11F

To improve the efficiency of high power microwave tubes, low secondary electron yield electrode surface for use in depressed collectors are needed. The secondary emission characteristics of a number of materials were investigated. The materials studied were beryllium, carbon (soot and pyrolytic graphite), copper, titanium carbide, and tantalum. Both total secondary yield delta and relative reflected primary yield were measured. These measurements were made in conjunction with Auger spectroscopy so that the secondary emission characteristics could be determined as a function of surface contamination or purity. The results show that low atomic weight elements, such as beryllium and carbon, have the lowest reflected primary yield and that roughening the surface of an electrode can markedly decrease secondary yield both for delta and reflected primaries. All factors considered a roughened pyrolytic graphite surface showed the greatest potential for use as an electrode surface in depressed collectors. Author

N78-13181*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

MECHANICAL PROPERTIES OF ION-BEAM-TEXTURED SURGICAL IMPLANT ALLOYS

A. J. Weigand 1977 24 p refs Presented at 24th Natl. Symp., Boston, 8-11 Nov. 1977, sponsored by Am. Vacuum Soc.

(NASA-TM-73742, E-9056-1) Avail: NTIS HC A02/MF A01 CSCL 11F

Ar electron-bombardment Hg ion thruster was used as an ion source to texture surfaces of materials used to make orthopedic and/or dental prostheses or implants. The materials textured include 316 stainless steel, titanium-6% aluminum, 4% vanadium, and cobalt-20% chromium, 15% tungsten. To determine the effect of ion texturing on the ultimate strength and yield strength, stainless steel and Co-Cr-W alloy samples were tensile tested to failure. Three types of samples of both materials were tested. One type was ion textured (the process also heats each sample to 300 C), another type was simply heated to 300 C in an oven, and the third type was untreated. Stress-strain diagrams, 0.2% offset yield strength data, total elongation data, and area reduction data are presented. Fatigue specimens of ion textured and untextured 316 stainless steel and Ti-6% Al-4% V were tested. Included as an ion textured sample is a Ti-6% Al-4% V sample which was ion machined by means of Ni screen mask so as to produce an array of 140 mu m x 140 mu m x 60 mu m deep pits. Scanning electron microscopy was used to characterize the ion textured surfaces. Author

N78-13182*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

ROOM TEMPERATURE CRACK GROWTH RATES AND -20 DEG F FRACTURE TOUGHNESS OF WELDED 1 1/4 INCH A-285 STEEL PLATE

John L. Shannon, Jr. and Walter Rzasnicki Nov 1977 22 p refs

(NASA-TM-73847, E-9435) Avail: NTIS HC A02/MF A01 CSCL 11F

Data are presented which were developed in support of a structural assessment of NASA-LEWIS' 10-foot by 10-foot supersonic wind tunnel, critical portions of which are fabricated from rolled and welded 1 1/4 inch thick A-285 steel plate. Test material was flame cut from the tunnel wall and included longitudinal and circumferential weld joints. Parent metal, welds, and weld heat affected zone were tested. Tensile strength and fracture toughness were determined at -20 F, the estimated lowest tunnel operating temperature. Crack growth rates were measured at room temperature, where growth rates in service are expected to be highest. Author

N78-13183*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CYCLIC STRESS-STRAIN CURVE DETERMINATION FOR D6AC STEEL BY THREE METHODS

Alfred J. Nachtigall [1977] 6 p refs

(NASA-TM-73815, E-9402) Avail: NTIS HC A02/MF A01 CSCL 11F

The room temperature cyclic stress-strain was determined for D6AC low alloy steel by three different methods. The method that involves the use of a single specimen monotonic tension test after cyclic straining provided the best agreement with the accepted basic method which requires a number of companion specimen tests. The single specimen test is also the simplest to conduct. Author

N78-15229*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

FRICTION AND WEAR OF SEVERAL COMPRESSOR GAS-PATH SEAL MOVEMENTS

Robert C. Bill and Donald W. Wisander Jan 1978 42 p refs

(NASA-TP-1128, E-9276) Avail: NTIS HC A03/MF A01 CSCL 11A

Rub interaction experiments were conducted on a series of sintered and plasma sprayed compressor gas path seal materials in contact with Ti-6Al-4V blade tip and knife edge rotors. The most rub tolerant materials investigated were sintered Nichrome and plasma sprayed nickel-25 percent graphite. The effectiveness of providing a compliant substrate for dense seal material coatings was also demonstrated. In general, it was observed that rotor wear and high frictional energy generation rates accompanied smearing or surface densification of the materials investigated. The onset of smearing was sensitive to rub interaction parameters and seal geometry. Two complementary models were proposed to account for the smearing trends. One is based on thermal effects, the other on particulate escape effects. They were shown to be consistent with the experimental evidence at hand and together they predict that smearing, with the onset of high energy rub conditions, is favored when incursion rates (radial motion) are low, incursion depths are high, the seal geometry is of a knife edge character, and the seal particle size is small. Author

N78-15230*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

FEASIBILITY STUDY OF TUNGSTEN AS A DIFFUSION BARRIER BETWEEN NICKEL-CHROMIUM-ALUMINUM AND GAMMA-GAMMA PRIME - DELTA EUTECTIC ALLOYS

Stanley G. Young and Glenn R. Zellars Jan 1978 35 p refs

(NASA-TP-1131, E-9271) Avail: NTIS HC A03/MF A01 CSCL 11F

Coating systems proposed for potential use on eutectic alloy components in high-temperature gas turbine engines were studied with emphasis on deterioration of such systems by diffusion. A 1-mil thick W sheet was placed between eutectic alloys and a NiCrAl layer. Layered test specimens were aged at 1100 C for as long as 500 hours. Without the W barrier, the delta phase of the eutectic deteriorated by diffusion of Nb into the NiCrAl. Insertion of the W barrier stopped the diffusion of Nb from delta. Chromium diffusion from the NiCrAl into the gamma/gamma prime phase of the eutectic was greatly reduced by the barrier. However, the barrier thickness decreased with time, and W diffused into both the NiCrAl and the eutectic. When the delta platelets were aligned parallel to the NiCrAl layer rather than perpendicular, diffusion into the eutectic was reduced. Author

N78-15236*# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio
THE INFLUENCE OF COMPOSITION, ANNEALING TREATMENT, AND TEXTURE ON THE FRACTURE TOUGHNESS OF Ti-5Al-2.5Sn PLATE AT CRYOGENIC TEMPERATURES
R H VanStone (GE, Schenectady, N Y.), J L Shannon, Jr., W S Pierce, and J R Low, Jr (Carnegie-Mellon Univ.) May 1977 46 p refs Presented at Symp on Toughness and Fracture Behavior of Titanium, Toronto, Ontario, 2-3 May 1977, sponsored by Am Soc Testing and Mater
(NASA TM-73872) Avail NTIS HC A03/MF A01 CSCL 11F

The plane strain fracture toughness K sub Ic and conventional tensile properties of two commercially produced one-inch thick Ti-5Al-2 5Sn plates were determined at cryogenic temperatures One plate was extra-low interstitial (ELI) grade, the other normal interstitial Portions of each plate were mill annealed at 1088 K (1500 F) followed by either air cooling or furnace cooling The tensile properties, flow curves, and K sub Ic of these plates were determined at 295 K (room temperature), 77 K (liquid nitrogen temperature), and 20 K (liquid hydrogen temperature)
Author

N78-17187*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
MATERIALS TECHNOLOGY ASSESSMENT FOR STIRLING ENGINES
Joseph R Stephens, Walter R Witzke, Gordon K Watson, James R Johnston, and William J Croft (Army Materials and Mechanics Res Center Watertown, Mass) Oct 1977 16 p refs Presented at Dept of Energy Highway Vehicle Sys Contractors' Coordination Meeting, Dearborn Mich 4-6 Oct 1977
(Contract EC-77-A-31-1011)
(NASA-TM-73789, E-9356, CONS/1011-22) Avail NTIS HC A02/MF A01 CSCL 11F

A materials technology assessment of high temperature components in the improved (metal) and advanced (ceramic) Stirling engines was undertaken to evaluate the current state-of-the art of metals and ceramics identify materials research and development required to support the development of automotive Stirling engines and to recommend materials technology programs to assure material readiness concurrent with engine system development programs The most critical component for each engine is identified and some of the material problem areas are discussed
Author

N78-17189*# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio
ELEVATED-TEMPERATURE TENSILE AND CREEP PROPERTIES OF SEVERAL FERRITIC STAINLESS STEELS
J Daniel Whittenberger Dec 1977 22 p refs
(NASA-TM-73853 E-9440) Avail NTIS HC A02/MF A01 CSCL 11F

The elevated temperature mechanical properties of several ferritic stainless steels were determined The alloys evaluated included Armco 18SR GE 1541, and NASA 18T A Tensile and creep strength properties at 1073 and 1273 K and residual room temperature tensile properties after creep testing were measured In addition 1273 K tensile and creep tests and residual property testing were conducted with Armco 18SR and GE 1541 which were exposed for 200 hours to a severe oxidizing environment in automotive thermal reactors Aside from the residual tensile properties for Armco 18SR prior exposure did not affect the mechanical properties of either alloy The 1273 K creep strength parallel to the sheet rolling direction was similar for all three alloys At 1073 K NASA 18T A had better creep strength than either Armco 18SR or GE 1541 NASA-18T-A possesses better residual properties after creep testing than either Armco 18SR or Ge 1541
Author

N78-17190*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ELEVATED-TEMPERATURE FLOW STRENGTH, CREEP RESISTANCE AND DIFFUSION WELDING CHARACTERISTICS OF Ti-6Al-2Nb-1Ta-0.8Mo
J Daniel Whittenberger and Thomas J Moore Dec 1977 31 p refs
(NASA-TM-73864; E-9441) Avail NTIS HC A03/MF A01 CSCL 11F

A study of the flow strength, creep resistance and diffusion welding characteristics of the titanium alloy Ti-6Al-2Nb-1Ta-0 8Mo was conducted Two mill-processed forms of this alloy were examined The forged material was essentially processed above the beta transus while the rolled form was subjected to considerable work below the beta transus. Between 1150 and 1250 K, the forged material was stronger and more creep resistant than the rolled alloy Both forms exhibit superplastic characteristics in the temperature range. Strain measurements during diffusion welding experiments at 1200 K reveal that weld interfaces have no measurable effect on the overall creep deformation Significant deformation appears to be necessary to produce a quality diffusion weld between superplastic materials A 'soft' interlayer inserted between faying surfaces would seemingly allow manufacture of quality diffusion welds with little overall deformation
Author

N78-18182* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
TANTALUM MODIFIED FERRITIC IRON BASE ALLOYS Patent
Robert E Oldrieve and Charles P. Blankenship, inventors (to NASA) Issued 25 Oct 1977 3 p Filed 21 Jan. 1976 Supersedes N76-17233 (14 - 08, p 0958)
(NASA-Case-LEW-12095-1; US-Patent-4,055,416, US-Patent-Appl-SN-651008; US-Patent-Class-75-124, US-Patent-Class-75-126D; US-Patent-Class-75-126F, US-Patent-Class-75-128G; Us-Patent-Class-75-128T) Avail: US Patent Office CSCL 11F

Strong ferritic alloys of the Fe-CR-Al type containing 0.4% to 2% tantalum were developed These alloys have improved fabricability without sacrificing high temperature strength and oxidation resistence in the 800 C (1475 F) to 1040 C (1900 F) range.
Official Gazette of the U.S. Patent Office

N78-18183* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
DIRECTIONALLY SOLIDIFIED EUTECTIC GAMMA-GAMMA NICKEL-BASE SUPERALLOYS Patent
Melvin R Jackson, inventor (to NASA) Issued 25 Oct 1977 7 p Filed 7 May 1976
(NASA-Case-LEW-12905-1, US-Patent-4,055,447, US-Patent-Appl-SN 684171, US-Patent-Class-148-32; US-Patent-Class 75-170, US-Patent-Class-148-32.5) Avail: US Patent Office CSCL 11F

A directionally solidified multivariant eutectic gamma-gamma prime nickel-base superalloy casting having improved high temperature properties was developed The alloy is composed of a two phase eutectic structure consisting essentially of, on a weight percent basis, 6.0 - 9.0 aluminum, 5.0 - 17.0 tantalum, 0-10 cobalt, 0-6 vanadium, 0-6 rhenium, 2.0-6.0 tungsten, and the balance being nickel, subject to the proviso that the sum of the atomic percentages of aluminum plus tantalum is within the range of from 19 22, and the ratio of atomic percentages of tantalum to aluminum plus tantalum is within the range of from 0 12 - 0 23 Embedded within the gamma nickel-base matrix are aligned eutectic gamma prime phase (primarily nickel-aluminum-tantalum) reinforcing fibers
Official Gazette of the U.S Patent Office

N78-19261*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
CORRELATIONS BETWEEN ULTRASONIC AND FRACTURE TOUGHNESS FACTORS IN METALLIC MATERIALS
Alex Vary 1978 18 p refs Proposed for Presentation at the 11th Symp on Fracture Mech., Blacksburg, Va., 12-14 Jun 1978
(NASA-TM-73805) Avail. NTIS HC A02/MF A01 CSCL 11F

A heuristic mathematical basis was proposed for the experimental correlations found between ultrasonic propagation factors and fracture toughness factors in metallic materials. A crack extension model was developed wherein spontaneous stress

A78-40371 * Fracture surface characteristics of off-axis composites. J. H. Sinclair and C. C. Chamis (NASA Lewis Research Center, Cleveland, Ohio). *Society of Engineering Science, Annual Meeting, 14th, Lehigh University, Bethlehem, Pa., Nov. 14-16, 1977, Paper.* 22 p.

The fracture surface characteristics of off-axis high modulus graphite-fiber epoxy composite specimens were studied using a scanning electron microscope (SEM). The specimens were subjected to tensile loading at various angles (0-90 deg) to the fiber direction. SEM photomicrographs of the fractured surfaces revealed three different load angle regions with distinct fracture characteristics. Based on these revelations, criteria were established which can be used to characterize fracture surfaces with respect to a predominant tensile stress fracture mode. (Author)

N78-14119*# West Virginia Univ., Morgantown. Coll. of Engineering.

FLUIDIZED BED COMBUSTOR MODELING

M. Horio, P. Rengarajan, R. Krishnan, and C. Y. Wen. Jan. 1977. 214 p. refs.

(Contract NAS3-19725)

(NASA-CR-135164) Avail: NTIS HC A10/MF A01 CSCL 21B

A general mathematical model for the prediction of performance of a fluidized bed coal combustor (FBC) is developed. The basic elements of the model consist of: (1) hydrodynamics of gas and solids in the combustor, (2) description of gas and solids contacting pattern, (3) kinetics of combustion, and (4) absorption of SO2 by limestone in the bed. The model is capable of calculating the combustion efficiency, axial bed temperature profile, carbon hold-up in the bed, oxygen and SO2 concentrations in the bubble and emulsion phases, sulfur retention efficiency, and particulate carry over by elutriation. The effects of bed geometry, excess air, location of heat transfer coils in the bed, calcium to sulfur ratio in the feeds, etc. are examined. The calculated results are compared with experimental data. Agreement between the calculated results and the observed data are satisfactory in most cases. Recommendations to enhance the accuracy of prediction of the model are suggested. Author

N78-25160*# Notre Dame Univ., Ind. Dept. of Aerospace and Mechanical Engineering.

BURNING OF LIQUID POOLS IN REDUCED GRAVITY. Final Report, Mar. 1976 - Feb. 1977

A. Murty Kanury. Jun. 1977. 141 p. refs.

(Contract NAS3-20087)

(NASA-CR-135234 TR-77-33) Avail: NTIS HC A07/MF A01 CSCL 21B

The existing literature on the combustion of liquid fuel pools is reviewed to identify the physical and chemical aspects which require an improved understanding. Among the pre-, trans- and post-ignition processes a delineation was made of those which seem to uniquely benefit from studies in the essential environment offered by spacelab. The role played by the gravitational constant in analytical and experimental justifications was developed. The analytical justifications were based on hypotheses, models and dimensional analyses whereas the experimental justifications were based on an examination of the range of gravity and gravity-dependent variables possible in the earth based laboratories. Some preliminary expositions into the questions of feasibility of the proposed spacelab experiment are also reported. Author

A78-41901 * Analytical study of laser-supported combustion waves in hydrogen. N. H. Kemp and R. G. Root (Physical Sciences Inc., Woburn, Mass.). *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 11th, Seattle, Wash., July 10-12, 1978, Paper 78-1219.* 14 p. 15 refs. Contract No. NAS3-20381.

Laser supported combustion (LSC) waves are an important ingredient in the fluid mechanics of CW laser propulsion using a hydrogen propellant and 10.6 micron lasers. Therefore, a computer model has been constructed to solve the one-dimensional energy equation with constant pressure and area. Physical processes considered include convection, conduction, absorption of laser energy, radiation energy loss, and accurate properties of equilibrium hydrogen. Calculations for 1, 3, 10 and 30 atm were made for intensities of 10 to the 4th to 10 to the 6th W/sq cm, which gave temperature profiles, wave speed, etc. To pursue the propulsion application, a second computer model was developed to describe the acceleration of the gas emerging from the LSC wave into a variable-pressure, converging streamtube, still including all the above-mentioned physical processes. The results show very high temperatures in LSC waves which absorb all the laser energy, and high radiative losses. (Author)

(elastic) waves produced during microcracking are instrumental in promoting the onset of unstable crack extension. Material microstructural factors involved in the process are measurable by ultrasonic probing. Experimental results indicate that ultrasonic attenuation and velocity measurements will produce significant correlations with fracture toughness properties and also yield strength. Author

N78-19282*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PRINCIPLES OF ESCA AND APPLICATION TO METAL CORROSION, COATING AND LUBRICATION
Donald R. Wheeler. 1978. 15 p. refs. Presented at the Symp. on Mod. Mat. Alloy. Tech. and Their Appl., Cleveland, 10-11 Apr. 1978.
(NASA-TM-78839) Avail: NTIS HC A02/MF A01 CSCL 11F

The principles of ESCA (electron spectroscopy for chemical analysis) were described by comparison with other spectroscopic techniques. The advantages and disadvantages of ESCA as compared to other surface sensitive analytical techniques were evaluated. The use of ESCA was illustrated by actual applications to oxidation of steel and Rene 41, the chemistry of lubricant additives on steel, and the composition of sputter deposited hard coatings. A bibliography of material that was useful for further study of ESCA was presented and commented upon. Author

N78-21288*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
STRENGTH ENHANCEMENT PROCESS FOR PREALLOYED POWDER SUPERALLOYS
William J. Waters and John C. Freche. 1977. 31 p. refs. Presented at the TMS-AIME Fall Meeting, Chicago, 24-27 Oct. 1977.
(NASA-TM-78834, E-9544) Avail: NTIS HC A03/MF A01 CSCL 11F

A technique involving superplastic processing and high pressure autoclaving was applied to a nickel base prealloyed powder alloy. Tensile strengths as high as 2865 MN sq m at 480 C were obtained with as superplastically deformed material. Appropriate treatments yielding materials with high temperature tensile and stress rupture strengths were also devised. Author

N78-21287*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
STRAINRANGE PARTITIONING BEHAVIOR OF THE NICKEL BASE SUPERALLOYS, RENE' 80 AND IN 100
G. R. Halford and A. J. Nachtigall. Apr. 1978. 17 p. refs. Presented at the 46th Meeting of the Struct. and Mater. Panel of AGARD Specialists Meeting on Characterization of Low Cycle High Temp. Fatigue by Strainrange Partitioning Method, Aalborg, Denmark, 9-14 Apr. 1978.
(NASA-TM-78828) Avail: NTIS HC A02/MF A01 CSCL 11F

A study was made to assess the ability of the method of Strainrange Partitioning (SRP) to both correlate and predict high temperature low cycle fatigue lives of nickel base superalloys for gas turbine applications. The partitioned strainrange versus life relationships for uncoated Rene' 80 and cast IN 100 were also determined from the ductility normalized Strainrange Partitioning equations. These were used to predict the cyclic lives of the baseline tests. The life predictability of the method was verified for cast IN 100 by applying the baseline results to the cyclic life prediction of a series of complex strain cycling tests with multiple hold periods at constant strain. It was concluded that the method of SRP can correlate and predict the cyclic lives of laboratory specimens of the nickel base superalloys evaluated in this program. Author

N78-21289*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
INFLUENCE OF FRETTING ON FLEXURAL FATIGUE OF 304 STAINLESS STEEL AND MILD STEEL
Robert C. Bill (Army R and T Labs.) and Douglas A. Rohn. Apr. 1978. 19 p. refs.
(NASA-TP-1193, E-9414) Avail: NTIS HC A02/MF A01 CSCL 11F

Fretting fatigue experiments conducted on 304 stainless steel using a flexural fatigue test arrangement with bolted on fretting pads demonstrated that fatigue life is reduced by at least a factor of 10 in the 265 to 334 MPa (38,500 to 48,500 psi) nominal flexural fatigue stress range. In addition, experiments in which the fretting pads were removed after selected numbers of cycles, followed by continued flexural fatigue without fretting show that continued fretting beyond 50,000 cycles does not significantly further reduce fatigue life of 304 stainless steel at 317 MPa (46,000 psi). Microscopic examination of the fretted contact areas revealed fracture initiation sites as well as numerous cracks that did not propagate to failure. Flexural fretting fatigue experiments performed on mild steel showed an insensitivity of fatigue life to the incidence of fretting under flexural stress conditions of from 162 to 217 MPa (23,500 to 31,500 psi). Author

N78-22286*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
HIGH TOUGHNESS-HIGH STRENGTH IRON ALLOY Patent Application
J. R. Stephens and W. R. Witzke, inventors (to NASA). Filed 13 Dec. 1977. 12 p.
(NASA-Case-LEW-12542-2; US-Patent-Appl-SN-860405) Avail: NTIS HC A02/MF A01 CSCL 11F

A steel alloy is provided which exhibits excellent strength and toughness characteristics at cryogenic temperatures. The alloy consists essentially of about 10 to 18 percent by weight nickel, about 0.1 to 1.0 percent by weight aluminum, and 0 to about 3 percent by weight of at least one of the following additional elements: copper, lanthanum, niobium, tantalum, titanium, vanadium, yttrium, zirconium, and the rare earth metals with the balance being essentially iron. The steel alloy is produced by a process which includes using cold rolling at room temperature and subsequent heat treatment at temperatures ranging from 500 to 650 C and possesses a fracture toughness ranging from 200 to 230 ksi square root of (in.) and yield strengths up to 230 ksi. NASA

N78-23192*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THE ROLE OF THERMAL SHOCK IN CYCLIC OXIDATION
Carl E. Lowell and Daniel L. Deadmore. 1978. 14 p. refs. Presented at 153d Meeting of the Electrochem. Soc., Seattle, 21-26 May 1978.
(NASA-TM-78876, E-9610) Avail: NTIS HC A02/MF A01 CSCL 11F

The effect of thermal shock on the spalling of oxides from the surfaces of several commercial alloys was determined. The average cooling rate was varied from approximately 240 C per second to less than 1.0 C per second during cyclic oxidation tests in air. The tests consisted of one hundred cycles of one hour at the maximum temperature (1100 or 1200 C). The alloys were HOS 875, TD Ni, TD NiCrAl, IN 601, IN 702, and B 1900 plus Hf. All of these alloys exhibited partial spalling with the oxide rather than total oxide loss down to bare metal. Thermal shock resulted in deformation of the metal which in turn resulted in most cases in changing the oxide failure mode from compressive to tensile. Tensile failures were characterized by cracking of the oxide and little loss, while compressive failures were characterized by explosive loss of platelets of oxide. This behavior was confirmed by examination of mechanically stressed oxide scales. The thermally shocked oxides spalled less than the slow cooled specimens with the exception of TD NiCrAl. This material failed in a brittle manner rather than by plastic deformation. Author

N78-24336*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
NEW ALLOYS TO CONSERVE CRITICAL ELEMENTS
Joseph R. Stephens. 1978. 15 p. refs. Presented at the Intern. Eng. Conf. and Tool Exposition, Philadelphia, 8-11 May 1978; sponsored by the Soc. of Manufacturing Engr.

(NASA TM 78840 E 9551) Avail NTIS HC A02/MF A01 CSCL 11F

Based on availability of domestic reserves chromium is one of the most critical elements within the U S metal industry New alloys having reduced chromium contents which offer potential as substitutes for higher chromium containing alloys currently in use are being investigated This paper focuses primarily on modified Type 304 stainless steels having one third less chromium but maintaining comparable oxidation and corrosion properties to that of type 304 stainless steel the largest single use of chromium Substitutes for chromium in these modified Type 304 stainless steel alloys include silicon and aluminum plus molybdenum Author

N78-24336*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

CYCLIC OXIDATION OF COATED OXIDE DISPERSION STRENGTHENED (ODS) ALLOYS IN HIGH VELOCITY GAS STREAMS AT 1100 DEG C

Michael A Gedwill May 1978 20 p refs

(NASA TM 78877 E 9611) Avail NTIS HC A02/MF A01 CSCL 11F

Several overlay coatings on ODS NiCrAl s were tested in Mach 1 and Mach 0 3 burner rigs to examine oxidation and thermal fatigue performance The coatings were applied by various methods Based on weight change macroscopic and metallographic observations in Mach 1 tests Nascoat 70 on ID NiCrAl exhibited the best oxidation resistance In Mach 0 3 tests PWA 267 and A1D 1 about equally were the best coatings on YD NiCrAl (Nascoat 70 was not tested in Mach 0 3 rigs) Author

N78-26198*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

ROLE OF ALLOYING ELEMENTS IN ADHESIVE TRANSFER AND FRICTION OF COPPER BASE ALLOYS

Donald H Buckley Jun 1978 19 p refs

(NASA TP 1256 E 9471) Avail NTIS HC A02/MF A01 CSCL 11F

Sliding friction experiments were conducted in a vacuum with binary copper alloy riders sliding against a conventional bearing steel surface with normal residual oxides present The binary alloys contained 1 atomic percent of various alloying elements Auger spectroscopy analysis was used to monitor the adhesive transfer of the copper alloys to the bearing steel surface A relation was found to exist between adhesive transfer and the reaction potential and free energy of formation of the alloying element in the copper The more chemically active the element and the more stable its oxide the greater was the adhesive transfer and wear of the copper alloy Transfer occurred in all the alloys except copper gold after relatively few (25) passes across the steel surface Author

N78-26199*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

MORPHOLOGY OF GOLD AND COPPER ION-PLATED COATINGS

Talivaldis Spalvins Jun 1978 17 p refs

(NASA-TP 1262 E 9528) Avail NTIS HC A02/MF A01 CSCL 11F

Copper and gold films (0 2 to 2 microns thick) were ion plated onto polished 304 stainless steel glass mica surfaces These coatings were examined by SEM for defects in their morphological growth Three types of defects were distinguished nodular growth abnormal or runaway growth and spits The cause for each type of defect was investigated Nodular growth is due to inherent substrate microdefects abnormal or runaway growth is due to external surface inclusions and spits are due to nonuniform evaporation (ejection of droplets) All these defects induce stresses and produce porosity in the coatings and thus weaken their mechanical properties During surface rubbing large nodules are pulled out leaving vacancies in the coatings Author

N78-26225*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

EROSION CORROSION OF TURBINE AIRFOIL MATERIALS IN THE HIGH-VELOCITY EFFLUENT OF A PRESSURIZED FLUIDIZED COAL COMBUSTOR

Glenn R Zellars Anne P Lowe and Carl E Lowell Jul 1978 33 p refs

(NASA TP 1274 E 9507) Avail NTIS HC A03/MF A01 CSCL 11F

Four candidate turbine airfoil superalloys were exposed to the effluent of a pressurized fluidized bed with a solids loading of 2 to 4 g/scm for up to 100 hours at two gas velocities 160 and 270 m/sec and two temperatures 730 deg and 795 C Under these conditions both erosion and corrosion occurred The damaged specimens were examined by cross section measurements scanning electron and light microscopy and X ray analysis to evaluate the effects of temperature velocity particle loading and alloy material Results indicate that for a given solids loading the extent of erosion is primarily dependent on gas velocity Corrosion occurred only at the higher temperature There was little difference in the erosion/corrosion damage to the four alloys tested under these severe conditions G G

N78-29214*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

ADHESION OF A BIMETALLIC INTERFACE Ph D Thesis - Case Western Reserve Univ.

John Ferrante Jun 1978 332 p refs

(NASA TM 78890) Avail NTIS HC A15/MF A01 CSCL 11A

The Hohenberg Kohn and Kohn Sham formalisms are used to examine binding (binding energy as a function of separation) for combinations of the simple metals Al(111) Zn(0001) Mg(0001) and Na(110) in contact Similar metal contacts between Al Zn Mg and Na are examined self consistently in an ab initio calculation using the Kohn Sham formalism Crystallinity is included using the Aschroft pseudopotential via first order perturbation theory for the electron ion interaction and the ion ion interaction is included exactly via a lattice sum Binding energy was determined both in the local density approximation and including gradient corrections to the exchange and correlation energy Binding was found in all cases In dissimilar metal contacts interfacial bonding was greater than that in the weaker material predicting the possibility of metallic transfer The nonzero position of the energy minimum in like metal contacts is explained in terms of consistency between the Ashcroft pseudopotential and the bulk charge density Good agreement with experimental surface energies is obtained in the self consistent calculation when nonlocal terms are included Author

N78-29215*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

RUB TOLERANCE EVALUATION OF TWO SINTERED NiCrAl GAS PATH SEAL MATERIALS

Robert C Bill Jul 1978 12 p

(NASA TM 78967 AVRADCOM TR 78 39(PL) E 9726) Avail NTIS HC A02/MF A01 CSCL 11F

Two strength level variations of sintered NiCrAl (about 40 percent dense) candidate high pressure turbine seal materials were subject to rub tolerance testing against AM 355 steel blade tips The high strength material (17 N/sq mm tensile strength) showed fictional and radial loads that were 20 to 50 percent higher than those measured for the low strength material (15 5 N/ sq mm tensile strength) Measured wear to the AM 355 blade tips was not significantly different for the two sintered NiCrAl seal materials Wear of the sintered NiCrAl was characterized by material removal to a depth greater than the depth to which blade tips were driven into the seal indicating self erosion effects Author

N78-29216*# National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio

REACTIONS OF YTTRIA-STABILIZED ZIRCONIA WITH OXIDES AND SULFATES OF VARIOUS ELEMENTS Final Report

Isidor Zaplatynsky Jul 1978 16 p refs

(Contract EF-77-A-01-2593)
(NASA-TM-78942, DOE/NASA/2593-78/1, E-9689) Avail NTIS HC A02/MF A01 CSCL 11B

The reactions between partially stabilized zirconia, containing 8 weight percent yttria, and oxides and sulfates of various elements were studied at 1200, 1300, and 1400 C for times to 800, 400, and 200 hours, respectively. These oxides and sulfates represent impurities and additives potentially present in gas turbine fuels or impurities in the turbine combustion air as well as the elements of the substrate alloys in contact with zirconia. Based on the results, these compounds can be classified in four groups: (1) compounds which did not react with zirconia (Na2SO4, K2SO4, Cr2O3, Al2O3 and NiO), (2) compounds that reacted completely with both zirconia phases (CaO, BaO, and BaSO4), (3) compounds that reacted preferentially with monoclinic zirconia (Na2O, K2O, CoO, Fe2O3, MgO, SiO2, and ZnO), and (4) compounds that reacted preferentially with cubic zirconia (V2O5, P2O5). Author

N78-30205*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
SIMULATION MODEL OF A SINGLE-STAGE LITHIUM BROMIDE-WATER ABSORPTION COOLING UNIT
David Miao. Aug 1978. 44 p. refs
(NASA-TP-1296, E-9547) Avail NTIS HC A03/MF A01 CSCL 20K

A computer model of a LiBr-H2O single stage absorption machine was developed. The model, utilizing a given set of design data such as water flow rates and inlet or outlet temperatures of these flow rates but without knowing the interior characteristics of the machine (heat transfer rates and surface areas), can be used to predict or simulate off-design performance. Results from 130 off-design cases for a given commercial machine agree with the published data within 2 percent. Author

N78-30206*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EFFECT OF OXYGEN, METHYL MERCAPTAN, AND METHYL CHLORIDE ON FRICTION BEHAVIOR OF COPPER-IRON CONTACTS
Donald H. Buckley. Aug. 1978. 19 p. refs
(NASA-TP-1309, E-9606) Avail NTIS HC A02/MF A01 CSCL 11F

Sliding friction experiments were conducted with an iron rider on a copper disk and a copper rider on an iron disk. The sputter-cleaned iron and copper disk surfaces were saturated with oxygen, methyl mercaptan, and methyl chloride at atmospheric pressure. Auger emission spectroscopy was used to monitor the surfaces. Lower friction was obtained in all experiments with the copper rider sliding on the iron disk than when the couple was reversed. For both iron and copper disks, methyl mercaptan gave the best surface coverage and was most effective in reducing friction. For both iron and copper disks, methyl chloride was the least effective in reducing friction. With sliding, copper transferred to iron and iron to copper. Author

N78-31208*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
INHIBITION OF HOT SALT CORROSION BY METALLIC ADDITIVES
Daniel L. Deadmore and Carl E. Lowell. Jul. 1978. 20 p. refs
(Contract EF-77-A-01-2593)
(NASA-TM-78966, E-9725, DOE/NASA/2953-78/2) Avail NTIS HC A02/MF A01 CSCL 07D

The effectiveness of several potential fuel additives in reducing the effects of sodium sulfate-induced hot corrosion was evaluated in a cyclic Mach 0.3 burner rig. The potential inhibitors examined were salts of Al, Si, Cr, Fe, Zn, Mg, Ca, and Ba. The alloys tested were IN-100, U-700, IN-738, IN-792, Mar-M-509, and 304 stainless steel. Each alloy was exposed for 100 cycles of 1 hour each at 900 C in combustion gases doped with the corrodant and inhibitor salts and the extent of attack was determined by measuring maximum metal thickness loss. The most effective and consistent inhibitor additive was Ba(NO3)2 which reduced the hot corrosion attack to nearly that of simple oxidation. Author

N78-31209*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
REVIEW OF THE AGARD S AND M PANEL EVALUATION PROGRAM OF THE NASA-LEWIS SRP APPROACH TO HIGH-TEMPERATURE LCF LIFE PREDICTION
Marvin H. Hirschberg. 1978. 11 p. refs. Proposed for presentation at the 52d Meeting of the Propulsion and Energetics Panel, Cleveland, 23-27 Oct. 1978, sponsored by AGARD
(NASA-TM-78877, E-9772) Avail NTIS HC A02/MF A01 CSCL 11F

Twenty laboratories in six countries participated in testing their own materials of interest under their own laboratory conditions. In this way the results obtained provided validation of the Strainrange Partitioning (SRP) method for a wide range of materials and insured maximum usefulness to each of the participating laboratories. The various investigators shared their findings, thus providing the basis for an in-depth evaluation of the SRP method. While the results were variable from laboratory to laboratory, most investigators agreed that the SRP method was a significant step toward life prediction in the presence of high temperature and cyclic stresses. L.S.

N78-31210*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THE EFFECT OF FUEL-TO-AIR RATIO ON BURNER-RIG HOT CORROSION
Daniel L. Deadmore, Carl E. Lowell, and Fred J. Kohl. Jul. 1978. 20 p. refs
(NASA-TM-78960, E-9649) Avail NTIS HC A02/MF A01 CSCL 07A

Samples of a cobalt base alloy, Mar-M-509, were subjected to hot corrosion in a Mach 0.3 burner rig. The corrodent was NaCl added as an aqueous solution to the combustion products of a sulfur-containing Jet A fuel. The metal temperature was fixed at 900 C. The extent of hot corrosion increased by a factor of three as the fuel-to-air mass ratio was increased from 0.033 to 0.050. Because the depositing salt was always Na2SO4, the increased attack appeared to be related to the gas composition. Author

N78-31211*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
LONGITUDINAL SHEAR BEHAVIOR OF SEVERAL OXIDE DISPERSION STRENGTHENED ALLOYS
T. K. Glasgow. Aug. 1978. 20 p. refs. Proposed for presentation at the Fall Meeting of the Am. Inst. of Mining, Metallurgical and Petrol. Engr., Chicago, 24-27 Oct. 1978
(NASA-TM-78973, E-9746) Avail NTIS HC A02/MF A01 CSCL 11F

Two commercial oxide dispersion strengthened (ODS) alloys, MA-753 and MA-754, and three experimental ODS alloys, MA-757E, MA-755E, and MA-6000E, were tested in shear at 760 C. Comparisons were made with other turbine blade and vane alloys. All of the ODS alloys exhibited less shear strength than directionally solidified Mar-M-200 + Hf or then conventionally cast B-1900. The strongest ODS alloy tested, MA-755E, was comparable in both shear and tensile strength to the lamellar directionally solidified eutectic alloy gamma/gamma prime - delta. Substantial improvements in shear resistance were found for all alloys tested when the geometry of the specimen was changed from one generating a transverse tensile stress in the shear area to one generating a transverse compressive stress. Finally, 760 C shear strength as a fraction of tensile strength was found to increase linearly with the log of the transverse tensile ductility. Author

N78-31212*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EFFECTS OF COMPOSITIONAL CHANGES ON THE PERFORMANCE OF A THERMAL BARRIER COATING SYSTEM
Stephan Stecura. Aug. 1978. 33 p. refs. Proposed for presentation at the 3d Ann. Conf. on Composite and Advanced Mater., Merritt Island, Fla., 21-24 Jan. 1979
(NASA-TM-78976, E-9751) Avail NTIS HC A03/MF A01 CSCL 11F

Currently proposed thermal barrier systems for aircraft gas turbine engines consist of NiCrAlY bond coating covered with an insulating oxide layer of yttria stabilized zirconia. The effect of yttrium concentration (from 0.15 to 1.08 w/o) in the bond coating and the yttria concentration (4 to 24.4 w/o) in the oxide layer were evaluated. Furnace, natural gas-oxygen torch, and Mach 1.0 burner rig cyclic tests on solid specimens and air cooled blades were used to identify trends in coating behavior. Results indicate that the combinations of yttrium levels between 0.15 - 0.35 w/o in the bond coating and the yttria concentration between 6 - 8 w/o in the zirconium oxide layer were the most adherent and resistant to high temperature cyclic exposure. Author

N78-31213*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
EFFECTS OF THERMOMECHANICAL PROCESSING ON STRENGTH AND TOUGHNESS OF IRON - 12-PERCENT-NICKEL - REACTIVE METAL ALLOYS AT -196 C
Joseph R. Stephens and Walter R. Witzke. Aug. 1978. 36 p. refs.
(NASA-TP-1308; E-9583) Avail: NTIS HC A03/MF A01; CSCL 11F.

Thermomechanical processing (TMP) was evaluated as a method of strengthening normally tough iron-12 nickel reactive metal alloys at cryogenic temperatures. Five iron-12 nickel alloys with reactive metal additions of aluminum, niobium, titanium, vanadium, and aluminum plus niobium were investigated. Primary evaluation was based on the yield strength and fracture toughness of the thermomechanically processed alloys at -196 C. B.B.

N78-33196*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
LONG TERM HOT-HARDNESS CHARACTERISTICS OF FIVE THROUGH HARDENED BEARING STEELS
Neil E. Anderson. Oct. 1978. 20 p. refs. Prepared in cooperation with US Army Aviation Research and Development Command, St. Louis, Mo.
(NASA-TP-1341; E-9533) Avail: NTIS HC A02/MF A01; CSCL 11F.

Five vacuum melted bearing steels tempered to various room temperature hardnesses: AISI 52100 and the tool steels AISI M-1, AISI M-50, Halmo, and WB-49 were studied. Hardness measurements were taken on AISI 52100 at room temperature and at elevated temperatures after soaking it at temperatures to 478 K (400 F) for as long as 1000 hours. Hardness measurements were also taken on the tool steels after soaking them at temperatures to 700 K (800 F) for as long at 1000 hours. None of the tool steel tempered during soaking and AISI 52100 did not temper when soaked at 366 K (200 F) for 1000 hours. However, AISI 52100 that was initially hardened to room temperature hardness of 62.5 or 64.5 lost hardness during the first 500 hours of the 1000 hour soak tests at temperatures greater than 394 K (250 F), but it maintained its hardness during the final 500 hours of soaking. Similarly, AISI 52100 initially hardened to room temperature hardness of 60.5 lost hardness during the first 500 hours of the 1000 hour soaking at temperatures greater than 422 K (300 F), but it maintained its hardness during the final 500 hours of soaking. A.R.H.

A78-15335 * **An experimental P/M wrought superalloy for advanced temperature service.** R. V. Miner (NASA, Lewis Research Center, Cleveland, Ohio) and W. B. Kent (Cyclops Corp., Bridgeville, Pa.). *International Journal of Powder Metallurgy and Powder Technology*, vol. 13, Oct. 1977, p. 293-294, 296 (6 ff.). 7 refs.

A study was undertaken in order to adapt HB-11 (an experimental wrought superalloy with high temperature strength) to manufacture via powder metallurgy techniques, and to improve its microstructural stability. Three compositional modifications were produced and evaluated. Among the conclusions reached it was found that: (1) HB-11 having a low C and low Hf alloy content is suitable for advanced temperature turbine disks, and is applicable to fabrication by powder metallurgy techniques; (2) HB-11, when compared to modifications with higher C and or higher Hf, is somewhat weaker in tension at intermediate temperatures but superior in tensile ductility, rupture strength and ductility, and stability during long-time heating; (3) increases in the cross-rolling temperature increase the grain size of alloys after solution treatment, and (4) both the lower C modifications develop larger grain sizes than the higher C modification. S.C.S.

A78-15825 * # **Cryogenic properties of a new tough-strong iron alloy.** J. R. Stephens and W. R. Witzke (NASA, Lewis Research Center, Cleveland, Ohio). *National Bureau of Standards, International Cryogenic Materials Conference, University of Colorado, Boulder, Colo., Aug. 2-5, 1977, Paper.* 12 p. 5 refs.

A program was undertaken to develop an iron base alloy having a fracture toughness of 220 MPa-sq root meters with a corresponding yield stress of 1.4 GPa (200 ksi) at -196 C. An Fe-12Ni alloy was selected as the base alloy. Factors considered include reactive metal additions, effects of interstitial impurities, strengthening mechanisms, and weldability. The goals of this program were met in an Fe-12Ni-0.5Al alloy strengthened by thermomechanical processing or by precipitate strengthening with 2 percent Cu. The alloy is weldable with the weld metal and heat affected zone in the post-weld annealed condition having toughness equivalent to the base alloy. (Author)

A78-18631 * Volatilization of oxides during oxidation of some superalloys at 1200 C. I. Zaplatynsky (NASA, Lewis Research Center, Cleveland, Ohio). *Oxidation of Metals*, vol. 11, Dec. 1977, p. 289-305. 15 refs.

Volatilization of oxides during cyclic oxidation of commercial Nichrome, Inconel 750, Rene 41, Stellite 6B, and GE 1541 was studied at 1200 C in static air. Quantitative analysis of oxide vapor deposits revealed that oxides of tungsten, molybdenum, niobium, manganese, and chromium volatilized preferentially from the oxide scales. Aluminum and silicon were not detected in vapor deposits. For all the alloys except GE 1541 chromium was found to be the most volatile element in the oxide scales. (Author)

A78-18792 * Effects of heat treating PM Rene' 95 slightly below the gamma-prime solvus. R. L. Dreshfield (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Mining, Metallurgical, and Petroleum Engineers, Annual Meeting, 106th, Atlanta, Ga., Mar. 6-10, 1977, Paper.* 18 p. 5 refs.

An investigation was performed on As HIP Rene' 95 to obtain additional information on the variation of the amount of gamma-prime with solutioning temperatures near the gamma prime solvus temperature and the resulting effects on tensile and stress rupture strengths of As HIP Rene' 95. The amount of gamma prime phase was found to increase at a rate of about 0.5% per degree Celsius as the temperature decreased from the solvus temperature to about 50 C below the gamma prime solvus temperature. The change in the amount of gamma prime phase with decreasing solutioning temperature was observed to be primarily associated with decreasing solubilities of Al+Ti+Nb and increasing solubility of Cr in the gamma phase. For As HIP Rene' 95 solutioned at either 1107 or 1135 C and subsequently water quenched and double aged for 4 hours at 815 C followed by 24 hours at 650 C, the higher solution temperature resulted in significantly greater yield strengths at room temperature and 650 C as well as a greater room temperature ultimate strength. Also, longer stress rupture lives at 650 C were associated with the higher solution temperature. (Author)

A78-18793 * Burner rig alkali salt corrosion of several high temperature alloys. D. Deadmore and C. Lowell (NASA, Lewis Research Center, Cleveland, Ohio). *Electrochemical Society, Meeting, 151st, Philadelphia, Pa., May 8-13, 1977, Paper.* 19 p. 17 refs.

The hot corrosion of five alloys was studied in cyclic tests in a Mach 0.3 burner rig facility whose combustion chamber various aqueous salt solutions were injected. Three nickel-base alloys (IN-792, IN-738, and IN-100), a cobalt-base alloy (MM-509), and an iron-base

alloy (304 stainless steel) were studied at temperatures of 700, 800, 900, and 1000 C with various salt concentrations and compositions. The relative resistance of the alloys to hot corrosion attack was found to vary with temperature and with both the concentration and composition of the injected salt solution. Results indicate that the corrosion of these alloys is a function of both the presence of salt condensed as a liquid on the surface and of the composition of the gas phases present (Author)

A78-21431 * Effect of prior creep at 1365 K on the room temperature tensile properties of several oxide dispersion strengthened alloys. J. D. Whittenberger (NASA, Lewis Research Center, Cleveland, Ohio). *Metallurgical Transactions A - Physical Metallurgy and Materials Science*, vol. 8A, Dec. 1977, p. 1863-1870. 21 refs.

An experimental study was conducted to determine whether oxide dispersion strengthened (ODS) Ni-base alloys in wrought bar form are subject to creep degradation effects similar to those found in thin-gage sheet. The bar products evaluated included ODS Ni, ODS-NiCr, and advanced ODS-NiCrAl types; the alloys included microstructures ranging from an essentially perfect single crystal to a structure consisting of very small elongated grains. Tensile test specimens were exposed to creep at various stress levels at 1365 K and then tensile tested at room temperature. Low residual tensile properties, change in fracture mode, appearance of dispersoid free bands, grain boundary cavitation, and/or internal oxidation are interpreted as creep degradation effects. The amount of degradation depends on creep strain, and degradation appears to be due to diffusional creep which produces dispersoid free bands around grain boundaries acting as vacancy sources. S.D.

A78-21439 * Effects of silicon on the oxidation, hot corrosion, and mechanical behavior of two cast nickel-base superalloys. R. V. Miner, Jr. (NASA, Lewis Research Center, Cleveland, Ohio). *Metallurgical Transactions A - Physical Metallurgy and Materials Science*, vol. 8A, Dec. 1977, p. 1949-1954. 6 refs.

Cast specimens of nickel-base superalloys 713C and Mar-M200 with nominal additions of 0, 0.5, and 1 wt% Si were evaluated for oxidation and corrosion resistance, tensile and stress-rupture properties, microstructure, and phase relations. Results are compared with those of an earlier study of the effects of Si in B-1900. Si had similar effects on all three superalloys. It improves oxidation resistance but the improvement in 713C and Mar-M200 was considerably less than in B-1900. Hot corrosion resistance is also improved somewhat. Si is, however, detrimental to mechanical properties, in particular, rupture strength and tensile ductility. Si has two obvious microstructural effects. It increases the amount of gamma-prime precipitated in eutectic nodules and promotes a Mo(Ni,Si)2 Laves phase in the alloys containing Mo. These microstructural effects do not appear responsible for the degradation of mechanical properties, however. (Author)

A78-21858 * Tensile and creep properties of the experimental oxide dispersion strengthened iron-base sheet alloy MA-956E at 1365 K. J. D. Whittenberger (NASA, Lewis Research Center, Cleveland, Ohio). *Metallurgical Transactions A - Physical Metallurgy and Materials Science*, vol. 9A, Jan. 1978, p. 101-110. 13 refs.

A study of the 1365 K tensile properties, creep characteristics and residual room temperature properties after creep testing of the experimental oxide dispersion strengthened iron base alloy MA-956E (Fe-20Cr-4.5Al-0.5Ti-0.5Y2O3) was conducted. The 1365 K tensile properties, particularly ductility, are strongly dependent on strain rate. It appears that MA-956E does not easily undergo slow, plastic deformation. Rather than deform under creep loading conditions, the alloy apparently fails by a crack nucleation and growth mechanism. Fortunately, there appears to be a threshold stress below which crack nucleation and/or growth does not occur. (Author)

A78-23451 * # Friction and wear of sintered fibermetal abradable seal materials. R. C. Bill (NASA, Lewis Research Center; U.S. Army, Air Mobility Research and Development Laboratory, Cleveland, Ohio) and L. T. Shiembob (United Technologies Corp., Pratt and Whitney Aircraft Group, East Hartford, Conn.). *ASME, ASTM, ASM, SME, ASLE, and SAE, International Conference on Wear of Materials, St. Louis, Mo., Apr. 25-28, 1977, Paper.* 26 p. 10 refs.

Three abradable gas-path seal material systems based on a sintered NiCrAlY fiber metal structure were evaluated under a range of wear conditions representative of those likely to be encountered in various knife-edge seal (labyrinth or shrouded turbine) applications. Conditions leading to undesirable wear of the rotating knife were identified, and a model proposed based on thermal effects arising under different rub conditions. It was found, and predicted by the model, that low incursion (plunge) rates tended to promote smearing of the low-density sintered material with consequent wear to the knife edge. Tradeoff benefits between baseline 19 percent dense material, a similar material of increased density, and a self-lubricating coating applied to the 19 percent dense material were identified on the basis of relative rub tolerance and erosion resistance. (Author)

A78-24369 * Volume fraction determination in cast superalloys and directionally solidified eutectic alloys by a new manual point count practice. C. W. Andrews (NASA, Lewis Research Center, Electron Optics and Microscopy Unit, Cleveland, Ohio). *Journal of Testing and Evaluation*, vol. 6, Jan. 1978, p. 20-28. 6 refs.

A78-24370 * Load-displacement measurement and work determination in three-point bend tests of notched or precracked specimens. R. J. Buzzard and D. M. Fisher (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Testing and Evaluation*, vol. 6, Jan. 1978, p. 35-39.

Suggestions for testing of notched or cracked three-point bend specimens are presented that (1) correct displacement measurement errors resulting from misalignment between the load applicator and specimen, (2) account for coincidental strains not associated with the work of crack extension, (3) simplify record analysis and processing, and (4) extend displacement gage range without sacrifice of sensitivity or accuracy. These testing details are particularly applicable to procedures in which the crack extension force J(I) is determined from the work done on the specimen. (Author)

A78-24372 * Comparison of equivalent energy and energy per unit area (W bar/A) data with valid fracture toughness data for iron, aluminum, and titanium alloys. W. R. Witzke and J. R. Stephens (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Testing and Evaluation*, vol. 6, Jan. 1978, p. 75-79. 15 refs.

A78-24882 * # The promise of eutectics for aircraft turbines. H. R. Gray (NASA, Lewis Research Center, Cleveland, Ohio). *American Society for Metals, Materials Show and Conference, Chicago, Ill., Oct. 25-27, 1977, Paper.* 20 p. 13 refs.

Gas turbine blades and vanes for the 1980s call for new materials with higher operational temperature capabilities. The potential increase of from 40 to 110 C in operational temperature capabilities predicted for directionally solidified eutectics is a larger increment over currently available alloys than previously obtained in any new turbine blade alloy. The paper discusses the properties of gamma-gamma prime-delta and NiTaC-13 directionally solidified first-generation eutectics for use as gas turbine blade materials. A few of the more promising second-generation eutectics for blade applications (gamma-gamma prime-alpha, NiTaC-3-116A) and for vane applications (gamma-beta, COTAC-74) are also discussed. Attention is given to mechanical properties, such as transverse ductility and shear strength, that can be inherently critical in a directionally solidified eutectic. Further R&D requirements for properties, coatings, and lower-cost processing technology are identified. S.D.

A78-28423 * // Rolling-element fatigue life of AMS 5749 corrosion resistant, high temperature bearing steel. R. J. Parker (NASA, Lewis Research Center, Cleveland, Ohio) and R. S. Hodder (Latrobe Steel Co., Latrobe, Pa.). *American Society of Lubrication Engineers and American Society of Mechanical Engineers, Joint Lubrication Conference, Kansas City, Mo., Oct. 3-5, 1977, ASME Paper 77-Lub-30.* 7 p. 9 refs. Members, $1.50; nonmembers, $3.00.

A78-29329 * // High temperature environmental effects on metals. S. J. Grisaffe, C. E. Lowell, and C. A. Stearns (NASA, Lewis Research Center, Cleveland, Ohio). *U.S. Army, Sagamore Army Materials Research Conference on Risk and Failure Analysis for Reliability, 24th, Bolton Landing, N.Y., Aug. 22-26, 1977, Paper.* 18 p. 25 refs.

The current status of knowledge and ability to predict high-temperature environmental attack of metals is reviewed with particular reference to the gas turbine engine. Environmental attack is caused by high temperatures, combustion products, and impurities. A schematic representation of life-limiting factors of turbine components shows that environmental attack can lead to very early failures. Attention is given to high-temperature oxidation with prevailing modes of oxidation attack, and to hot corrosion and other impurity effects. Erosion attack results from the direct mechanical removal of component material by impact of hard substances like ash, sand, or dirt. Solutions to hot-corrosion problems can be found semiempirically by using improved alloys or ceramics, protective surface coatings, additives to the engine environment, and air/fuel cleanup to eliminate detrimental impurities. S.D.

A78-30112 * Oxide morphology and spalling model for NiAl. J. L. Smialek (NASA, Lewis Research Center, Cleveland, Ohio). *Metallurgical Transactions A - Physical Metallurgy and Materials Science*, vol. 9A, Mar. 1978, p. 309-320. 17 refs.

A scanning electron microscope equipped with an energy dispersive spectrographic unit was used to study in detail the Al2O3 oxide morphology and oxide-metal interface of a nickel-rich NiAl alloy (Ni-42 at% Al) with a view toward providing information relevant to spalling theories in the MCrAlY system. In addition, the kinetics of spalling was studied for critical evaluation of one of the step-process spall models and for collection of pertinent experimental data. Cyclic oxidation tests were run in 1-atm air at about 1100 C, and isothermal specimens were examined from 2 min to 200 hr of exposure. It is shown that oxide spalling occurs primarily at the oxide-metal interface in an intergranular mode, that crystallographic Kirkendall voids arise as a result of oxidation, and that the fractional area of spalled oxide varies widely in cyclic tests but increases with the square of oxide thickness for isothermal tests. A spall model is developed in the form of a summation series. S.D.

A78-32319 * Investigation of the fracture mechanism of Ti-5Al-2.5Sn at cryogenic temperatures. R. H. Van Stone (GE Research and Development Center, Schenectady, N.Y.), J. R. Low, Jr., and J. L. Shannon, Jr. (NASA, Lewis Research Center, Strength of Materials Section, Cleveland, Ohio). *Metallurgical Transactions A - Physical Metallurgy and Materials Science*, vol. 9A, Apr. 1978, p. 539-552. 56 refs. Grant No. NGR-39-087-047.

Fractography and metallographic sectioning were used to investigate the influence of microstructure on the fracture mechanism and fracture toughness (KIC) of normal interstitial and extra low interstitial (ELI) Ti-5Al-2.5Sn at 20 K (-423 F) and 77 K (-320 F). Plates of each grade were mill annealed at 815 C followed by either air or furnace cooling. These variations in composition and cooling rate resulted in differences in the volume fraction and internal structure of the dispersed beta phase and in the ordering of the alpha matrix. The ELI alloys were tougher than the normal interstitial plates. KIC of the furnace-cooled ELI plate was 25% lower than that of the air-cooled ELI material. Variations in cooling rate had no influence of KIC of the normal interstitial alloys. Fractography showed that a large portion of the fracture surfaces were covered with elongated dimples. Metallographic sections of specimens deformed at 77 K showed that these features form at the intersections of slip bands or deformation twins with grain or twin boundaries. Ordering and higher interstitial levels increase the local strain in slip bands resulting in void nucleation at lower macroscopic strains and lower KIC values. (Author)

A78-33214 * Strainrange partitioning behavior of the nickel base superalloys, Rene 80 and 100. G. R. Halford and A. J. Nachtigall (NASA, Lewis Research Center, Cleveland, Ohio). *NATO AGARD, Specialists Meeting on Characterization of Low Cycle High Temperature Fatigue by Strainrange Partitioning Method, Aalborg, Denmark, Apr. 9-14, 1978, Paper.* 16 p. 18 refs.

A study has been made to assess the ability of the method of Strainrange Partitioning (SRP) to both correlate and predict high-temperature low-cycle fatigue lives of nickel-base superalloys for gas turbine applications. SRP is shown to correlate the cyclic lives of the baseline tests to within factors of nearly two. The partitioned strainrange versus life relationships for uncoated Rene 80 and cast IN 100 have also been determined from the ductility-normalized strainrange partitioning equations. These were used to predict the cyclic lives of the baseline tests. Predicted and observed cyclic lives agreed to within factors of nearly three. The life predictability of the method is also verified for cast IN 100 by applying the baseline results to the cyclic life prediction of a series of complex strain-cycling tests with multiple hold periods at constant strain. It is concluded that the method of SRP can correlate and predict the cyclic lives of laboratory specimens of the nickel-base superalloys evaluated in this program. (Author)

A78-33216 * Strength enhancement process for prealloyed powder superalloys. W. J. Waters and J. C. Freche (NASA, Lewis Research Center, Cleveland, Ohio). *Metallurgical Society of AIME, Fall Meeting, Chicago, Ill., Oct. 24-27, 1977, Paper.* 30 p. 11 refs.

A technique involving superplastic processing and high-pressure autoclaving was applied to a nickel-base prealloyed powder alloy. Tensile strengths as high as 2865 MN/sq m (415 ksi) at 480 C (900 F) were obtained with as-superplastically deformed material. Appropriate treatments yielding materials with high temperature tensile and stress-rupture strengths (980 C (1800 F) Author (abstract)

A78-35394 * Surface-crack shape change in bending fatigue using an inexpensive resonant fatiguing apparatus. W. S. Pierce and J. L. Shannon, Jr. (NASA, Lewis Research Center, Strength of Materials Section, Cleveland, Ohio). *Journal of Testing and Evaluation*, vol. 6, May 1978, p. 183-188. 5 refs.

An inexpensive device for producing surface cracks of controlled size and shape is described along with results of its use which show how the shape of the surface crack changes as it grows in bending fatigue from a variety of crack starter shapes. The growth pattern for any crack is uniquely defined by the crack starter configuration and appears to be independent of alloy. Shape changes are substantial and all growth curves tend toward a common growth curve. Circular cracks tend to become elliptical with an associated increase in stress intensity factor. This increase accelerates the crack growth rate and proximity to the critical flaw size. Through-cracks produced by the extension of a surface crack in a bending stress field will have length ten times the section thickness. The results demonstrate the necessity of taking into account changing crack shape in the calculation of structural life when bending is a significant component of the stress field. (Author)

A78-36045 * Mechanical properties on ion-beam-textured surgical implant alloys. A. J. Weigand (NASA, Lewis Research Center, Cleveland, Ohio). *(American Vacuum Society, National Symposium, 24th, and Conference on Microbalance Techniques, 15th, Boston, Mass., Nov. 8-11, 1977.) Journal of Vacuum Science and Technology*, vol. 15, Mar.-Apr. 1978, p. 718-724. 14 refs.

A78-37075 * # The effect of microstructure on hydrogen embrittlement of the nickel base superalloy, Udimet 700. H. R. Gray (NASA, Lewis Research Center, Cleveland, Ohio). In: Structures, Structural Dynamics and Materials Conference, 19th, Bethesda, Md., April 3-5, 1978, Technical Papers. New York, American Institute of Aeronautics and Astronautics, Inc., 1978, 31 p. 12 refs.

Material from a single heat of cast and wrought Udimet 700 was processed and/or heat treated to produce five material conditions with identical chemical compositions but with distinct microstructural variations, and then evaluated for susceptibility to hydrogen embrittlement. Two prealloyed powder conditions exhibited significantly improved resistance to hydrogen embrittlement, as compared to wrought material. No degradation in notch or smooth tensile strengths occurred, and average ductilities of 25 percent reduction of area were determined for 2 hydrogen evaluation procedures. For the most severe hydrogenation procedure, ductility levels were reduced to 15 percent. These improvements were attributed to cleaner grain boundaries and decreased grain size.
(Author)

A78-37676 * # The role of thermal shock in cyclic oxidation. C. E. Lowell and D. L. Deadmore (NASA, Lewis Research Center, Cleveland, Ohio). *Electrochemical Society, Meeting, 153rd, Seattle, Wash., May 21-26, 1978, Paper.* 13 p. 11 refs.

The effect of thermal shock on the spalling of oxides from the surfaces of several commercial alloys was determined. The average cooling rate was varied from approximately 240 C/sec to less than 1.0 C/sec during cyclic oxidation tests in air. The tests consisted of one hundred cycles of one hour at the maximum temperature (1100 or 1200 C). The alloys were HOS-875, TD-Ni, TD NiCrAl, IN-601, IN-702, and B-1900 plus Hf. Thermal shock resulted in deformation of the metal which in turn resulted, in most cases, in changing the oxide failure mode from compressive to tensile. Tensile failures were characterized by cracking of the oxide and little loss, while compressive failures were characterized by explosive loss of platelets of oxide. The thermally shocked oxides spalled less than the slow cooled samples with the exception of TD-NiCrAl. This material failed in a brittle manner rather than by plastic deformation. The HOS-875 and the TD-Ni did not spall during either type of cooling. Thus, the effect of thermal shock on spalling is determined, in large part, by the mechanical properties of the metal.
(Author)

A78-37680 * # New alloys to conserve critical elements. J. R. Stephens (NASA, Lewis Research Center, Cleveland, Ohio). *Society of Manufacturing Engineers, International Engineering Conference and Tool Exposition, Philadelphia, Pa., May 8-11, 1978, Paper.* 14 p. 12 refs.

Previous studies and surveys on availability of domestic reserves have shown that chromium is a most critical element within the U.S. metal industry. More precisely, the bulk of chromium is consumed in the production of stainless steels, specifically Type 304 stainless steel (304SS) which contains 18% Cr. The present paper deals with means of reducing chromium in commercial stainless steels by substituting more abundant or less expensive elements with the intent of maintaining the properties of 304SS. The discussion focuses on some of the oxidation and corrosion properties of new substitute stainless steels with only 12% Cr, which represents a potential saving of 33% of the chromium consumed in the production of 304SS. The alloying elements substituted for Cr in 304SS are selected according to their potential for protective oxide formation during high temperature oxidation; these are Al, Si, Ti, Y, and misch metal which is 99.7% rare-earth metals containing 50 to 55% cerium. Other alloying elements to impart corrosion resistance are Mn, Mo, and V.
S.D.

A78-41400 * Cleaning process for contaminated superalloy powders. A. E. Anglin (NASA, Lewis Research Center, Cleveland, Ohio). *Powder Technology*, vol. 20, 1978, p. 137, 138.

A cleaning process for removing interstitial contaminants from superalloy powders after wet grinding is described. Typical analyses of oxygen, carbon, nitrogen, and hydrogen in ball-milled WAZ-20 superalloy samples after hydrogen plus vacuum cleaning are presented. The hydrogen cleaning step involves heating retorts containing superalloy powder twice under flowing hydrogen with a 24 hour hold at each temperature. The vacuum step involves heating cold-pressed billets two hours at an elevated temperature at a pressure of 10 microPa. It is suggested that the hydrogen plus vacuum cleaning procedure can be applied to superalloys contaminated by other substances in other industrial processes.
M.L.

A78-41465 * Development of strong and tough cryogenic Fe-12Ni alloys containing reactive metal additions. W. R. Witzke and J. R. Stephens (NASA, Lewis Research Center, Cleveland, Ohio). *Cryogenics*, vol. 17, Dec. 1977, p. 681-688. 17 refs.

The fracture toughness and tensile behaviour of arc melted and hot-rolled Fe-12Ni alloys containing up to 4 atomic percent reactive metal additions of Al, Nb, Ti, or V were determined at 77 K. Cryogenic toughness was improved up to 7.5 times that of binary Fe-12Ni, depending on the reactive metal, its concentration, and annealing temperature.
(Author)

A78-45426 * Interpolation and extrapolation of creep rupture data by the minimum commitment method. II - Oblique translation. S. S. Manson (Case Western Reserve University, Cleveland, Ohio) and C. R. Ensign (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers and Canadian Society of Mechanical Engineers, Pressure Vessels and Piping Conference, Montreal, Canada, June 26-29, 1978, Paper.* 28 p. 5 refs. Research supported by the Electric Power Research Institute and NASA.

An outline is presented of a new procedure, termed the oblique translation method, which emerged in the development of the focal point convergence method. Approaches for implementing the oblique translation method are discussed. It is shown that the new method is essentially a minimum commitment method when manually graphically implemented, in the sense that the form of the functions involved are not forced into particular analytical forms. The individual constants and functions are independently determined. The minimum commitment concept is extended to the analysis of creep rupture data wherein each isothermal is to be generated by an oblique translation of the 'master curve' when plotted. Attention is given to a manual graphical analysis, the preassessment of data, and an analysis by computer code.
G.R.

A78-45427 * Interpolation and extrapolation of creep rupture data by the minimum commitment method. I - Focal point convergence. S. S. Manson (Case Western Reserve University, Cleveland, Ohio) and C. R. Ensign (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers and Canadian Society of Mechanical Engineers, Pressure Vessels and Piping Conference, Montreal, Canada, June 26-29, 1978, Paper.* 100 p. 16 refs. Research supported by the Electric Power Research Institute and NASA.

The minimum commitment method has been applied to the analysis of creep rupture data. The method is based on a parameter representing the focal point of convergence of all isothermals when extended to the long or short times necessary for such convergence to occur. The technique may be applied by manual graphic analysis on computer code. It is illustrated for the nickel base alloy Astroloy.
S.C.S.

A78-45428 * Interpolation and extrapolation of creep rupture data by the minimum commitment method. III - Analysis of multiheats. S. S. Manson (Case Western Reserve University, Cleveland, Ohio) and C. R. Ensign (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers and Canadian Society of Mechanical Engineers, Pressure Vessels and Piping Conference, Montreal, Canada, June 26-29, 1978, Paper.* 32 p. 5 refs. Research supported by the Electric Power Research Institute

and NASA.

An outline is presented of approaches for treating multiheats on the basis of the focal point convergence method. The method has been employed in the case of two highly characterized multiheats, including a 304 stainless steel studied in Japan and a low alloy carbon steel studied in England. The method makes use of the same functional form for all materials. Only the constants are varied for each multiheat. Completely computerized procedures are employed for the determination of the constants. Once the basic analysis has been performed, the representation of various members in the same system is achieved by adding linear expressions of log stress, changing only two constants in the equations to represent a selected heat.

G.R.

A78-45434 * Correlations between ultrasonic and fracture toughness factors in metallic materials. A. Vary (NASA, Lewis Research Center, Cleveland, Ohio). *Symposium on Fracture Mechanics, 11th, Blacksburg, Va., June 12-14, 1978, Paper.* 17 p. 18 refs.

A heuristic mathematical basis is proposed for the experimental correlations found between ultrasonic propagation factors and fracture toughness factors in metallic materials. A crack extension model is proposed wherein spontaneous stress (elastic) waves produced during microcracking are instrumental in promoting the onset of unstable crack extension. Material microstructural factors involved in this process are measurable by ultrasonic probing. Experimental results indicate that ultrasonic attenuation and velocity measurements will produce significant correlations with fracture toughness properties and also yield strength. (Author)

A78-50086 * The cyclic oxidation resistance of cobalt chromium-aluminum alloys at 1100 and 1200 C and a comparison with the nickel-chromium-aluminum alloy system. C. A. Barrett and C. E. Lowell (NASA, Lewis Research Center, Cleveland, Ohio). *Oxidation of Metals*, vol. 12, Aug. 1978, p. 293-311. 13 refs.

A78-51714 * # Substitution for chromium in 301 stainless steel. J. R. Stephens and C. A. Barrett (NASA, Lewis Research Center, Cleveland, Ohio). In: Environmental degradation of engineering materials; Proceedings of the Conference, Blacksburg, Va., October 10-12, 1977. (A78-51701 23-23) Blacksburg, Va., Virginia Polytechnic Institute and State University, 1978, p. 257-266. 5 refs.

An investigation was conducted to determine the effects of substituting less strategic elements for Cr on oxidation and corrosion resistance of AISI 304 stainless steel. Cyclic oxidation resistance was evaluated at 870 C. Corrosion resistance was determined by exposure of specimens to a boiling copper-rich solution of copper sulfate and sulfuric acid. Alloy substitutes for Cr included Al, Mn, Mo, Si, Ti, V, Y, and misch metal. A level of about 12% Cr was the minimum amount of Cr required for adequate oxidation and corrosion resistance in the modified composition 304 stainless steels. This represents a Cr saving of 33 percent. Two alloys containing 12% Cr plus 2% Al plus 2% Mo and 12% Cr plus 2.65% Si were identified which exhibited oxidation and corrosion resistance comparable to AISI 304 stainless steel. (Author)

A78-51716 * # 10,000-hour cyclic oxidation behavior at 815 C (1500 F) of 33 high-temperature alloys. C. A. Barrett (NASA, Lewis Research Center, Cleveland, Ohio). In: Environmental degradation of engineering materials; Proceedings of the Conference, Blacksburg, Va., October 10-12, 1977. (A78-51701 23-23) Blacksburg, Va., Virginia Polytechnic Institute and State University, 1978, p. 319-327.

Thirty-three commercial high-temperature Fe-, Ni-, and Co-base alloys were oxidized in air at 815 C (1500 F) for ten 1000-hour cycles. Specific weight change versus time curves were derived and the 10,000-hour surface oxides were analyzed by X-ray diffraction. The alloys were ranked by a combination of appearance and metal loss estimates derived from gravimetric data. (Author)

A78-51739 * # Ductility normalized-strain-range partitioning life relations for creep-fatigue life predictions. G. R. Halford, J. F. Saltsman, and M. H. Hirschberg (NASA, Lewis Research Center, Cleveland, Ohio). In: Environmental degradation of engineering materials; Proceedings of the Conference, Blacksburg, Va., October 10-12, 1977. (A78-51701 23-23) Blacksburg, Va., Virginia Polytechnic Institute and State University, 1978, p. 599-612. 24 refs.

Techniques utilizing strainrange partitioning may be used to estimate the effects of the environment on the high-temperature, low-cycle, creep-fatigue resistance of alloys. Three levels of ductility-normalized strainrange-partitioning life relations are discussed: (1) strainrange partitioning relations from ductility data, (2) strainrange partitioning relations scaled by ductility ratios, and (3) strainrange partitioning life relations with measured PP lines. The procedures have demonstrated good agreement with available creep-fatigue data.

S.C.S.

A78-53063 * Reaction diffusion in the NiCrAl and CoCrAl systems. S. R. Levine (NASA, Lewis Research Center, Coatings Section, Cleveland, Ohio). *Metallurgical Transactions A: Physical Metallurgy and Materials Science*, vol. 9A, Sept. 1978, p. 1237-1250. 18 refs.

The paper assesses the effect of overlay coating and substrate composition on the kinetics of coating depletion by interdiffusion. This is accomplished by examining the constitution, kinetics and activation energies for a series of diffusion couples primarily of the NiCrAl/Ni-10Cr or CoCrAl/Ni-10Cr type annealed at temperatures in the range 1000-1205 C for times up to 500 hr. A general procedure is developed for analyzing diffusion in multicomponent multiphase systems. It is shown that by introducing the concept of beta-source strength, which can be determined from appropriate phase diagrams, the Wagner solution for consumption of a second phase in a semiinfinite couple is successfully applied to the analysis of MCrAl couples. Thus, correlation of beta-recession rate constants with couple composition, total and diffusional activation energies, and interdiffusion coefficients are determined. S.D.

N78-11232*# General Electric Co., Cincinnati, Ohio. Material and Process Technology Labs

MANUFACTURE AND ENGINE TEST OF ADVANCED OXIDE DISPERSION STRENGTHENED ALLOY TURBINE VANES Final Report

P. G. Bailey Oct. 1977 158 p. refs

(Contract NAS3-18915)

(NASA-CR-135289, R77AEG569) Avail: NTIS HC A08/MF A01 CSCL 11F

Oxide-Dispersion-strengthened (ODS) Ni-Cr-Al alloy systems were exploited for turbine engine vanes which would be used for the space shuttle thermal protection system. Available commercial and developmental advanced ODS alloys were evaluated, and three were selected based on established vane property goals and manufacturing criteria. The selected alloys were evaluated in an engine test. Candidate alloys were screened by strength, thermal fatigue resistance, oxidation and sulfidation resistance. The Ni-16Cr (3 to 5)Al-ThO2 system was identified as having attractive high temperature oxidation resistance. Subsequent work also indicated exceptional sulfidation resistance for these alloys. G.D.H.

N78-14143*# Ford Motor Co., Dearborn, Mich. Engineering and Research Staff

FABRICATION OF THIN LAYER BETA ALUMINA

Gerald J. Tennenhouse [1977] 41 p. refs

(Contract NAS3-19782)

(NASA-CR-135308) Avail: NTIS HC A03/MF A01 CSCL 11F

Beta alumina tubes having walls 700 microns, 300 microns, and 140 microns were processed by extrusion and sintering utilizing Ford proprietary binder and fabrication systems. Tubes prepared by this method have properties similar to tubes prepared by isostatic pressing and sintering, i.e. density greater than 98% of theoretical and a helium leak rate less than 3 x 10 to the

-9th power cc/sq cm/sec. Ford ultrasonic bonding techniques were used for bonding beta alumina end caps to open ended beta -alumina tubes prior to sintering. After sintering, the bond was hermetic, and the integrity of the bonded area was comparable to the body of the tube. Author

N78-15233*# IIT Research Inst., Chicago, Ill. Metals Research Div.

THERMAL FATIGUE AND OXIDATION DATA OF SUPERALLOYS INCLUDING DIRECTIONALLY SOLIDIFIED EUTECTICS

V. L. Hill and V. E. Humphreys. Jun. 1977. 66 p. refs.
(Contract NAS3-17787)
(NASA-CR-135272; IITRI-B6124-48) Avail: NTIS HC A04/MF A01. CSCL 11F

Thermal fatigue and oxidation data were obtained on 61 specimens, representing 15 discrete alloy compositions or fabricating techniques and three coating systems. Conventionally fabricated alloys included V57, MM 200, Rene 77, Rene 125, MM 246, MM 509, IN-738, IN-792 + Hf, and MM 200 + Hf. The directionally solidified alloys were MM 200, MM 200 single crystal, MM 200 bicrystal, cellular gamma/gamma' - delta and lamellar gamma/gamma' - delta. The coatings systems included NiCrAlY on IN-738, In-792 + Hf, MM 200 DS, MM 200 DS single crystal, and cellular gamma/gamma' - delta and NiCrAlY/Pt on lamellar gamma/gamma' - delta. Crack initiation survival rates were recorded for all alloys, with and without coatings. All uncoated alloys, except MM 509, exhibited significant oxidation weight loss in 75,000 to 15,000 cycles. MM 509 specimens had weight losses only slightly higher than coated specimens through 7,500 cycles. All coated specimens had low weight loss. Author

N78-15234*# Massachusetts Inst. of Tech., Cambridge. Aeroelastic and Structures Research Lab.

EXPERIMENTAL TRANSIENT AND PERMANENT DEFORMATION STUDIES OF STEEL-SPHERE-IMPACTED OR EXPLOSIVELY-IMPULSED ALUMINUM PANELS

Emmett A. Witmer, Fred Merlis, Jose J. A. Rodal, and Thomas R. Stagliano. May 1977. 144 p. refs.
(Grant NGR-22-009-339)
(NASA-CR-135315; ASRL-TR-154-12) Avail: NTIS HC A07/MF A01. CSCL 11F

The sheet explosive loading technique (SELT) was employed to obtain elastic-plastic large deflection 3-d transient and/or permanent strain data on simple well defined structural specimens and materials: initially-flat 6061-T651 aluminum panels with all four sides ideally clamped via integral construction. The SELT loading technique was chosen since it is both convenient and provides 'forcing function information' of small uncertainty. These data will be useful for evaluating pertinent 3-d structural response prediction methods. Author

N78-16149*# IIT Research Inst., Chicago, Ill.

THERMAL FATIGUE AND OXIDATION DATA FOR ALLOY/BRAZE COMBINATIONS. Technical Report, May 1975 - May 1977

V. L. Hill and V. E. Humphreys. Jun. 1977. 55 p. refs.
(Contract NAS3-18942)
(NASA-CR-135299; IITRI-B6134-25) Avail: NTIS HC A04/MF A01. CSCL 11F

Thermal fatigue and oxidation data were obtained for 62 brazed specimens of 3 iron-, 3 nickel-, and 1 cobalt-base alloy. Fluidized bed thermal cycling was conducted over the range 740-25 C employing 10-cm long single edge wedge specimens. Immersion time was always 4 minutes in each bed. Types of test specimens employed in the program include those with brazed overlays on the specimen radius, those butt brazed at midspan and those with a brazed foil overlay on the specimen radius. Of the 18 braze overlay specimens, 5 generated fatigue cracks by 7,000 cycles. Thermal cracking of butt brazed specimens occurred exclusively through the butt braze. Of the 23 butt brazed specimens, 7 survived 11,000 thermal cycles without cracking. Only 2 of the 21 foil overlaid specimens exhibiting cracking in 7,000 cycles. Blistering of the foil did occur for 2 alloys by 500 cycles. Oxidation of the alloy/braze combination was limited at the test maximum test temperature of 740 C. Author

N78-16150*# Carnegie-Mellon Univ., Pittsburgh, Pa. Dept. of Metallurgy and Materials Science.

THE EFFECT OF MICROSTRUCTURE AND STRENGTH ON THE FRACTURE TOUGHNESS OF AN 18 Ni, 300 GRADE MARAGING STEEL. Final Report

J. A. Psioda and J. R. Low, Jr. Nov. 1977. 94 p. refs.
(Grant NGR-39-087-003)
(NASA-CR-135288; CMU-NASA-8) Avail: NTIS HC A05/MF A01. CSCL 11F

Fractography and metallographic sectioning were used to investigate the influence of microstructure and strength on the fracture toughness (Kic) and fracture mechanism of an 18 Ni, 300 grade maraging steel. Increased yield strength from 1442 to 2070 MN/m squared through precipitation hardening results in a Kic loss from 143 to 55 MN/m superscript 3/2. Ti (C,N), Ti2S, and TiC inclusions in sizes from 1 to 8, 1 to 15, and 0.1 to 2 microns respectively serve as sites for void nucleation and lead to fracture by the dimpled rupture process in all strength levels considered. TiC nucleated dimples occupy more than half the fracture in all conditions. Void nucleation rate and resultant number of dimples per unit area of fracture increase with increasing yield strength. Average dimple size decreases with increasing strength and/or overaging which follows from the decreasing amount of stable void growth measured by sectioning tensile specimens. Void growth is assisted by crack branching along a path of TiC inclusions. Coalescence occurs in the highest strength materials by a combination of TiC void nucleation and premature separation at strengthening precipitates. Author

N78-19280*# Kentucky Univ., Lexington. Dept. of Metallurgical Engineering and Materials Science.

THE EFFECT OF MINOR ADDITIONS OF TITANIUM ON THE FRACTURE TOUGHNESS OF Fe-12Ni ALLOYS AT 77K. Final Report, 1 Nov. 1976 - 31 Oct. 1977

H. Conrad, C. Yin, and G. Sargent. 16 Jan. 1978. 92 p. refs.
(Grant NsG-3125)
(NASA-CR-135351) Avail: NTIS HC A05/MF A01. CSCL 11F

Titanium additions ranging from 0.18 to 0.99 atomic percent and heat treatments of 2 hours at 550, 685 and 820 C respectively followed by a water quench were considered. Cubic and rectangular shaped inclusions were noted in the SEM fractographs of the alloys with the Ti additions. A fine precipitate was observed by TEM for the Fe-12Ni-0.18Ti alloys heat treated at 550 C; this precipitate was not observed for the 685 and 820 C heat treatments of the same alloy. Auger mappings of the fracture surfaces indicated a weak to moderate association of the interstitials C, N and O with Ti, the degree of which depended on the particular interstitial and the heat treatment temperature. Author

N78-20310*# California Univ., Berkeley. Lawrence Berkeley Lab.

THE DESIGN OF AN Fe-12Mn-0.2Ti ALLOY STEEL FOR LOW TEMPERATURE USE. Final Report

S. K. Hwang and J. W. Morris, Jr. 6 Dec. 1977. 107 p.
(Grant NGR-05-003-562)
(NASA-CR-135310) Avail: NTIS HC A06/MF A01. CSCL 11F

An investigation was made to improve the low temperature mechanical properties of Fe-8 approximately 12% Mn-0.2Ti alloy steels. A two-phase(alpha + gamma) tempering in combination with cold working or hot working was identified as an effective treatment. A potential application as a Ni-free cryogenic steel was shown for this alloy. It was also shown that an Fe-8Mn steel could be grain-refined by a purely thermal treatment because of its dislocated martensitic structure and absence of epsilon phase. A significant reduction of the ductile-brittle transition temperature was obtained in this alloy. The nature and origin of

brittle fracture in Fe-Mn alloys were also investigated. Two embrittling regions were found in a cooling curve of an Fe-12Mn-C 2Ti steel which was shown to be responsible for intergranular fracture. Auger electron spectroscopy identified no segregation during solution-annealing treatment. Avoiding the embrittling zones by controlled cooling led to a high cryogenic toughness in a solution-annealed condition. Author

N78-21266*# Colt Industries, Inc., Pittsburgh, Pa. Crucible Materials Research Center.
FABRICATION OF STAINLESS STEEL CLAD TUBING Final Report
C. W. Kovach 7 Apr. 1978 102 p
(Contract NAS3-20098)
(NASA-CP-135347) Avail: NTIS HC A06/MF A01 CSCL 11F

The feasibility of producing stainless steel clad carbon steel tubing by a gas pressure bonding process was evaluated. Such a tube product could provide substantial chromium savings over monolithic stainless tubing in the event of a serious chromium shortage. The process consists of the initial assembly of three component tubesets from conventionally produced tubing, the formation of a strong metallurgical bond between the three components by gas pressure bonding, and conventional cold draw and anneal processing to final size. The quality of the tubes produced was excellent from the standpoint of bond strength, mechanical, and forming properties. The only significant quality problem encountered was carburization of the stainless clad by the carbon steel core which can be overcome by further refinement through at least three different approaches. The estimated cost of clad tubing produced by this process is greater than that for monolithic stainless tubing, but not so high as to make the process impractical as a chromium conservation method. Author

N78-21268*# United Technologies Research Center, East Hartford, Conn.
STUDY OF THE EFFECTS OF GASEOUS ENVIRONMENTS ON SULFIDATION ATTACK OF SUPERALLOYS Final Report
John G. Smeggil and Norman S. Bornstein Nov. 1977 166 p refs
(Contract NAS3-20039)
(NASA-CR-135348; R77-912613-5) Avail: NTIS HC A08/MF A01 CSCL 11F

Studies were conducted to examine the effect of the gaseous corrodents NaCl, HCl, and NaOH on the high temperature oxidation and Na2SO4-induced corrosion behavior of the alumina former NiAl, the chromia former Ni-25 wt % Cr, elemental Cr, and the superalloy B-1900. Experiments were conducted at 900 and 1050 C in air in the presence and absence of the gaseous corrodents. Effects involving both reaction rates and microstructural changes in oxide morphology were observed due to the presence of these corrodents at levels anticipated to be present in operating industrial and marine gas turbines. The effect of gaseous NaCl, HCl, and possibly NaOH on NiAl in simple oxidation was to remove aluminum from below the protective alumina layer and to simultaneously weaken the adherence of the protective alumina oxide scale to the substrate. The aluminum removed from below the oxide scale was redeposited on its surface as alpha-Al2O3 whiskers. With respect to the chromia formers, gaseous NaCl and HCl promoted breakaway oxidation kinetics and changes in the microstructures of the oxide scales. Author

N78-25166*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
MANUFACTURE OF ASTROLOY TURBINE DISK SHAPES BY HOT ISOSTATIC PRESSING, VOLUME 1 Final Report
R. D. Eng and D. J. Evans Mar. 1978 89 p refs
(Contract NAS3-20072)
(NASA-CR-135409; PWA-5574-12-Vol-1) Avail: NTIS HC A05/MF A01 CSCL 11F

The Materials in Advanced Turbine Engines project was conducted to demonstrate container technology and establish manufacturing procedures for fabricating direct Hot Isostatic Pressing (HIP) of low carbon Astroloy to ultrasonic disk shapes. The HIP processing procedures including powder manufacture and handling, container design and fabrication, and HIP consolidation techniques were established by manufacturing five HIP disks. Based upon dimensional analysis of the first three disks, container technology was refined by modifying container tooling which resulted in closer conformity of the HIP surfaces to the sonic shape. The microstructure, chemistry and mechanical properties of two HIP low carbon Astroloy disks were characterized. One disk was subjected to a ground base experimental engine test, and the results of HIP low carbon Astroloy were analyzed and compared to conventionally formed Waspaloy. The mechanical properties of direct HIP low carbon Astroloy exceeded all property goals and the objectives of reduction in material input weight and reduction in cost were achieved. Author

A78-24901 * # The effect of NaCl/g/ on the Na2SO4-induced hot corrosion of NiAl. J. G. Smeggil, N. S. Bornstein, and M. A. DeCrescente (United Technologies Research Center, East Hartford, Conn.). *Engineering Foundation, Conference on Ash Deposits and Corrosion Due to Impurities in Combustion Gases, Henniker, N.H., June 26-July 1, 1977, Paper.* 14 p. 33 refs. Contract No. NAS3-20039.

Studies have been performed to examine the effect of NaCl vapor on the Na2SO4-induced hot corrosion of the alumina former NiAl. In the incubation period associated with such hot corrosion, NaCl(g) has been shown to be effective in removing aluminum from below the protective alumina scale and redepositing it as Al2O3 whiskers on the surface of the Na2SO4-coated sample. Similar effects seen in simple oxidation are associated with isothermal rupturing of the protective alumina scale. (Author)

27 NONMETALLIC MATERIALS

Includes physical, chemical, and mechanical properties of plastics, elastomers, lubricants, polymers, textiles, adhesives, and ceramic materials.

N78-10294*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IMPROVED PERFORMANCE OF SILICON NITRIDE-BASED HIGH TEMPERATURE CERAMICS
Richard L. Ashbrook. 1977. 26 p. refs. Presented at Mater. Show and Conf., Chicago, 25-27 Oct. 1977; sponsored by ASM
(NASA-TM-73719; E-9268) Avail: NTIS HC A03/MF A01 CSCL 11B

Recent progress in the production of Si3N4 based ceramics is reviewed. (1) high temperature strength and toughness of hot pressed Si3N4 were improved by using high purity powder and a stabilized ZrO2 additive, (2) impact resistance of hot pressed Si3N4 was increased by the use of a crushable energy absorbing layer, (3) the oxidation resistance and strength of reaction sintered Si3N4 were increased by impregnating reaction sintered silicon nitride with solutions that oxidize Al2O3 or ZrO2, (4) beta prime SiAlON compositions and sintering aids were developed for improved oxidation resistance or improved high temperature strength. Author

N78-10295*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FRICTION AND WEAR OF SINGLE-CRYSTAL AND POLYCRYSTALLINE MAGANESE ZINC FERRITE IN CONTACT WITH VARIOUS METALS
Kazuhisa Miyoshi (Kanazawa Univ.) and Donald H. Buckley. 1977. 28 p. refs.
(NASA-TP-1059) Avail: NTIS HC A03/MF A01 CSCL 20G

Sliding friction experiments were conducted with single-crystal (SCF) and hot-pressed polycrystalline (HPF) manganese-zinc ferrite in contact with various metals. Results indicate that the coefficients of friction for SCF and HPF are related to the relative chemical activity of those metals in high vacuum. The more active the metal, the higher the coefficient of friction. The coefficients of friction for both SCF and HPF were the same and much higher in vacuum than in argon at atmospheric pressure. All the metals tested transferred to the surface of both SCF and HPF in sliding. Both SCF and HPF exhibited cracking and fracture with sliding. Cracking in SCF is dependent on crystallographic characteristics. In HPF, cracking depends on the orientation of the individual crystallites. Author

N78-12222*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
EFFECTIVENESS OF VARIOUS ORGANOMETALLICS AS ANTIWEAR ADDITIVES IN MINERAL OIL
Donald H. Buckley. Nov. 1977. 20 p. refs.
(NASA-TP-1096) Avail: NTIS HC A02/MF A01 CSCL 11H

Sliding friction experiments were conducted with 1045 steel contacting 302 stainless steel and lubricated with various organometallics in mineral oil. Auger emission spectroscopy was used to determine the element present in the wear contact zone. The results indicate that there are organometallics which are as effective as antiwear additives as the commonly used zinc dialkyl dithiophosphate. Those include dimethyl cadmium, triphenyl lead thiomethoxide, and triphenyl tin chloride. The additives were examined in concentrations to 1 weight percent. With dimethyl cadmium at concentrations of 0.5 weight percent and above, cadmium was detected in the contact zone. Coincident with the detection of cadmium, a marked decrease in the friction coefficient was observed. All additives examined reduced friction, but only the aforementioned reduced wear to a level comparable to that observed with zinc dialkyl dithiophosphate. Author

N78-15277*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
EFFECT OF THERMAL EXPOSURE ON LUBRICATING PROPERTIES OF POLYIMIDE FILMS AND POLYIMIDE-BONDED GRAPHITE FLUORIDE FILMS
Robert L. Fusaro. Jan. 1978. 26 p. refs.
(NASA-TP-1125; E-9179) Avail: NTIS HC A03/MF A01 CSCL 11G

The effect of thermal exposure on the weight loss, adherence, friction, and wear properties of polyimide films and polyimide bonded graphite fluoride films was investigated. Films bonded to 304 stainless steel or 440C-HT steel were thermally exposed at temperatures of 315, 345, 370, or 400 C for 100 hours or more and then evaluated, using a pin-on-disk machine, at temperatures of 25, 315, or 345 C in atmospheres of dry or moist air. Polyimide films were brittle after thermal exposure. Polyimide bonded graphite fluoride films had adherence and gave low friction and wear results, thus, they appear to be good candidates for solid lubrication applications where long thermal soaks are prevalent. Author

N78-15276* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TRIMERIZATION OF AROMATIC NITRILES Patent
Li-Chen Hsu, inventor (to NASA). Issued 6 Dec. 1977. 18 p. Filed 10 Oct. 1974. Supersedes N74-34579 (12 - 24, p. 2914)
(NASA-Case-LEW-12053-1; US-Patent-4,061,856; US-Patent-Appl-SN-513613; US-Patent-Class-544-193; US-Patent-Class-260-2R; US-Patent-Class-526-193; US-Patent-Class-526-225) Avail: US Patent Office CSCL 07C

Triazine compounds and cross-linked polymer compositions were made by heating aromatic nitriles to a temperature in the range of about 100 C to about 700 C, in the presence of a catalyst or mixture of catalysts. Aromatic nitrile-modified (terminated and/or appended) imide, benzimidazole, imidazopyrrolone, quinoxaline, and other condensation type prepolymers or their precopolymers were made which were trimerized with or without a filler by the aforementioned catalytic trimerization process. Official Gazette of the U.S. Patent Office

N78-15278*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
FRICTION AND WEAR OF POLYETHYLENE OXIDE POLYMER HAVING A RANGE OF MOLECULAR WEIGHTS
Donald H. Buckley. Jan. 1978. 17 p. refs.
(NASA-TP-1129; E-9261) Avail: NTIS HC A02/MF A01 CSCL 11G

Sliding friction and wear experiments were conducted at light loads (25 to 250 g) with various molecular weights of the polyethylene oxide polymer sliding on itself and iron. Results of the experimental investigation indicate that: (1) the coefficient of friction for the polymer decreases with increasing molecular weight; (2) the friction coefficient is higher for the polymer sliding on itself than it is for the polymer sliding on iron; (3) at sufficiently high loads localized surface melting occurs and the friction coefficient is the same for the polymer sliding on itself and iron; (4) fracture cracks develop in the sliding wear track at higher, but not lower sliding velocities, reflecting a strain rate sensitivity to crack initiation; and (5) the friction coefficient for the polymer sliding on iron increases with the formation of a polymer film on the iron surface. Author

N78-15280*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
PRELIMINARY STUDY OF CYCLIC THERMAL SHOCK RESISTANCE OF PLASMA SPRAYED ZIRCONIUM OXIDE TURBINE OUTER AIR SEAL SHROUDS
Robert C. Bill, Aero. R and T Lab., and Donald W. Wisander. Oct. 1977. 14 p. refs.
(NASA-TM-73852; E-9404) Avail: NTIS HC A02/MF A01 CSCL 11A

Several wear material systems requiring potential high pressure turbine wear material systems were subjected to cyclic

thermal shock exposures similar to those that might be encountered under severe engine start-up and shut-down sequences. All of the experimental concepts consisted of plasma-sprayed yttria stabilized ZrO2 on the high temperature side of the blade tip seal shroud. Between the ZrO2 and a cooled, dense metal backing, various intermediate layer concepts intended to mitigate thermal stresses were incorporated. Performance was judged on the basis of the number of thermal shock cycles required to cause loss of seal material through spallation. The most effective approach was to include a low modulus, sintered metal pad between the ZrO2 and the metallic backing. It was also found that reducing the density of the ZrO2 layer significantly improved the performance of specimens with plasma-sprayed metal/ceramic composite intermediate layers. Author

N78-17220*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECTS OF HYDROTHERMAL EXPOSURE ON A LOW-TEMPERATURE CURED EPOXY

Richard W. Lauver. 1978. 12 p. refs. Presented at the 33rd Ann. Conf. of Reinforced Plastics/Composites Inst. of the Soc. of the Plastics Ind., Inc., Wash., D. C., 7-10 Feb. 1978.

(NASA-TM-73841; E-9428) Avail: NTIS HC A02/MF A01 CSCL 11C

Thermal mechanical analysis was employed to monitor the penetration temperature of a low-temperature epoxy resin. Both neat resin and E-glass composite samples were examined. The effects of cure temperature variation and moisture content on the apparent glass transition temperature were determined. Author

N78-17221*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PMR POLYIMIDE PREPREG WITH IMPROVED TACK CHARACTERISTICS

Tito T. Serafini and Peter Delvigs. 1978. 13 p. refs. Proposed for presentation at 2d Intern. Conf. on Composite Materials, Toronto, Can., 16-21 Apr. 1978, sponsored by Am. Inst. of Mining, Metallurgical and Petroleum Engineers.

(NASA-TM-73898) Avail: NTIS HC A02/MF A01 CSCL 11C

Current PMR Polyimide prepreg technology utilizes methanol or ethanol solvents for preparation of the PMR prepreg solutions. The volatility of these solvents limits the tack and drape retention characteristics of unprotected prepreg exposed to ambient conditions. Studies conducted to achieve PMR 15 Polyimide prepreg with improved tack and drape characteristics were described. Improved tack and drape retention were obtained by incorporation of an additional monomer. The effects of various levels of the added monomer on the thermo-oxidative stability and mechanical properties of graphite fiber reinforced PMR 15 composites exposed and tested at 316 C (600 F) were discussed. Author

N78-20323*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COATINGS FOR WEAR AND [illegible]ATION

Talivaldis Spalvins. 1978. 32 p. refs. Presented at the 3d Intern. Conf. on Metallurgical Coatings, San Francisco, 3-7 Apr. 1978, sponsored by Am. Vacuum Soc., Inc.

(NASA-TM-78341) Avail: NTIS HC A03/MF A01 CSCL 11G

Recent advances in the tribological uses of rf sputtered and ion plated films of solid film lubricants, laminar solids, soft metals, organic polymers, and wear resistant refractory compounds (carbides, nitrides, silicides) are reviewed. The sputtering and ion plating potentials and the corresponding coatings formed were evaluated relative to the friction coefficient, wear endurance life, and mechanical properties. The tribological and mechanical properties for each kind of film are discussed in terms of film adherence, coherence, tension, grain size, morphology, internal stresses, thickness, and substrate conditions such as temperature, topography, chemistry, and degassing. The ion plated metallic films in addition to improved tribological properties, may have better mechanical properties such as tensile strength and fatigue life. Author

N78-20326*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

X-RAY PHOTOELECTRON SPECTROSCOPY STUDY OF RADIOFREQUENCY-SPUTTERED REFRACTORY COMPOUND STEEL INTERFACES

Donald R. Wheeler and William A. Brainard. Feb. 1978. 20 p. refs.

(NASA-TP-1161; E-9374) Avail: NTIS HC A02/MF A01 CSCL 11G

Radiofrequency sputtering was used to deposit Mo2C, Mo2B5, and MoSi2 coatings on 440C steel substrates. Both sputter etched and preoxidized substrates were used, and the films were deposited with and without a substrate bias of -300 V. The composition of the coatings was measured as a function of depth by X-ray photoelectron spectroscopy combined with argon ion etching. In the interfacial region there was evidence that bias produced a graded interface in Mo2B5 but not in Mo2C. Oxides of iron and of all film constituents except carbon were presented in all cases but the iron oxide concentration was higher and the layer thicker on the preoxidized substrates. The film and iron oxides were mixed in the MoSi2 and Mo2C films but layered in the Mo2B5 film. The presence of mixed oxides correlates with enhanced film adhesion. Author

N78-20327*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LUBRICATION AND FAILURE MECHANISMS OF GRAPHITE FLUORIDE FILMS

Robert L. Fusaro. Apr. 1978. 32 p. refs.

(NASA-TP-1197; E-9346) Avail: NTIS HC A03/MF A01 CSCL 11H

An optical microscope, equipped with a vertical illuminator and two polaroid filters (one rotatable), was used to visually study 440C HT steel surfaces lubricated with rubbed graphite fluoride films. Friction and wear results were compared to visual observations as a function of sliding distance for films applied to three surface finishes - polished, sanded, and sand-blasted. In general, the lubricating process was one of initial deformation or wear of metallic asperities into flat plateaus and then the formation of thin, layer-like, dynamic films which sheared between the flats and eventually flowed through the contact area. Failure was due to depletion of the graphite fluoride with the subsequent formation of excessive powdery metallic debris that formed a heavy, powdery film on both the rider and disk surfaces. Author

N78-20328*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FRICTION AND WEAR OF RADIOFREQUENCY-SPUTTERED BORIDES, SILICIDES, AND CARBIDES

William A. Brainard and Donald R. Wheeler. Apr. 1978. 19 p. refs.

(NASA-TP-1156; E-9384) Avail: NTIS HC A02/MF A01 CSCL 11G

The friction and wear properties of several refractory compound coatings were examined. These compounds were applied to 440 C bearing steel surfaces by radiofrequency (RF) sputtering. The refractory compounds were: titanium and molybdenum borides, the titanium and molybdenum silicides, and the titanium, molybdenum, and boron carbides. Friction testing was done with a pin on disk wear apparatus at loads from 0.1 to 5.0 newtons. Generally, the best wear properties were obtained when the coatings were bias sputtered onto 440 C disks that had been preoxidized. Adherence was improved because of the better bonding of the coatings to the iron oxide formed during preoxidation. As a class, the carbides provided wear protection to the highest loads. Titanium boride coatings provided low friction and good wear properties to moderate loads. Author

N78-21284*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FRICTION AND METAL TRANSFER FOR SINGLE-CRYSTAL SILICON CARBIDE IN CONTACT WITH VARIOUS METALS IN VACUUM
Kazuhisa Miyoshi (Kanazawa Univ., Japan) and Donald H. Buckley Apr. 1978 27 p refs
(NASA-TP-1191; E-9307) Avail: NTIS HC A03/MF A01 CSCL 11G

Sliding friction experiments were conducted with single-crystal silicon carbide in contact with transition metals (tungsten, iron, rhodium, nickel, titanium, and cobalt), copper, and aluminum. Results indicate the coefficient of friction for a silicon carbide-metal system is related to the d band character and relative chemical activity of the metal. The more active the metal, the higher the coefficient of friction. All the metals examined transferred to the surface of silicon carbide in sliding. The chemical activity of metal to silicon and carbon and shear modulus of the metal may play important roles in metal transfer and the form of the wear debris. The less active and greater resistance to shear the metal has, with the exception of rhodium and tungsten, the less transfer to silicon carbide. Author

N78-21286*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
WEAR OF SINGLE-CRYSTAL SILICON CARBIDE IN CONTACT WITH VARIOUS METALS IN VACUUM
Kazuhisa Miyoshi and Donald H. Buckley Apr. 1978 24 p refs
(NASA-TP-1198; E-9360) Avail: NTIS HC A02/MF A01 CSCL 11G

Sliding friction experiments were conducted in vacuum with single crystal silicon carbide (0001) surface in contact with transition metals (tungsten, iron, rhodium, nickel, titanium, and cobalt), copper, and aluminum. The hexagon shaped cracking and fracturing of silicon carbide that occurred is believed to be due to cleavages of both the prismatic and basal planes. The silicon carbide wear debris, which was produced by brittle fracture, slides or rolls on both the metal and silicon carbide and produces grooves and indentations on these surfaces. The wear scars of aluminum and titanium, which have much stronger chemical affinity for silicon and carbon are generally rougher than those of the other metals. Fracturing and cracking along the grain boundary of rhodium and tungsten were observed. These may be primarily due to the greater shear moduli of the metals.
Author

N78-22232*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE EFFECT OF MICROSTRUCTURE ON HYDROGEN EMBRITTLEMENT OF THE NICKEL-BASE SUPERALLOY, UDIMET 700
Hugh R. Gray 1978 32 p refs Presented at the 19th Struct. Structural Dyn. and Mater. Conf., Bethesda, Md., 3-5 Apr. 1978 sponsored by the AIAA and the Am. Soc. of Mech. Engr.
(NASA-TM-73772; E-9574) Avail: NTIS HC A03/MF A01 CSCL 11F

Material from a single heat of cast and wrought Udimet 700 was processed and or heat treated to produce five material conditions with identical chemical compositions but with distinct microstructural variations and then evaluated for susceptibility to hydrogen embrittlement. Two prealloyed powder conditions exhibited significantly improved resistance to hydrogen embrittlement as compared to wrought material. No degradation in notch or smooth tensile strengths occurred and average ductilities of 25 percent reduction of area were determined for 2 hydrogen evaluation procedures. For the most severe hydrogenation procedure, ductility levels were reduced to 15 percent. These improvements were attributed to cleaner grain boundaries and decreases grain size.
Author

N78-22243*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL EVALUATION OF FUEL PREPARATION SYSTEMS FOR AN AUTOMOTIVE GAS TURBINE CATALYTIC COMBUSTOR
Robert R. Tacina 1977 22 p refs Presented at the 2d Workshop on Catalytic Combust., Raleigh, N. C.; sponsored by EPA. Prepared for DOE
(NASA-TM-78856; DOE/NASA-1011-78/23; E-9585) Avail: NTIS HC A02/MF A01 CSCL 21D

Spatial fuel distributions, degree of vaporization, pressure drop and air velocity profiles were measured. Three airblast injectors and an air-assist nozzle were tested. Air swirlers were used to improve the spatial fuel-air distribution. The work was done in a 12 cm tubular duct. Test conditions were a pressure of 0.3 MPa, inlet air temperatures up to 800 K, air velocity 20 m/s and fuel-air ratios up to 0.020. The fuel was A. The best results were obtained with an airblast configuration that used multiple cones to provide high velocity air for atomization and also straightened the inlet airflow. With this configuration, uniform spatial fuel-air distributions were obtained with mixing lengths greater than 17.8 cm. In this length, vaporization of the fuel was 98.5 percent complete at an inlet air temperature of 700 K. The total pressure loss was 1.0 percent with a reference velocity of 20 m/s and 0.25 percent at 10 m/s. The air velocity was uniform across the duct and no autoignition reactions were observed.
Author

N78-23231*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
KINETICS OF IMIDIZATION AND CROSSLINKING IN PMR-POLYIMIDE RESIN
Richard W. Lauver 1977 24 p refs Presented at the 9th Central Reg. Meeting of the Am. Chem. Soc., Charleston, W. Va., 12-14 Oct. 1977. Submitted for publication
(NASA-TM-78844; E-9561) Avail: NTIS HC A02/MF A01 CSCL 11D

Infrared spectroscopy and differential scanning calorimetry were employed to study the imidization and crosslinking kinetics of norbornenyl capped addition type polyimide resins designated PMR for polymerization of monomer reactants. The optical and thermal analyses were performed on resin specimens which had been isothermally aged at temperatures appropriate for imidization (120 to 204 C) and crosslinking (275 to 325 C). Imidization occurs rapidly (approximately 0.01 min) at short times, while at times longer than approximately 0.5 hour the rate decreases significantly (approximately 0.0001 min). The crosslinking reaction exhibits first order kinetics during the initial portion of the reaction and its rate appears to be limited by the reversion of the norbornenyl Diels Alder adduct. The total heat evolved per mole of end cap during crosslinking shows an inverse dependence on the molecular weight of the imide prepolymers. This reflects the effect of endcap dilution and decreased mobility of the larger oligomers.
Author

N78-25215*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRESSURELESS SINTERED SIALONS WITH LOW AMOUNTS OF SINTERING AID
Alan Ahas Jun. 1978 16 p refs
(NASA-TP-1246; E-9522) Avail: NTIS HC A02/MF A01 CSCL 11G

Two Beta prime Sialon compositions, $Si_{6-z}Al_zO_zN_{8-z}$ ($z = 0.3$ and $z = 0.6$), were pressureless sintered from mixtures of Y_2O_3 and separately mixed Beta prime Si_3N_4, AlN, and SiO_2. These Sialons had densities of over 98% of the theoretical. Four point bend strengths of 460 and 455 MPa at room temperature and 340 MPa at 1400 C, respectively, and 1400 C oxidation rates were similar to hot pressed Si_3N_4 and for a stronger Sialon with 2.5 weight percentage Y_2O_3.
Author

N78-26236*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

CATALYTIC DECOMPOSITION OF METHANOL FOR ONBOARD HYDROGEN GENERATION

Theodore Brabbs Jun 1978 47 p refs

(NASA-TP-1247; E-9472) Avail: NTIS HC A03/MF A01 CSCL 21D

The steam reformation of an equimolar mixture of methanol and water on a copper chromite catalyst was studied at three furnace temperatures and at feed space velocities from 800 to 2600 per hour. The hydrogen space velocity could be related to the reactor temperature by the equation Sv = A exp (-omega/T), where A and omega are constants determined for each value of alpha and T is temperature. At a methanol conversion of 0.87 and a reactor temperature of 589 K, the extrapolated value of the hydrogen space velocity was 9400 per hour. This velocity was used to estimate the size of an onboard hydrogen reactor for automotive applications. Such a reactor would need only about 0.8 liter of catalyst to produce 7630 STP liters (1.5 lb) of hydrogen per hour. This quantity of catalyst would fit into nine tubes 17.8 centimeters along and 2.54 centimeters in inside diameter, which is smaller than most mufflers. The reactor products would contain 12 to 13 percent more chemical energy than the incoming methanol and water. Author

N78-26214*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

SPUTTERING TECHNOLOGY IN SOLID FILM LUBRICATION

Talivaldis Spalvins 1978 18 p refs To be presented at the 2d Intern. Conf. on Solid Lubrication, Denver, 14-18 Aug. 1978; sponsored by the Am. Soc. of Lub. Engr.

(NASA TM-78914) Avail: NTIS HC A02/MF A01 CSCL 11H

Potential and present sputtering technology is discussed as it applies to the deposition of solid film lubricants, particularly MoS2, WS2, and PTFE. Since the sputtered films are very thin, the selection of the sputtering parameters and substrate condition is very critical as reflected by the lubricating properties. It was shown with sputtered MoS2 films that the lubricating characteristics are directly affected by the selected sputtering parameters (power density, pressure, sputter etching, dc biasing, etc.) and the substrate temperature, chemistry, topography, and the environmental conditions during the friction tests. Electron microscopy and other surface sensitive analytical techniques illustrate the resulting changes in sputtered MoS2 film morphology and chemistry which directly influence the film adherence and frictional properties. G.G.

N78-26215*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

A COMPARISON OF THE LUBRICATING MECHANISMS OF GRAPHITE FLUORIDE AND MOLYBDENUM DISULFIDE FILMS

Robert L. Fusaro Aug 1978 42 p refs Proposed for presentation at the 2d Intern. Conf. on Solid Lubrication, Denver, 14-18 Aug. 1978; sponsored by the Am. Soc. of Lubrication Engr.

(NASA TM-78897; E-9533) Avail: NTIS HC A03/MF A01 CSCL 11H

A microscopic study of 440C steel sliding surfaces lubricated by graphite fluoride or molybdenum disulfide solid lubricant rubbed films was conducted. The sliding surfaces, along with the friction, wear, and wear life were observed as a function of the number of sliding revolutions in three different atmospheres: moist air, dry air, or dry argon. In general, the lubricating mechanisms of the two solid lubricants were found to be relatively similar; that is, a dynamic thin layer like film was formed between the two metallic surfaces. The mechanisms of failure were found to be somewhat different, however. Failure of MoS2 films was very dependent on atmospheric degradation, while that of graphite fluoride films was more dependent on flow of the lubricant film out of the contact zone. Author

N78-27274*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

EFFECTS OF PRESSURE AND TEMPERATURE ON HOT PRESSING A SIALON

Hun C. Yeh 1977 18 p refs Presented at the Fall Meeting of the Basic Sci. Div. of the Am. Ceram. Soc., Hyannis, Mass., 25-28 Sep. 1977

(NASA-TM-78945; E-9692) Avail: NTIS HC A02/MF A01 CSCL 11D

Mixed powders (60 m/o Al2O3-40 m/o Si3N4) were hot pressed at temperatures and pressures from 1360 to 1750 C and 3.5 to 27.5 MPa (0.5 to 4.0 ksi). Fully dense sialon bodies are obtainable at temperatures and pressures as low as 1550 C and 0.5 ksi. The fully dense bodies contain Beta prime and x-phase. There is some evidence that plastic deformation has contributed to densification. Author

N78-27287*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE USE OF ION BEAM CLEANING TO OBTAIN HIGH QUALITY COLD WELDS WITH MINIMAL DEFORMATION

Bernard Sater and Thomas J. Moore 1978 13 p refs Presented at 10th Natl. Technical Conf., N. Y., 17-19 Oct. 1978; sponsored by Soc. for the Advancement of Material and Process Engineering

(NASA-TM-78933; E-9676) Avail: NTIS HC A02/MF A01 CSCL 11F

A variation of cold welding is described which utilizes an ion beam to clean mating surfaces prior to joining in a vacuum environment. High quality solid state welds were produced with minimal deformation. L.S.

N78-28247*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF OXYGEN AND NITROGEN INTERACTIONS ON FRICTION OF SINGLE-CRYSTAL SILICON CARBIDE

Kazuhisa Miyoshi and Donald H. Buckley (Kanazawa Univ., Japan) Jul. 1978 22 p refs

(NASA-TP-1265; E-9424) Avail: NTIS HC A02/MF A01 CSCL 11G

Friction studies were conducted with single-crystal silicon carbide contacting silicon carbide and titanium after having been exposed to oxygen and nitrogen in various forms. After they had been sputter cleaned, the surfaces were (1) exposed to gaseous oxygen and nitrogen (adsorption), (2) ion bombarded with oxygen and nitrogen, or (3) reacted with oxygen (SiC only). Auger emission spectroscopy was used to determine the presence of oxygen and nitrogen. The results indicate that the surfaces of silicon carbide with reacted and ion-bombarded oxygen ions give higher coefficients of friction than do argon sputter-cleaned surfaces. The effects of oxygen on friction may be related to the relative chemical, thermodynamic properties of silicon, carbon, and titanium for oxygen. The adsorbed films of oxygen, nitrogen, and mixed gases of oxygen and nitrogen on sputter-cleaned, oxygen-ion bombarded, and oxygen-reacted surfaces generally reduce friction. Adsorption to silicon carbide is relatively weak. Author

N78-28248*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

PRESSURELESS SINTERED BETA PRIME Si3N4 SOLID SOLUTION: FABRICATION, MICROSTRUCTURE, AND STRENGTH

Sunil Dutta 1977 19 p refs Presented at the Fall Meeting of the Basic Sci. Div. of the Am. Ceramic Soc., Hyannis, Mass., 25-28 Sep. 1977

(NASA-TM-78950) Avail: NTIS HC A02/MF A01 CSCL 11B

Si3N4-AlN and Al2O3 were used as basic constituents in a study of the pressureless sintering of beta prime Si3N4 solid solution as a function of temperature. Y2O3-SiO2 additions were used to promote liquid phase sintering. The sintered specimens were characterized with respect to density, microstructure, strength, oxidation, and thermal shock resistance. Density greater than 98 percent of theoretical was achieved by pressureless sintering at 1750 C. The microstructure consisted

essentially of fine-grained beta prime-Si3N4 solid solution as the major phase. Modulus of rupture strengths up to 483 MPa were achieved at moderate temperature (1000 C), but decreased to 228 MPa at 1380 C. This substantial strength loss was attributed to a glassy grain boundary phase formed during cooling from the sintering temperature. The best oxidation resistance was exhibited by a composition containing 3 mol % Y2O3-SiO2 additives. Water quench thermal shock resistance was equivalent to that of reaction sintered silicon nitride but lower than hot-pressed silicon nitride. A.R.H.

N78-29246*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SUBSTITUTION OF CERAMICS FOR HIGH TEMPERATURE ALLOYS

H. B. Probst. 1978. 19 p. refs. Presented at the 14th State-of-the-Art Symp. on Scarce and Critical Mater., Washington, D. C., 5-7 June 1978, sponsored in part by the Am. Chem. Soc., the Federation of Mater. Soc. and the Am. Soc. for Metals.

(NASA-TM-78931; E-9674) Avail: NTIS HC A02/MF A01 CSCL 11C

The high temperature capability of ceramics such as silicon nitride and silicon carbide can result in turbine engines of improved efficiency. Other advantages when compared to the nickel and cobalt alloys in current use are raw material availability, lower weight, erosion/corrosion resistance, and potentially lower cost. The use of ceramics in three different sizes of gas turbine is considered; these are the large utility turbines, advanced aircraft turbines, and small automotive turbines. Special consideration, unique to each of these applications, arise when one considers substituting ceramics for high temperature alloys. The effects of material substitutions are reviewed in terms of engine performance, operating economy, and secondary effects. A.R.H.

N78-30238*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

FRICTION AND WEAR OF METALS WITH A SINGLE-CRYSTAL ABRASIVE GRIT OF SILICON CARBIDE: EFFECT OF SHEAR STRENGTH OF METAL

Kazuhisa Miyoshi (Kanazawa Univ., Japan) and Donald H. Buckley. Aug. 1978. 27 p. refs.

(NASA-TP-1293; E-9499) Avail: NTIS HC A03/MF A01 CSCL 11G

Sliding friction experiments were conducted with spherical, single-crystal silicon carbide riders in contact with various metals and with metal riders in contact with silicon carbide flats. Results indicate that (1) the friction force in the plowing of metal and (2) the groove height (corresponding to the volume of the groove) are related to the shear strength of the metal. That is, they decrease linearly as the shear strength of the bulk metal increases. Grooves are formed in metals primarily from plastic deformation, with occasional metal removal. The relation between the groove width D and the load W can be expressed by $W = kD^n$, superscript n which satisfies Meyer's law. Author

N78-31238*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

EFFECT OF ATTRITION MILLING ON THE REACTION SINTERING OF SILICON NITRIDE

T. P. Herbell, T. K. Glasgow, and H. C. Yeh (Cleveland State Univ.). 1978. 21 p. refs. Presented at the 80th Ann. Meeting of the Am. Ceram. Soc., Detroit, 7-12 May 1978.

(Contract EC-77-A-31-1040)

(NASA-TM-78985; E-9723; DOE/NASA/1040-78/2) Avail: NTIS HC A02/MF A01 CSCL 11G

Silicon powder was ground in a steel attrition mill under nitrogen. Air exposed powder was compacted, prefired in helium, and reaction sintered in nitrogen-4 v/o hydrogen. For longer grinding times, oxygen content, surface area and compactability of the powder increased, and both alpha/beta ratio and degree of nitridation during sintering increased. Iron content remained constant. Author

A78-11847* **Directionally solidified ceramic eutectics.** R. L. Ashbrook (NASA, Lewis Research Center, Cleveland, Ohio). *American Ceramic Society, Journal*, vol. 60, Sept.-Oct. 1977, p. 428-435. 29 refs.

The aligned structures which result from the directional solidification (DS) of ceramic eutectics are of interest because of their potential for use in electronic devices and as structural materials. Techniques for growing DS ceramic eutectics are briefly discussed. The principles and controlling parameters of DS eutectic growth are described. The criteria for plane-front growth and the effect of growth rate on interlamellar or interfiber spacing are discussed. Examples of the effect of growth parameters on the alignment of the microstructure are given. Examples of the mechanical properties of directionally solidified oxide-oxide ceramics are also cited. (Author)

A78-17456* **Microstructure of hot-pressed Al2O3-Si3N4 mixtures as a function of holding temperature.** H. C. Yeh (NASA, Lewis Research Center; Cleveland State University, Cleveland, Ohio). In: Ceramic microstructures '76; With emphasis on energy related applications; Proceedings of the Sixth International Materials Symposium, Berkeley, Calif., August 24-27, 1976. (A78-17451 05-27) Boulder, Colo., Westview Press, Inc., 1977, p. 444-455. 9 refs.

Powder mixtures of 40 m/o Si3N4-60 m/o Al2O3 were hot-pressed at 4000 psi at various holding temperatures from 1100 C to 1700 C. Scanning and transmission electron microscopy results were correlated to X-ray phase analysis and density measurements. The progressively developed microstructure was used to interpret the densification behavior of SiAlON. (Author)

A78-18787* **Two-layer thermal barrier coating for high temperature components.** S. Stecura (NASA, Lewis Research Center, Surface Protection Branch, Cleveland, Ohio). (*American Ceramic Society, Joint Fall Meeting of the Basic Science, San Francisco, Calif., Nov. 1, 1976, Paper 31-BEN-76P.*) *American Ceramic Society Bulletin*, vol. 56, Dec. 1977, p. 1082-1085, 1089. 12 refs.

A simple two-layer plasma-sprayed thermal barrier coating system was developed which has the potential for protecting high temperature air-cooled gas turbine components. Of the initially examined coatings, the most promising system is an Ni-16Cr-6Al-0.6Y (in wt%) bond coating (about 0.005 to 0.010 cm thick) and a ZrO2-12Y2O3 (in wt%) thermal barrier coating (about 0.025 to 0.064 cm thick). This thermal barrier substantially lowered the metal temperature of the air-cooled airfoil. The coating withstood 3200 cycles (80 s at 1289 C surface temperature) and 275 cycles (1 hr at 1490 C surface temperature) without cracking or spalling. No separation of the thermal barrier from the bond coating or the bond coating from the substrate was observed. (Author)

A78-23445* **Microstructural and wear properties of sputtered carbides and silicides.** T. Spalvins (NASA, Lewis Research Center, Cleveland, Ohio). In: Wear of materials - 1977; Proceedings of the International Conference, St. Louis, Mo., April 25-28, 1977 (A78-23426 08-37) New York, American Society of Mechanical Engineers, 1977, p. 358-363. 6 refs.

Sputtered Cr3C2, Cr3Si2, and MoSi2 wear-resistant films (0.05 to 3.5 microns thick) were deposited on metal and glass surfaces. Electron transmission, electron diffraction, and scanning electron microscopy were used to determine the microstructural appearance. Strong adherence was obtained with these sputtered films. Internal stresses and defect crystallographic growth structures of various configurations within the film have progressively more undesirable effects for film thicknesses greater than 1.5 microns. Sliding contact and rolling-element bearing tests were also performed with these sputtered films. (Author)

A78-24895 * # Consolidation of silicon nitride without additives. P. F. Sikora (NASA, Lewis Research Center, Cleveland, Ohio) and H. C. Yeh (NASA, Lewis Research Center, Cleveland State University, Cleveland, Ohio). *American Ceramic Society, Fall Meeting, San Francisco, Calif., Oct. 31-Nov. 3, 1975, Paper.* 12 p. 6 refs.

The use of ceramics for gas turbine engine construction might make it possible to increase engine efficiency by raising operational temperatures to values beyond those which can be tolerated by metallic alloys. The most promising ceramics being investigated in this connection are Si3N4 and SiC. A description is presented of a study which had the objective to produce dense Si3N4. The two most common methods of consolidating Si3N4 currently being used include hot pressing and reaction sintering. The feasibility was explored of producing a sound, dense Si3N4 body without additives by means of conventional gas hot isostatic pressing techniques and an uncommon hydraulic hot isostatic pressing technique. It was found that Si3N4 can be densified without additions to a density which exceeds 95% of the theoretical value. G.R.

A78-24908 * # Optical and electrical properties of ion beam textured Kapton and Teflon. M. J. Mirtich and J. S. Sovey (NASA, Lewis Research Center, Cleveland, Ohio). *American Vacuum Society, National Vacuum Symposium, 24th, Boston, Mass., Nov. 8-11, 1977, Paper.* 15 p. 10 refs.

Results are given for ion beam texturing of polyimide (Kapton) and fluorinated ethylene propylene (Teflon) by means of a 30-cm diam electron bombardment argon ion source. Ion beam-textured Kapton and Teflon surfaces are evaluated for various beam energies, current densities, and exposure times. The optical properties and sheet resistance are measured after each exposure. Provided in the paper are optical spectral data, resistivity measurements, calculated absorptance and emittance measurements, and surface structure SEM micrographs of various exposures to argon ions. It is found that Kapton becomes conducting and Teflon nonconducting when ion beam-textured. Textured Kapton exhibits large changes in the transmittance and solar absorptance, but only slight changes in reflectance. Surface texturing of Teflon may allow better adherence of subsequent sputtered metallic films for a high absorptance value. The results are valuable in spacecraft charging applications. S.D.

A78-28438 * Friction, deformation and fracture of single-crystal silicon carbide. K. Miyoshi (Kanazawa University, Kanazawa, Japan) and D. H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Lubrication Engineers and American Society of Mechanical Engineers, Joint Lubrication Conference, Kansas City, Mo., Oct. 3-5, 1977, ASLE Preprint 77-LC-5C-3.* 10 p. 14 refs.

An investigation was conducted to determine the nature of the deformation and fracture of silicon carbide and its effects on friction properties. Friction experiments were conducted with hemispherical and conical diamond riders sliding on the basal plane of silicon carbide. The results indicate that, when deformation is primarily elastic, the friction does not depend on crystallographic orientation and there is no detectable fracture or cracking. When, however, plastic deformation occurs, silicon carbide exhibits anisotropic friction and deformation behavior. Surface fracture crack patterns surrounding wear tracks are observed to be of three types. The crack-geometries of two types are generally independent of orientation, the third crack, however, depends on the orientation. All surface cracks extend into subsurface. (Author)

A78-29328 * # Ceramics in gas turbines - Powder and process characterization. S. Dutta (NASA, Lewis Research Center, Cleveland, Ohio). *American Ceramic Society, Conference on Composites and Advanced Materials, Cocoa Beach, Fla., Jan. 17-19, 1977, Paper.* 15 p. 5 refs.

The role of powder and process characterization in producing high quality silicon nitride and silicon carbide components, for gas turbine applications, is described. Some of the intrinsic properties of various forms of Si3N4 and SiC are listed and limitations of such materials' availability have been pointed out. The essential features/parameters to characterize a batch of powder have been discussed including the standard techniques for such characterization. In process characterization, parameters in sintering, reaction sintering, and hot pressing processes are discussed including the factors responsible for strength limitations in ceramic bodies. It is inevitable that significant improvements in material properties can be achieved by reducing or eliminating the strength limiting factors with consistent powder and process characterization along with process control. (Author)

A78-30301 * Composition of RF-sputtered refractory compounds determined by X-ray photoelectron spectroscopy. D. R. Wheeler and W. A. Brainard (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Vacuum Science and Technology*, vol. 15, Jan.-Feb. 1978, p. 24-30. 17 refs.

RF-sputtered coatings of CrB2, MoSi2, Mo2C, TiC, and MoS2 were examined by X-ray photoelectron spectroscopy (XPS). Data on stoichiometry, impurity content, and chemical bonding were obtained. The influences of sputtering target history, deposition time, RF power level, and substrate bias were studied. Significant deviations from stoichiometry and high oxide levels were related to target outgassing. The effect of substrate bias depended on the particular coating material studied. (Author)

A78-33206 * # Mechanical and physical properties of modern boron fibers. J. A. DiCarlo (NASA, Lewis Research Center, Cleveland, Ohio). *Metallurgical Society of AIME, International Conference on Composite Materials, 2nd, Toronto, Canada, Apr. 16-20, 1978, Paper.* 19 p. 22 refs.

Measurements of the Young's modulus, flexural modulus, shear modulus and Poisson's ratio for boron fibers prepared by modern deposition techniques are reported. Physical properties of the boron fibers, including density, thermal expansion and resistance, are also surveyed. In addition, prediction of the total deformation strain in an anelastic boron fiber subjected to tensile or flexural stress is discussed. J.M.B.

A78-37684 * # Ion beam sputter etching and deposition of fluoropolymers. B. A. Banks, J. S. Sovey, T. B. Miller, and K. S. Crandall (NASA, Lewis Research Center, Cleveland, Ohio). *Electrochemical Society, International Conference on Electron and Ion Beam Science and Technology, 8th, Seattle, Wash., May 21-26, 1978, Paper.* 16 p. 21 refs.

Fluoropolymer etching and deposition techniques including thermal evaporation, RF sputtering, plasma polymerization, and ion beam sputtering are reviewed. Etching and deposition mechanisms and material characteristics are discussed. Ion beam sputter etch rates for polytetrafluoroethylene (PTFE) were determined as a function of ion energy, current density and ion beam power density. Peel strengths were measured for epoxy bonds to various ion beam sputtered fluoropolymers. Coefficients of static and dynamic friction were measured for fluoropolymers deposited from ion bombarded PTFE. (Author)

A78-38706 * High temperature compressive cracking in hot-pressed silicon nitride. W. A. Sanders (NASA, Lewis Research Center, Cleveland, Ohio). *American Ceramic Society, Journal*, vol. 61, May-June 1978, p. 278, 279. 5 refs.

Results are presented for high-temperature (1370, 1430, 1540, 1590 C) slow-strain-rate compression tests on cylindrical specimens of hot-pressed Si3N4 of the HS 130 brand under various compressive loads. The results are presented in terms of number of longitudinal cracks, percent increase in diameter, percent decrease in length, and percent loss in weight. Scanning electron micrographs are presented of cylindrical surfaces of compression specimens tested at 1430 C for

640 MN/sq m and at 1590 C for 220 MN/sq m. As compared to results obtained by other investigators, it appears more likely that the cracks resulting from compressive loading are due to subcritical crack growth caused by circumferential tensile stresses acting across grain boundaries that contain a viscous silicate glass phase. S.D.

A78-44095 * Friction and wear behavior of single-crystal silicon carbide in sliding contact with various metals. K. Miyoshi and D. H. Buckley, (NASA Lewis Research Center, Cleveland, Ohio). *American Society of Lubrication Engineers Annual Meeting, 33rd, Dearborn, Mich., Apr. 17-20, 1978, Paper.* 27 p. 11 refs.

Sliding friction experiments were conducted with single crystal silicon carbide in contact with various metals. Results indicate the coefficient of friction is related to the relative chemical activity of the metals. The more active the metal, the higher the coefficient of friction. All the metals examined transferred to silicon carbide. The chemical activity of the metal and its shear modulus may play important roles in metal transfer, the form of the wear debris and the surface roughness of the metal wear scar. The more active the metal and the less resistance to shear, the greater the transfer to silicon carbide and the rougher the wear scar on the surface of the metal. Hexagon shaped cracking and fracturing formed by cleavage of both prismatic and basal planes is observed on the silicon carbide surface. (Author)

A78-47595 * Pressureless sintered beta-prime-Si3N4 solid solution - Fabrication, microstructure, and strength. S. Dutta (NASA, Lewis Research Center, Cleveland, Ohio). *American Ceramic Society, Fall Meeting, Hyannis, Mass., Sept. 25-28, 1977, Paper.* 19 p. 26 refs.

Pressureless sintering of beta-prime-Si3N4 solid solution was studied as a function of temperature using Si3N4, AlN, and Al2O3 as basic constituents. Y2O3-SiO2 additions were used to promote liquid-phase sintering. The sintered specimens were characterized with respect to density, microstructure, strength, oxidation, and thermal shock resistance. Density greater than 98 percent of theoretical was achieved by pressureless sintering at 1750 C. The microstructure consisted essentially of fine-grained beta-prime Si3N4 solid solution as the major phase. Modulus of rupture strengths up to 483 M Pa were achieved at moderate temperature (1000 C), but decreased to 228 M Pa at 1380 C. This substantial strength loss was attributed to a "glassy" grain boundary phase formed during cooling from the sintering temperature. The best oxidation resistance was exhibited by a composition containing 3 mol % Y2O3-SiO2 additives. Water quench thermal shock resistance was equivalent to that of reaction sintered silicon nitride but lower than hot-pressed silicon nitride. (Author)

A78-47596 * Substitution of ceramics for high temperature alloys. H. B. Probst (NASA, Lewis Research Center, Cleveland, Ohio). *American Chemical Society, Federation of Materials Societies and American Society for Metals, State-of-the-Art Symposium on Science and Critical Materials, 14th, Washington, D.C., June 5-7, 1978, Paper.* 17 p. 20 refs.

Ceramics such as silicon nitride and silicon carbide are currently receiving a great deal of attention as potential materials for advanced gas turbine engines. The primary advantage offered by ceramics is their high temperature capability which can result in turbine engines of improved efficiency. Other advantages when compared to the nickel and cobalt alloys in current use are raw material availability, lower weight, erosion-corrosion resistance, and potentially lower cost. The use of ceramics in three different sizes of gas turbine engines is considered: these are the large utility turbines, advanced aircraft turbines, and small automotive turbines. The effects of ceramic substitution are discussed in terms of engine performance, operating economy, and secondary effects. (Author)

A78-50524 * Effect of attrition milling on the reaction sintering of silicon nitride. T. P. Herbell, T. K. Glasgow (NASA, Lewis Research Center, Cleveland, Ohio), and H. C. Yeh (Cleveland State University, Cleveland, Ohio). *American Ceramic Society Annual Meeting, 80th, Detroit, Mich., May 7-12, 1978, Paper.* 18 p. 8 refs. Contract No. EC-77-A-31-1040.

Silicon powder was ground in a steel attrition mill under nitrogen. Air-exposed powder was compacted, prefired in helium, and reaction-sintered in nitrogen-4 v/o hydrogen. For longer grinding times, oxygen content, surface area and compactability of the powder increased, and both alpha/beta ratio and degree of nitridation during sintering increased. Iron content remained constant. (Author)

N78-10291*# Owens-Illinois, Inc., Toledo, Ohio
IMPROVED CERAMIC HEAT EXCHANGE MATERIAL
Interim Report
H. L. McCollister. Sep. 1977. 40 p.
(Contracts NAS3-19733; EC-77-A-31-1011)
(NASA-CR-135262; CONS/733-1) Avail: NTIS
HC A03/MF A01. CSCL 11B

Improved corrosion resistant ceramic materials that are suitable for use as regenerative heat exchangers for vehicular gas turbines is reported. Two glass-ceramic materials, C-144 and C-145, have superior durability towards sulfuric acid and sodium sulfate compared to lithium aluminosilicate (LAS) Corning heat exchange material 9455. Material C-144 is a leached LAS material whose major crystalline phase is silica keatite plus mullite, and C-145 is a LAS keatite solid solution (S.S.) material. In comparison to material 9455, material C-144 is two orders of magnitude better in dimensional stability to sulfuric acid at 300 C, and one order of magnitude better in stability to sodium sulfate at 1000 C. Material C-145 is initially two times better in stability to sulfuric acid, and about one order of magnitude better in stability to sodium sulfate. Both C-144 and C-145 have less than 300 ppm delta L/L thermal expansion from ambient to 1000 C, and good dimensional stability of less than approximately 100 ppm delta L/L after exposure to 1000 C for 100 hours. The glass-ceramic fabrication process produced a hexagonal honeycomb matrix having an 85% open frontal area, 50 micrometer wall thickness, and less than 5% porosity. Author

N78-13208*# General Electric Co., Philadelphia, Pa.
IMPROVED CERAMIC HEAT EXCHANGER MATERIAL
Interim Report
H. W. Rauch. Nov. 1977. 35 p. ref.
(Contracts NAS3-19698; EC-77-A-31-1011)
(NASA-CR-135292; CONS/9698-1) Avail: NTIS
HC A03/MF A01. CSCL 11G

Various ceramic materials in the form of small, monolithic bars were screened as candidate materials in heat exchanger structures for automotive gas turbine engines. Small bar-shaped specimens of the honeycomb were used to measure thermal, chemical, and mechanical properties and for macro- and microstructure examinations. Cylindrical honeycomb specimens about 15.2 cm diameter and 10.2 in. thick are currently being tested in a gas turbine engine. Data obtained from testing the bar-shaped honeycomb specimens of GE-3200 and from testing bar-shaped honeycomb specimens of Corning 9455 were compared. Results indicate that GE-3200 has significantly better resistance to sulfuric acid and to sodium chloride than Corning 9455; thermal expansion of GE-3200 is higher than that of Corning 9455; mechanical properties of GE-3200 are higher in the tangential direction, but lower in the radial direction than Corning 9455, and during thermal cycling between R.T. 1000 C and R.T. - 1100 C, GE-3200 tends to elongate while Corning 9455 tends to slightly contract. Overall assessment of GE-3200 properties, ease of material preparation, ready adaptability to honeycomb fabrication, and refractoriness qualify this new material as a candidate for heat exchanger application in automotive gas turbine engines. Author

N78-17218*# United Technologies Research Center, East Hartford, Conn.

DEVELOPMENT OF Si3N4 AND SiC OF IMPROVED TOUGHNESS Final Report

John J. Brennan and Charles O. Hulse. 25 Oct. 1977. 148 p. refs.

(Contract NAS3-19731)

(NASA-CR-135306; R77-912252-23) Avail: NTIS HC A07/MF A01; CSCL 11B

The application of energy absorbing surface layers to Si3N4 and SiC was investigated. Among the layers studied were microcracked materials such as iron titanate and a silica-zircon mixture and porous materials such as reaction sintered Si3N4. Energy absorption due to microcrack extension upon impact was found not to be an important mechanism. Instead, the fivefold improvement in Charpy and ballistic impact at elevated temperature (1250 C and 1370 C) found for Fe2TiO5 was due to plastic deformation while similar improvement found for silica-zircon mixtures at RT was due to crushing of the porous material. Due to thermal expansion mismatch, these two materials could not withstand thermal cycling when used as energy absorbing surface layers on Si3N4. Reaction sintered Si3N4 layers on dense Si3N4 were found to give up to a sevenfold increase in ballistic impact resistance due to crushing of the layer upon impact. High porosity (45%), large particle size R.S. Si3N4 layers fabricated from -100, +200 mesh Si powder gave better impact improvement than less porous (30%), small particle size layers fabricated from -325 mesh Si powder. Author

N78-21289*# United Technologies Research Center, East Hartford, Conn.

DEVELOPMENT OF SiAlON MATERIALS Contractor Report, Jun. 1975 - Sep. 1977

G. K. Layden. Dec. 1977. 142 p. refs.

(Contract NAS3-19712)

(NASA-CR-135290; R77-912184-21) Avail: NTIS HC A07/MF A01; CSCL 11B

Cold pressing and sintering techniques were used to produce ceramic bodies in which the major phase was beta prime Si3-Al-O-N4 solid solution. A variety of foreign oxides were used to promote liquid phase sintering, and this resulted in the incorporation of additional solid phases in the ceramic bodies which controlled elevated temperature properties. None of the bodies studied to date exhibited both adequate high temperature mechanical properties and oxidation resistance. Criteria are suggested to guide the formulation of bodies with improved high temperature properties. Author

N78-31235*# Ultrasystems, Inc., Irvine, Calif.

SYNTHESIS OF PERFLUOROALKYLENE AROMATIC DIAMINES Final Report, 14 Apr. 1977 - 12 May 1978

K. L. Paciorek, T. I. Ito, J. H. Nakahara, and R. H. Kratzer. Aug. 1978. 52 p. refs.

(Contract NAS3-20400)

(NASA-CR-159403; SN-8320-F) Avail: NTIS HC A04/MF A01; CSCL 07C

Analogues of methylene dianilines were synthesized, in which the methylene group between the two aromatic nuclei was replaced by various perfluoroalkylene linkages. The hydrolytic, thermal, and thermal oxidative stabilities of PMR Polyimides derived from these diamines were determined. Three types of PMR Polyimide discs were fabricated from the dimethyl ester of 3,3',4,4'-benzophenonetetracarboxylic acid, the methyl ester of 5-norbornene-2,3-dicarboxylic acid, and one of the following three diamines: methyl dianiline, 1,3-bis(4-aminophenyl) hexafluoropropane, and 2,2-bis(4-aminophenyl)hexafluoropropane. The polyimide based on 2,2-bis(4-aminophenyl) hexafluoropropane exhibited the best hydrolytic, thermal, and thermal oxidative stability as determined by moisture uptake and thermogravimetric analysis. Author

N78-31238*# International Harvester Co., San Diego, Calif. Solar Div.

ADVANCED CERAMIC MATERIAL FOR HIGH TEMPERATURE TURBINE TIP SEALS Interim Technical Progress Report, Feb. 1976 - Nov. 1977

N. G. Solomon and J. W. Vogan. Jan. 1978. 60 p.

(Contract NAS3-20061)

(NASA-CR-135317; RDR-1831-23) Avail: NTIS HC A04/MF A01; CSCL 11B

Ceramic material systems are being considered for potential use as turbine blade tip gas path seals at temperatures up to 1370 1/4 C. Silicon carbide and silicon nitride structures were selected for study since an initial analysis of the problem gave these materials the greatest potential for development into a successful materials system. Segments of silicon nitride and silicon carbide materials over a range of densities, processed by various methods, a honeycomb structure of silicon nitride and ceramic blade tip inserts fabricated from both materials by hot pressing were tested singly and in combination. The evaluations included wear under simulated engine blade tip rub conditions, thermal stability, impact resistance, machinability, hot gas erosion and feasibility of fabrication into engine components. The silicon nitride honeycomb and low-density silicon carbide using a selected grain size distribution gave the most promising results as rub-tolerant shroud liners. Ceramic blade tip inserts made from hot-pressed silicon nitride gave excellent test results. Their behavior closely simulated metal tips. Wear was similar to that of metals but reduced by a factor of six. Author

A78-24881* Improved performance of silicon nitride-based high temperature ceramics. R. L. Ashbrook (NASA, Lewis Research Center, Cleveland, Ohio). *American Society for Metals, Materials Show and Conference, Chicago, Ill., Oct. 25-27, 1977, Paper.* 25 p. 11 refs. Contracts No. NAS3-17768; No. NAS3-19731; No. NAS3-19723; No. NAS3-19712.

Results are presented regarding experiments intended for improving the strength and toughness of hot-pressed Si3N4 (HPSN), improving the strength and oxidation resistance of reaction-sintered Si3N4 (RSSN), and improving the strength and oxidation resistance of sinterable Si-Al-O-N compositions. It is shown that the use of ZrO2 instead of MgO as a sintering aid improved the room-temperature and high-temperature flexural strength of HPSN, in addition to enhancing the rupture strength and Charpy impact resistance. The use of crushable energy absorbing layers increased the impact resistance of HPSN. Impregnation of RSSN with solutions that oxidize to Al2O3 or ZrO2 resulted in increased bending strength at room temperature. Beta-prime Si-Al-O-N sintered to full density by means of the sintering aids CeO2, Y2O3, and ZrO2 yielded the greatest strength with Y2O3 and the greatest oxidation resistance with ZrO2. S.D.

A78-40997* Traction and lubricant film temperature as related to the glass transition temperature and solidification. J. L. Lauer and M. E. Peterkin (Suntech, Inc., Marcus Hook, Pa.). *(American Society of Lubrication Engineers, Annual Meeting, 32nd, Montreal, Canada, May 9-12, 1977.) ASLE Transactions*, vol. 21, July 1978, p. 250-256. 16 refs. Contracts No. F44620-74-C-0038; No. NAS3-19758.

Does a traction fluid have to be a glass or solid under operating conditions. Infrared spectra on dynamic EHD contacts of several types of fluid were used to determine the surface and oil film temperatures. Polarized spectral runs were made to study molecular alignment. Static glass transition pressures at appropriate temperatures were between 0.1 and 2.0 GPa, with the traction fluid showing the highest. In the EHD contact region, the traction fluid showed both the highest film temperatures as well as the greatest degree of molecular alignment. A plot of the difference between the film and surface temperatures vs shear rate resulted in a master plot valid for all the fluids. From this work, the authors propose a model of fluid traction where friction between parallel rough molecules provides the traction. (Author)

28 PROPELLANTS AND FUELS

Includes rocket propellants, igniters, and oxidizers; storage and handling; and aircraft fuels.

For related information see also *07 Aircraft Propulsion and Power, 20 Spacecraft Propulsion and Power,* and *44 Energy Production and Conversion.*

N78-13233*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HYDROCARBON GROUP TYPE DETERMINATION IN JET FUELS BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY

Albert C. Antoine 1977 13 p refs Presented at 4th Ann. Meeting of the Federation of Analytical Chem. and Spectroscopy Soc. (FACSS 4), Detroit, Mich., 7-11 Nov. 1977

(NASA-TM-73829; E-9418) Avail: NTIS HC A02/MF A01 CSCL 21D

Thirty-two jet and diesel fuel samples of varying chemical composition and physical properties were prepared from oil shale and coal syncrudes. Hydrocarbon types in these samples were determined by a fluorescent indicator adsorption analysis, and the results from three laboratories are presented and compared. Two methods of rapid high performance liquid chromatography were used to analyze some of the samples, and these results are also presented and compared. Two samples of petroleum-based Jet A fuel are similarly analyzed. Author

N78-14177*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE AND EMISSIONS OF A CATALYTIC REACTOR WITH PROPANE, DIESEL, AND JET A FUELS

David N. Anderson Sep 1977 26 p refs Presented at the Fall Meeting, Western States Section of the Combust. Inst., Stanford, Calif., 17-18 Oct. 1977

(Contract EC-77-A-31-1011)

(NASA-TM-73786; CONS/1011-20; E-9349) Avail: NTIS HC A03/MF A01 CSCL 21D

Tests were made to determine the performance and emissions of a catalytic reactor operated with propane, No. 2 diesel, and Jet A fuels. A 12-cm diameter and 16-cm long catalytic reactor using a proprietary noble metal catalyst was operated at an inlet temperature of 800 K, a pressure of 300,000 Pa and reference velocities of 10 to 15 m/s. No significant differences between the performance of the three fuels were observed when 98.5 percent purity propane was used. The combustion efficiency for 99.8-percent purity propane tested later was significantly lower, however. The diesel fuel contained 135 ppm of bound nitrogen and consequently produced the highest NOx emissions of the three fuels. As much as 85 percent of the bound nitrogen was converted to NOx. Steady-state emissions goals based on half the most stringent proposed automotive standards were met when the reactor was operated at an adiabatic combustion temperature higher than 1350 K with all fuels except the 99.8-percent purity propane. With that fuel, a minimum temperature of 1480 K was required. Author

N78-17229*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ALTERNATIVE AIRCRAFT FUELS

J. P. Longwell (MIT, Cambridge) and J. Grobman Jun. 1977 22 p refs Proposed for presentation at 23d Ann. Intern. Gas Turbine Conf., London, Engl., 9-13 Apr. 1978; sponsored by Am. Soc. of Mechan. Engineers

(NASA-TM-73836) Avail: NTIS HC A02/MF A01 CSCL 21D

The efficient utilization of fossil fuels by future jet aircraft may necessitate the broadening of current aviation turbine fuel specifications. The most significant changes in specifications would be an increased aromatics content and a higher final boiling point in order to minimize refinery energy consumption and costs. These changes would increase the freezing point and might lower the thermal stability of the fuel, and could cause increased pollutant emissions, increased combustor liner temperatures, and poorer ignition characteristics. The effects that broadened specification fuels may have on present-day jet aircraft and engine components and the technology required to use fuels with broadened specifications are discussed. Author

N78-19325*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

JET AIRCRAFT HYDROCARBON FUELS TECHNOLOGY

John P. Longwell, ed. 1978 64 p Workshop held at Cleveland, Ohio, 7-9 Jun. 1977

(NASA-CP-2033; E-9457) Avail: NTIS HC A04/MF A01 CSCL 21D

A broad specification, referee fuel was proposed for research and development. This fuel has a lower, closely specified hydrogen content and higher final boiling point and freezing point than ASTM Jet A. The workshop recommended various priority items for fuel research and development. Key items include prediction of tradeoffs among fuel refining, distribution, and aircraft operating costs; combustor liner temperature and emissions studies; and practical simulator investigations of the effect of high freezing point and low thermal stability fuels on aircraft fuel systems. Author

N78-20361*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

COMPUTER PROGRAM FOR OBTAINING THERMODYNAMIC AND TRANSPORT PROPERTIES OF AIR AND PRODUCTS OF COMBUSTION OF ASTM-A-1 FUEL AND AIR

Steven A. Hippensteele and Raymond S. Colladay Mar. 1978 56 p

(NASA-TP-1160; E-9371) Avail: NTIS HC A04/MF A01 CSCL 21B

A computer program for determining desired thermodynamic and transport property values by means of a three-dimensional (pressure, fuel-air ratio, and either enthalpy or temperature) interpolation routine was developed. The program calculates temperature (or enthalpy), molecular weight, viscosity, specific heat at constant pressure, thermal conductivity, isentropic exponent (equal to the specific heat ratio at conditions where gases do not react), Prandtl number, and entropy for air and a combustion gas mixture of ASTM-A-1 fuel and air over fuel-air ratios from zero to stoichiometric, pressures from 1 to 40 atm, and temperatures from 250 to 2800 K. Author

N78-24358*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

ION BEAM SPUTTER ETCHING AND DEPOSITION OF FLUOROPOLYMERS

Bruce A. Banks, James S. Sovey, Thomas B. Miller, and Karen S. Crandall 1978 17 p refs Presented at the 8th Intern. Conf. on Electron and Ion Beam Sci. and Tech., Seattle, 21-26 May 1978, sponsored by the Electrochemical Soc., Inc.

(NASA-TM-78888) Avail: NTIS HC A02/MF A01 CSCL 07D

Fluoropolymer etching and deposition techniques including thermal evaporation, RF sputtering, plasma polymerization, and ion beam sputtering are reviewed. Etching and deposition mechanism and material characteristics are discussed. Ion beam sputter etch rates for polytetrafluoroethylene (PTFE) were determined as a function of ion energy, current density and ion beam power density. Peel strengths were measured for epoxy bonds to various ion beam sputtered fluoropolymers. Coefficients of static and dynamic friction were measured for fluoropolymers deposited from ion bombarded PTFE. Author

N78-24366* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

ATOMIC HYDROGEN STORAGE METHOD AND APPARATUS Patent

John A Woollam, inventor (to NASA) Issued 7 Mar 1978 4 p Filed 13 Apr 1976 Supersedes N76-22399 (14 - 13, p 1644)

(NASA-Case-LEW-12081-1; US-Patent-4,077,788; US-Patent-Appl-SN-676432; US-Patent-Class-62-48; US-Patent-Class-34-15; US-Patent-Class-62-100; US-Patent-Class-250-492R; US-Patent-Class-423-648R) Avail: US Patent Office CSCL 21D

Atomic hydrogen, for use as a fuel or as an explosive, is stored in the presence of a strong magnetic field in exfoliated layered compounds such as molybdenum disulfide or an elemental layer material such as graphite The compound is maintained at liquid helium temperatures and the atomic hydrogen is collected on the surfaces of the layered compound which are exposed during delamination (exfoliation) The strong magnetic field and the low temperature combine to prevent the atoms of hydrogen from recombining to form molecules

Official Gazette of the U S Patent Office

N78-24369*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

IMPACT OF FUTURE FUEL PROPERTIES ON AIRCRAFT ENGINES AND FUEL SYSTEMS

R A Rudey and J S Grobman 1978 33 p refs To be presented at Lecture Ser 96, Paris, Munich, and London, 12-20 Oct 1978, sponsored by AGARD

(NASA-TM 78866, E-9597) Avail: NTIS HC A03/MF A01 CSCL 21D

This paper describes and discusses the propulsion-system problems that will most likely be encountered if the specifications of hydrocarbon-based jet fuels must undergo significant changes in the future and, correspondingly, the advances in technology that will be required to minimize the adverse impact of these problems Several investigations conducted are summarized Illustrations are used to describe the relative effects of selected fuel properties on the behavior of propulsion-system components and fuel systems The selected fuel properties are those that are most likely to be relaxed in future fuel specifications Illustrations are also used to describe technological advances that may be needed in the future Finally, the technological areas needing the most attention are described, and programs that are under way to address these needs are briefly discussed

Author

N78-24370*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

CHARACTERISTICS AND COMBUSTION OF FUTURE HYDROCARBON FUELS

R A Rudey and J S Grobman 1978 26 p Proposed for presentation at Lecture Series 96, Paris, Munich, London, 12-20 Oct 1978 sponsored by AGARD

(NASA-TM 78865, E-9596) Avail NTIS HC A03/MF A01 CSCL 21D

As the world supply of petroleum crude oil is being depleted, the supply of high-quality crude oil is also dwindling This dwindling supply is beginning to manifest itself in the form of crude oils containing higher percentages of aromatic compounds, sulphur, nitrogen, and trace constituents The result of this trend is described and the change in important crude oil characteristics, as related to aircraft fuels, is discussed As available petroleum is further depleted, the use of synthetic crude oils (those derived from coal and oil shale) may be required The principal properties of these syncrudes and the fuels that can be derived from them are described In addition to the changes in the supply of crude oil, increasing competition for middle-distillate fuels may require that specifications be broadened in future fuels The impact that the resultant potential changes in fuel properties may have on combustion and thermal stability characteristics is illustrated and discussed in terms of ignition, soot formation, carbon deposition flame radiation, and emissions

Author

N78-27046*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

IMPACT OF BROAD-SPECIFICATION FUELS ON FUTURE JET AIRCRAFT c28

Jack Grobman *In* NASA Langley Res Center CTOL Transport Technol 1978 Jun 1978 p 217-233 refs (For primary document see N78-27046 18-01)

Avail NTIS HC A22/MF A01 CSCL 21D

The effects that broad specification fuels have on airframe and engine components were discussed along with the improvements in component technology required to use broad specification fuels without sacrificing performance, reliability, maintainability, or safety

J M S

A78-17482* # **Simulation of the heat transfer characteristics of LOX.** R C Hendricks (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Chemical Engineers and American Society of Mechanical Engineers, Heat Transfer Conference, Salt Lake City, Utah, Aug. 15-17, 1977, ASME Paper 77-HT-9.* 8 p. 10 refs. Members, $1.50; nonmembers, $3.00.

In connection with proposals for a second generation shuttle vehicle it has been suggested that the engine regenerative coolant be the oxidizer rather than a fuel. The feasibility of such an approach depends on the suitability of oxygen for the cooling functions. The information currently available concerning the heat transfer characteristics of liquid oxygen (LOX) in the near critical region at elevated pressures is not sufficient for an evaluation. It is, therefore, proposed to make use of data from similar fluids for a simulation of the heat transfer characteristics of LOX. Graphs are presented which demonstrate that experimental heat transfer results for fluid nitrogen can be used qualitatively to simulate heat transfer to liquid oxygen. Quantitative agreement appears satisfactory provided the proper level or adjusting constant can be determined.

G.R.

A78-24906* # **Hydrocarbon group type determination in jet fuels by high performance liquid chromatography.** A. C. Antoine (NASA, Lewis Research Center, Cleveland, Ohio). *Federation of Analytical Chemistry and Spectroscopy Societies, Annual Meeting, 4th, Detroit, Mich., Nov. 7-11, 1977, Paper.* 12 p.

Results are given for the analysis of some jet and diesel fuel samples which were prepared from oil shale and coal syncrudes. Thirty-two samples of varying chemical composition and physical properties were obtained. Hydrocarbon types in these samples were determined by fluorescent indicator adsorption (FIA) analysis, and the results from three laboratories are presented and compared. Recently, rapid high performance liquid chromatography (HPLC) methods have been proposed for hydrocarbon group type analysis, with some suggestion for their use as a replacement of the FIA technique. Two of these methods were used to analyze some of the samples, and these results are also presented and compared. Two samples of petroleum-based Jet A fuel are similarly analyzed.

(Author)

N78-16194*# United Technologies Research Center East Hartford Conn

DEVELOPMENT OF AN EXPERIMENT FOR DETERMINING THE AUTOIGNITION CHARACTERISTICS OF AIRCRAFT-TYPE FUELS

Louis J Spadaccini Sep 1977 30 p refs
(Contract NAS3-20066)
(NASA-CR-135329; R78-912881-2) Avail NTIS HC A03/MF A01 CSCL 21D

An experimental test apparatus was developed to determine the autoignition characteristics of aircraft-type fuels in premixing prevaporizing passages at elevated temperatures and pressures. The experiment was designed to permit independent variation and evaluation of the experimental variables of pressure, temperature, flow rate, and fuel air ratio. A comprehensive review of the autoignition literature is presented. Performance verification tests consisting of measurements of the ignition delay times for several lean fuel-air mixture ratios were conducted using Jet-A fuel at inlet air temperatures in the range 600 K to 900 K and pressures in the range 9 atm to 30 atm. Author

N78-19320*# Gordian Associates, Inc., New York.

COMPUTER MODEL FOR REFINERY OPERATIONS WITH EMPHASIS ON JET FUEL PRODUCTION. VOLUME 2: DATA AND TECHNICAL BASES Final Report

Daniel N. Dunbar and Barry G. Tunnah 21 Feb. 1978 55 p refs
(Contract NAS3-20620)
(NASA-CR-135334; Rept-1099-1) Avail: NTIS HC A04/MF A01 CSCL 21D

The FORTRAN computing program predicts the flow streams and material, energy, and economic balances of a typical petroleum refinery, with particular emphasis on production of aviation turbine fuel of varying end point and hydrogen content specifications. The program has provision for shale oil and coal oil in addition to petroleum crudes. A case study feature permits dependent cases to be run for parametric or optimization studies by input of only the variables which are changed from the base case. The report has sufficient detail for the information of most readers. Author

N78-20350*# Gordian Associates, Inc., New York.

COMPUTER MODEL FOR REFINERY OPERATIONS WITH EMPHASIS ON JET FUEL PRODUCTION. VOLUME 1: PROGRAM DESCRIPTION Final Report

Daniel N. Dunbar and Barry G. Tunnah 14 Feb. 1978 127 p refs
(Contract NAS3-20620)
(NASA-CR-135333; Rept-1099-1-Vol-1) Avail: NTIS HC A07/MF A01 CSCL 21D

A FORTRAN computer program is described for predicting the flow streams and material, energy, and economic balances of a typical petroleum refinery, with particular emphasis on production of aviation turbine fuel of varying end point and hydrogen content specifications. The program has provision for shale oil and coal oil in addition to petroleum crudes. A case study feature permits dependent cases to be run for parametric or optimization studies by input of only the variables which are changed from the base case. Author

N78-28235*# Gordian Associates, Inc., New York

COMPUTER MODEL FOR REFINERY OPERATIONS WITH EMPHASIS ON JET FUEL PRODUCTION. VOLUME 3: DETAILED SYSTEMS AND PROGRAMMING DOCUMENTATION Final Report

Daniel N. Dunbar and Barry G. Tunnah 27 Jun 1978 53 p
(Contract NAS3-20620)
(NASA-CR-135335; Rept-1099-1-Vol-3) Avail NTIS HC A04/MF A01 CSCL 21D

The FORTRAN computing program predicts flow streams and material, energy, and economic balances of a typical petroleum refinery, with particular emphasis on production of aviation turbine fuels of varying end point and hydrogen content specifications. The program has a provision for shale oil and coal oil in addition to petroleum crudes. A case study feature permits dependent cases to be run for parametric or optimization studies by input of only the variables which are changed from the base case. Author

A78-43415 * **Jet fuels from synthetic crudes.** A. C. Antoine (NASA, Lewis Research Center, Cleveland, Ohio) and J. P. Gallagher (Atlantic Richfield Co., Harvey, Ill.). In: Coal processing technology. Volume 3. (A78-43403 19-44) New York, American Institute of Chemical Engineers, 1977, p. 107-114. Contract No. NAS3-19747.

An investigation was conducted to determine the technical problems in the conversion of a significant portion of a barrel of either a shale oil or a coal synthetic crude oil into a suitable aviation turbine fuel. Three syncrudes were used, one from shale and two from coal, chosen as representative of typical crudes from future commercial production. The material was used to produce jet fuels of varying specifications by distillation, hydrotreating, and hydrocracking. Attention is given to process requirements, hydrotreating process conditions, the methods used to analyze the final products, the conditions for shale oil processing, and the coal liquid processing conditions. The results of the investigation show that jet fuels of defined specifications can be made from oil shale and coal syncrudes using readily available commercial processes. G.R.

31 ENGINEERING (GENERAL)

Includes vacuum technology, control engineering; display engineering; and cryogenics.

N78-17237* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CLOSED LOOP SPRAY COOLING APPARATUS Patent
Donald L. Alger, William B. Schwab, and Edward R. Furman, inventors (to NASA) Issued 17 Jan. 1978 4 p Filed 31 Mar. 1976 Supersedes n76-20486 (14 - 11, p 1394)
(NASA-Case-LEW-11981-1; US-Patent-4,068,495; US-Patent-Appl-SN-672220; US-Patent-Class-62-376; US-Patent-Class-62-514R; US-Patent-Class-313-22) Avail: US Patent Office CSCL 13G

A closed loop apparatus for spraying coolant against the back of a radiation target is described. The coolant was circulated through a closed loop with a bubble of inert gas being maintained around the spray. Mesh material was disposed between the bubble and the surface of the liquid coolant which was below the bubble at a predetermined level. In a second embodiment, no inert gas was used, the bubble consisting of a vapor produced when the coolant was sprayed against the target.
Official Gazette of the U.S. Patent Office

N78-22267*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
APPLIED ROUTH APPROXIMATION
Walter C. Merrill Apr. 1978 40 p refs
(NASA-TP-1231; E-9114) Avail: NTIS HC A03/MF A01 CSCL 12B

The Routh approximation technique for reducing the complexity of system models was applied in the frequency domain to a 16th order, state variable model of the F100 engine and to a 43d order, transfer function model of a launch vehicle boost pump pressure regulator. The results motivate extending the frequency domain formulation of the Routh method to the time domain in order to handle the state variable formulation directly. The time domain formulation was derived and a characterization that specifies all possible Routh similarity transformations was given. The characterization was computed by solving two eigenvalue-eigenvector problems. The application of the time domain Routh technique to the state variable engine model is described, and some results are given. Additional computational problems are discussed, including an optimization procedure that can improve the approximation accuracy by taking advantage of the transformation characterization. Author

N78-30303*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
GAS TURBINE PROJECT STATUS c37
W. E. Goette *In* DOE Highway Vehicle Systems Mar. 1978 p 125-129 (For primary document see N78-30293 21-31)
Avail: NTIS HC A20/MF A01 CSCL 21A

The state-of-the-art of automobile gas turbine technology, particularly with respect to fuel economy and emissions, was defined. An advanced gas turbine system is proposed which incorporates significant advances in technology and has a fifty to sixty percent gain in fuel economy over the spark ignition engine, while meeting the same goals of the improved gas turbine engine. J.A.M.

N78-30333*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
CATALYTIC COMBUSTION FOR THE AUTOMOTIVE GAS TURBINE ENGINE c37
D. N. Anderson *In* NATO Proc. of the 4th Intern. Symp. on Automotive Propulsion Systems, Vol. 1 Feb. 1978 p 47-64
(For primary document see N78-30332 21-31)
Avail: NTIS HC A23/MF A01 CSCL 21A

Fuel-air premixing-prevaporizing systems and commercial catalysts were studied as part of a demonstration of a low emissions combustor for an automotive gas turbine engine. A fuel preparation system which would supply a fuel-air mixture which was uniform to within + or - 10 percent of the mean fuel-air ratio, with 90 percent fuel vaporization and with no autoignition is described. The catalytic reactor was required to produce emissions which were low enough to meet the most stringent proposed U.S. automotive standards. The overall pressure drop for both systems was to be less than 3 percent, with 1 percent allowed in the fuel-air preparation system and the remainder in the catalytic reactor. B.B.

N78-18251*# Lockheed Missiles and Space Co., Palo Alto, Calif. Research Lab.
EVACUATED LOAD-BEARING HIGH PERFORMANCE INSULATION STUDY Final Report, May 1974 - Aug. 1977
R. T. Parmley and G. R. Cunnington Dec. 1977 264 p refs
(Contract NAS3-17817)
(NASA-CR-135342; LMSC-D564116) Avail: NTIS HC A12/MF A01 CSCL 22B

A light weight, vacuum jacketed, load bearing cryogenic insulation system was developed and tested on a 1.17-m (46-in.) spherical test tank. The vacuum jacket consists of 0.08 mm (0.003 in.) thick 321 stainless steel formed into a wedge design that allows elastic jacket movements as the tank shrinks (cools) or expands (warms up or is pressurized). Hollow glass spheres, approximately 80 micrometers in diameter with a bulk density of 0.069 g/cc (4.3 lb cubic foot), provide the insulating qualities and one atmosphere load bearing capability required. The design, fabrication, and test effort developed the manufacturing methods and engineering data needed to scale the system to other tank sizes, shapes, and applications. The program demonstrated that thin wall jackets can be formed and welded to maintain the required vacuum level of .013 Pa yet flex elastically for multiple reuses. No significant shifting or breakage of the microspheres occurred after 13 simulated Space Tug flight cycles on the test tank and a hundred 1 atmosphere load cycles in a flat plate calorimeter. The test data were then scaled to the Space Tug LO2 and LH2 tanks, and weight, thermal performance, payload performance, and costs were compared with a helium purged multilayer insulation system. Author

N78-29276*# Horizons Research, Inc., Cleveland, Ohio
HIGH RESOLUTION MASKS FOR ION MILLING PORES THROUGH SUBSTRATES OF BIOLOGICAL INTEREST
Sandra S. Donovan Jun. 1978 41 p refs
(Contract NAS3-21054)
(NASA-CR-135435, HRI-391) Avail: NTIS HC A03/MF A01 CSCL 13H

The feasibility was investigated of electrochemically oxidizing vapor deposited aluminum coatings to produce porous aluminum oxide coatings with submicron pore diameters and with straight channels normal to the substrate surface. Porous aluminum oxide coatings were produced from vapor deposited aluminum coatings on thin stainless steel (304), copper, Teflon (FEP) and Kapton substrates and also on pure aluminum substrates. Scanning electron microscope examination indicated that porous oxide coatings can be produced with straight channels, appropriate pore diameters and none or minimal intervening residual aluminum. The oxide coatings on the copper and Kapton substrates had the straightest channels and in general were superior to those fabricated on the other substrate materials. For oxide coatings fabricated at 600 V and 300 V, pore diameters were 0.4-0.6, and 0.3 micron with center-to-center spacing of 0.7-0.8, and 0.4 micron, respectively. Estimated direct labor and materials costs to prepare an oxide mask is anticipated to be about $4-$6 per square foot. F.O.S

32 COMMUNICATIONS

Includes land and global communications; communications theory; and optical communications.

For related information see also *04 Aircraft Communications and Navigation* and *17 Spacecraft Communications, Command and Tracking.*

N78-10346*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DISASTER WARNING SYSTEM STUDY SUMMARY
B. F. LeRoy, J. E. Maloy, R. C. Braley, C. E. Provencher, H. A. Schumaker, and M. E. Valgora Oct. 1977 21 p
(NASA-TM-73797; E-9366) Avail: NTIS HC A02/MF A01 CSCL 17B

A conceptual satellite system to replace or complement NOAA's data collection, internal communications, and public information dissemination systems for the mid-1980's was defined. Program cost and cost sensitivity to variations in communications functions are analyzed. Author

N78-13282*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE OF THE 12GHz, 200 WATT TRANSMITTER EXPERIMENT PACKAGE FOR THE HERMES SATELLITE
Robert S. Alexovich 1977 34 p refs Presented at Symp. on Hermes (Communications Technol. Satellite) its Performance and Applications, Ottawa, 29 Nov. - 1 Dec. 1977; sponsored by Royal Soc. of Canada, Canadian Dept. of Communications and NASA
(NASA-TM-73804; E-9385) Avail: NTIS HC A04/MF A01 CSCL 17B

Performance characteristics from on-orbit tests of the Transmitter Experiment Package (TEP) for the Hermes Satellite are presented. The TEP consists of a Power Processing System (PPS), an Output Stage Tube (OST) and a Variable Conductance Heat Pipe System (VCHPS), all of which are described. The OST is a coupled-cavity Traveling Wave Tube (TWT) with a Multistage Depressed Collector (MDC) and a stepped velocity-tapered slow wave structure for efficiency enhancement. It has an RF output power of 233 watts and overall efficiency of 50.75 percent at a center band frequency of 12.080 GHz. The PPS provides the required operating voltages, regulation, control and protection for the OST. The VCHPS consists of a fin radiator and three dual-artery stainless steel heat pipes using methanol and a mixture of inert gases. Test results presented include efficiencies, RF output power and body current. A discussion of thermal anomalies which occurred is presented. Author

N78-13283*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A DIGITALLY IMPLEMENTED COMMUNICATIONS EXPERIMENT UTILIZING THE HERMES (CTS) SATELLITE
H. D. Jackson and J. Fiala 1977 20 p refs Presented at Symp. on Hermes (Comm. Technol. Satellite) its Performance and Appl., Ottawa, Ontario, 29 Nov. - 1 Dec. 1977; Sponsored by The Royal Soc. of Canada, Canadian Dept. of Commun., and NASA
(NASA-TM-73827) Avail: NTIS HC A02/MF A01 CSCL 17B

The Hermes (CTS) experiment program made possible a significant effort directed toward new developments which will reduce the costs associated with the distribution of satellite services. Advanced satellite transponder technology and small inexpensive earth terminals were demonstrated as part of the Hermes program. Another system element that holds promise for reduced transmission cost is associated with the communication link implementation. An experiment is described which uses CTS to demonstrate digital link implementation and its advantages over conventional analog systems. A Digitally Implemented Communications experiment which demonstrates the flexibility and efficiency of digital transmission of television video and audio, telephone voice and high-bit-rate data is also described. Presentation of the experiment concept which concentrates on the evaluation of full-duplex digital television in the teleconferencing environment is followed by a description of unique equipment that was developed. Author

N78-18328*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
UTILIZATION OF NASA LEWIS MOBILE TERMINALS FOR THE HERMES SATELLITE
E. A. Edelman, J. L. Fiala, and L. Rizzolla 1977 30 p refs Presented at Symp. of Hermes, Commun. Technol. Satellite: Its Performance and Appl., Ottawa, 29 Nov. - 1 Dec. 1977; sponsored by NASA, Roy. Soc. Can. and Can. Dept. of Commun.
(NASA-TM-73859; E-9448) Avail: NTIS HC A03/MF A01 CSCL 17B

The high power of the Hermes satellite enables two-way television and voice communication with small ground terminals. The Portable Earth Terminal (PET) and the Transportable Earth Terminal (TET) were developed and built by NASA-Lewis to provide communications capability to short-term users. The NASA-Lewis mobile terminals are described in terms of vehicles and onboard equipment, as well as operation aspects, including use in the field. The section on demonstrations divides the uses into categories of medicine, education, technology and government. Applications of special interest within each category are briefly described. Author

N78-26373*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MEDIUM POWER VOLTAGE MULTIPLIERS WITH A LARGE NUMBER OF STAGES
W. T. Harrigill and I. T. Myers Jun. 1978 9 p refs Presented at Power Electron. Specialists Conf., Syracuse, N. Y., 13-15 Jun. 1978; sponsored by IEEE
(NASA-TM-78900; E-9636) Avail: NTIS HC A02/MF A01 CSCL 10C

Voltage multiplier techniques are extended at medium power levels to larger multiplication ratios. A series of dc-dc converters were built, with from 20 to 45 stages and with power levels up to 100 watts. Maximum output voltages were about 10,000 volts. Author

N78-31323*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE 20/30 GHz SATELLITE SYSTEMS TECHNOLOGY NEEDS ASSESSMENT
Grady Stevens and David Wright 1978 13 p refs Proposed for presentation at the Intern. Telemetry Conf., Los Angeles, 14-16 Nov. 1978; sponsored by Instrument Soc. of Am.
(NASA-TM-78975; E-9750) Avail: NTIS HC A02/MF A01 CSCL 17B

Rain attenuation in the 20/30 GHz bands, and the resultant impact on system user costs were estimated for a variety of satellite communication system concepts. Results of previous and current NASA Lewis contractual and in-house studies on system design are reported as well as market studies conducted to evaluate the concepts and test their relevancy against forecasted market needs. The 20/30 GHz bands appear attractive economically and, with certain technology, appear to offer a virtually unlimited spectrum resource. This attractiveness is especially relevant to high density trunking where there is sufficient traffic to justify dual-station site diversity. A.R.H.

N78-33283*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN AIRBORNE METEOROLOGICAL DATA COLLECTION SYSTEM USING SATELLITE RELAY (ASDAR)
James W. Begwell and Bruce G. Lindow 1978 17 p ref. To be presented at the Intern. Telemetering Conf., Los Angeles, 14-16 Nov. 1978 Sponsored by the Instr. Soc. of America
(NASA-TM-78992; E-9768) Avail: NTIS HC A02/MF A01 CSCL 17B

The National Aeronautics and Space Administration (NASA) has developed an airborne data acquisition and communication system for the National Oceanic and Atmospheric Administration (NOAA). This system known as ASDAR, the Aircraft to Satellite Data Relay, consists of a microprocessor based controller, time clock, transmitter and antenna. Together they acquire meteorological and position information from existing aircraft systems on B-747 aircraft, convert and format these, and transmit them to the ground via the GOES meteorological satellite series. The development and application of the ASDAR system is described with emphasis on unique features. Performance to date is exceptional, providing horizon-to-horizon coverage of aircraft flights. The data collected is of high quality and is considered a valuable addition to the data base from which NOAA generates its weather forecasts. Author

A78-24884 * # **A digitally implemented communications experiment utilizing the Hermes /CTS/ satellite.** H. D. Jackson and J. Fiala (NASA, Lewis Research Center, Cleveland, Ohio). *Royal Society of Canada, Symposium on Hermes (Communications Technology Satellite): Its Performance and Applications, Ottawa, Canada, Nov. 29-Dec. 1, 1977, Paper.* 19 p. 7 refs.

Attention is given to an investigation being conducted by NASA-Lewis and Comsat Laboratories which uses the Hermes (CTS) satellite to explain digital link implementation and the advantages it provides over conventional analog systems. The experiment concentrates on developing several video, audio, and data digital communications techniques. S.C.S.

A78-24885 * # **Utilization of NASA Lewis mobile terminals for the Hermes satellite.** E. A. Edelman, J. L. Fiala, and L. Rizzolla (NASA, Lewis Research Center, Cleveland, Ohio). *Royal Society of Canada, Symposium on Hermes (Communications Technology Satellite): Its Performance and Applications, Ottawa, Canada, Nov. 29-Dec. 1, 1977, Paper.* 29 p.

The paper describes the portable earth terminal (PET) and the transportable earth terminal (TET) which enable two-way television and voice communication. Both terminals were developed by NASA and utilize the high power of the Hermes satellite. PET is a bus-type vehicle which has receiving equipment for full duplex color television and which can transmit programs originating in either the on-board PET studio or in nearby buildings. PET has a collapsible 2.4-m diameter parabolic antenna interfacing with a 500-watt 14-GHz wideband TV transmitter and a 12-GHz wideband TV receiver system. TET uses two parabolic reflector antennas, 3 m and 1.2 m in diameter, mounted on a flat trailer towed by a truck. TET can receive and relay color TV signals, and its narrowband transmitter can serve as a return audio link permitting a question-and-answer format. Also described are uplink and downlink performance characteristics, operation procedures, and field demonstrations which enabled personnel at several hospitals to participate in a distant medical conference. M.L.

A78-24886 * # **CTS /Hermes/ - United States experiments and operations summary.** P. L. Donoughe and H. R. Hunczak (NASA, Lewis Research Center, Cleveland, Ohio). *Royal Society of Canada, Symposium on Hermes (Communications Technology Satellite): Its Performance and Applications, Ottawa, Canada, Nov. 29-Dec. 1, 1977, Paper.* 26 p. 29 refs.

The U.S. experiments conducted with the Communications Technology Satellite, a joint Canadian-U.S. venture launched in 1976, are discussed. The 14/12 GHz frequencies employed by the 200-W transmitter on board the satellite provide two-way television and voice communications. Applications of the satellite in the categories of health care, community services and education are considered; experiments have also made use of the special properties of the super-high frequency band (e.g. link characterization and digital communications). Time-sharing of the 14/12 GHz communication between the U.S. and Canada has functioned well. J.M.B.

A78-15615 * **A forecast of broadcast satellite communications.** J. P. Martino and R. C. Lenz, Jr. (Dayton, University Research Institute, Dayton, Ohio). In: NAECON '77; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 17-19, 1977. (A78-15551 04-33) New York, Institute of Electrical and Electronics Engineers, Inc., 1977, p. 536-540. Contract No. NAS3-20365.

This paper presents forecasts of likely changes in broadcast satellite technology, the technology of ground terminals, and the technology of terrestrial communications competitive with satellites. The impacts of these changes in technology are then assessed, using a cross-impact model of U.S. domestic telecommunications, to determine the consequences of various possible changes in communications satellite technology. These consequences are discussed in terms of various possible services, for households, businesses, and specialized customers, which might become economically viable as a result of improvements in satellite technology. (Author)

A78-31970 * # **Low cost Ku-band earth terminals for voice/data/facsimile.** R. L. Kelley (Fairchild Space and Electronics Co., Germantown, Md.). *Intelcom '77 Symposium, Atlanta, Ga., Oct. 9-15, 1977, Paper.* 7 p. Contract No. NAS3-23064.

A Ku-band satellite earth terminal capable of providing two way voice/facsimile teleconferencing, 128 Kbps data, telephone, and high-speed imagery services is proposed. Optimized terminal cost and configuration are presented as a function of FDMA and TDMA approaches to multiple access. The entire terminal from the antenna to microphones, speakers and facsimile equipment is considered. Component cost versus performance has been projected as a function of size of the procurement and predicted hardware innovations and production techniques through 1985. The lowest cost combinations of components has been determined in a computer optimization algorithm. The system requirements including terminal EIRP and G/T, satellite size, power per spacecraft transponder, satellite antenna characteristics, and link propagation outage were selected using a computerized system cost/performance optimization algorithm. System cost and terminal cost and performance requirements are presented as a function of the size of a nationwide U.S. network. Service costs are compared with typical conference travel costs to show the viability of the proposed terminal. (Author)

A78-31971 * # **Communication satellite services for special purpose users.** D. L. Wright (NASA, Lewis Research Center, System Analysis Section, Cleveland, Ohio) and J. D. Kiesling (Fairchild Space and Electronics Co., Germantown, Md.). *Intelcom 177 Symposium, Atlanta, Ga., Oct. 9-15, 1977, Paper.* 9 p. Contract No. NAS3-23064.

The present study identifies potential satellite services, examines the technology necessary for efficient implementation of these services, and determines minimum service cost versus user network size. The generic satellite services evaluated comprise TV and radio distribution (for retransmission), video teleconferencing (interactive), audio/facsimile teleconferencing (interactive), multiplexed data/voice (point-to-point), and satellite-supported land mobile. Satellite costs are based on extrapolations from ongoing commercial satellite programs. Production methods, new technology, and effect of production quantities on present and future production costs are examined to provide information on earth station equipment cost versus the variable 'buy'. Six different launch vehicles from a Delta 2914 to a dedicated Shuttle and three frequency bands and both broadcast (no eclipse capability) and fixed service satellites are considered to assess the effect of satellite size on cost and performance. It is assumed that the user pays only for his prorata share of the space segment costs. S.D.

C-2

A78-43173 * # **Low cost satellite land mobile service for nationwide applications.** J. A. Weiss (Fairchild Space and Electronics Co., Germantown, Md.). *Institute of Electrical and Electronics Engineers, Vehicular Technology Conference, Denver, Colo., Mar. 22-24, 1978, Paper.* 10 p. 5 refs. Contract No. NAS3-23064.

A satellite land mobile system using mobile radios in the UHF band, and Ku-band Communications Routing Terminals (earth stations) for a nationwide connection from any mobile location to any fixed or mobile location, and from any fixed location to any mobile location is proposed. The proposed nationwide satellite land mobile service provides: telephone network quality (1 out of 100 blockage) service, complete privacy for all the users, operation similar to the telephone network, alternatives for data services up to 32 Kbps data rates, and a cost effective and practical mobile radio compatible with system sizes ranging from 10,000 to 1,000,000 users. Seven satellite alternatives (ranging from 30 ft diameter dual beam antenna to 210 ft diameter 77 beam antenna) along with mobile radios having a sensitivity figure of merit (G/T) of -15 dB/deg K are considered. Optimized mobile radio user costs are presented as a function of the number of users with the satellite and mobile radio alternatives as system parameters. (Author)

33 ELECTRONICS AND ELECTRICAL ENGINEERING

Includes test equipment and maintainability; components, e.g., tunnel diodes and transistors; microminiaturization; and integrated circuitry.

For related information see also *60 Computer Operations and Hardware* and *76 Solid-State Physics*.

N78-11401*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INSTRUMENT TO AVERAGE 100 DATA SETS

George B. Tuma, Arthur G. Birchenough, and William J. Rice Oct 1977 19 p

(NASA-TP-1055; E-9159) Avail: NTIS HC A02/MF A01 CSCL 09C

An instrumentation system is currently under development which will measure many of the important parameters associated with the operation of an internal combustion engine. Some of these parameters include mass-fraction burn rate, ignition energy, and the indicated mean effective pressure. One of the characteristics of an internal combustion engine is the cycle-to-cycle variation of these parameters. A curve-averaging instrument has been produced which will generate the average curve, over 100 cycles, of any engine parameter. The average curve is described by 2048 discrete points which are displayed on an oscilloscope screen to facilitate recording and is available in real time. Input can be any parameter which is expressed as a + or - 10-volt signal. Operation of the curve-averaging instrument is defined between 100 and 6000 rpm. Provisions have also been made for averaging as many as four parameters simultaneously, with a subsequent decrease in resolution. This provides the means to correlate and perhaps interrelate the phenomena occurring in an internal combustion engine. This instrument has been used successfully on a 1975 Chevrolet V8 engine, and on a Continental 6-cylinder aircraft engine. While this instrument was designed for use on an internal combustion engine, with some modification it can be used to average any cyclically varying waveform. Author

N78-13330*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

POTENTIAL DAMAGE TO DC SUPERCONDUCTING MAGNETS DUE TO THE HIGH FREQUENCY ELECTROMAGNETIC WAVES

G. J. Gabriel (Notre Dame Univ.) 1977 10 p refs Presented at 7th Symp. on Engineering Problems of Fusion Res., Knoxville, Tenn., 25-28 Oct. 1977, sponsored by IEEE.

(NASA-TM-73808) Avail: NTIS HC A02/MF A01 CSCL 09C

Experimental data are presented in support of the hypothesis that a dc superconducting magnet coil does not behave strictly as an inductor, but as a complicated electrodynamic device capable of supporting electromagnetic waves. Travel times of nanosecond pulses and evidence of sinusoidal standing waves were observed on a prototype four-layer solenoidal coil at room temperature. Ringing observed during switching transients appears as a sequence of multiple reflected square pulses whose durations are related to the layer lengths. With sinusoidal excitation of the coil, the voltage amplitude between a pair of points on the coil exhibits maxima at those frequencies such that the distance between these points is an odd multiple of half wavelength in free space. Evidence indicates that any disturbance, such as that resulting from switching or sudden fault, initiates multiple reflections between layers, thus raising the possibility for sufficiently high voltages to cause breakdown. Author

N78-13331*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A SUSTAINED-ARC IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES

Arthur G. Birchenough Nov 1977 15 p refs

(NASA-TM-73833; E-9420) Avail: NTIS HC A02/MF A01 CSCL 09C

A sustained-arc ignition system was developed for internal combustion engines. It produces a very-long-duration ignition pulse with an energy in the order of 100 millijoules. The ignition pulse waveform can be controlled to predetermined actual ignition requirements. The design of the sustained-arc ignition system is presented in the report. Author

N78-17283* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PARTICLE PARAMETER ANALYZING SYSTEM Patent

David O. Hansen (TRW Inc., Redondo Beach, Calif.) and Neal L. Roy, inventors (to NASA) (TRW Inc., Redondo Beach, Calif.) Issued 21 Jan. 1969 5 p Filed 28 Jan. 1966 Sponsored by NASA

(NASA-Case-XLE-08094; US-Patent-3,423,627; US-Patent-Appl-SN-523632; US-Patent-Class-315-22) Avail: US Patent Office CSCL 09C

An X-Y plotter circuit apparatus is described which displays an input pulse representing particle parameter information, that would ordinarily appear on the screen of an oscilloscope as a rectangular pulse, as a single dot positioned on the screen where the upper right hand corner of the input pulse would have appeared. If another event occurs, and it is desired to display this event, the apparatus is provided to replace the dot with a short horizontal line.

Official Gazette of the U.S. Patent Office

N78-17286*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NOISE AS A TOOL FOR EVALUATING THE ACTIVATION OF CATHODES

Henry Kosmahl 1978 6 p Presented at the Space Traveling Wave Tube Cathode Conf., Washington, D. C., 30 Jan. - 1 Feb. 1978, sponsored by DoD and IEEE

(NASA-TM-73895; E-9520) Avail: NTIS HC A02/MF A01 CSCL 09C

Measurements, at low frequencies, of the shot noise current from space charge limited cathodes always produced results substantially in excess of theoretical predictions. Measuring the ratio (I sub eq)/S yielded a relation (I sub eq)/S = 1.288 V sub k = 1.288 k(T sub k)/e, independent of the operating point of the diode (triode) as long as all parts of the cathode had a full space charge controlled emission. This method was so sensitive as to permit detection of cathode temperature changes by 1 K, thus it allowed a powerful screening method between well and poorly activated cathodes, superior to dip tests and other current-voltage methods. Author

N78-18387*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

UP-DATE OF TRAVELING WAVE TUBE IMPROVEMENTS

Erik Buck 1978 15 p ref Presented at Electronic Warfare Symp., Warner Robins AFB, Ga., 20-24 Mar. 1978

(NASA-TM-78852; E-9572) Avail: NTIS HC A02/MF A01 CSCL 09C

A brief survey is presented of areas of progress on traveling wave tube designs. Data demonstrates the effect of multistage depressed collectors, the design of which is made possible by powerful NASA computer programs. Other topics include beam refocusing, RF circuit losses, and cathode testing. Author

N78-21372*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NASA CHARGING ANALYZER PROGRAM: A COMPUTER TOOL THAT CAN EVALUATE ELECTROSTATIC CONTAMINATION

N. John Stevens, James C. Roche, and Myron J. Mandell (Systems Sci. and Software, La Jolla, Calif.) 1978 14 p refs Presented at Intern. Spacecraft Contamination Conf., Colorado Springs, Colo., 7-9 Mar. 1978, sponsored in part by NASA and AF

(NASA-TM-73889; E-9526) Avail: NTIS HC A02/MF A01 CSCL 09C

A computer code, the NASA Charging Analyzer Program (NASCAP), was developed to study the surface charging of bodies subjected to geomagnetic substorm conditions. This program will treat the material properties of a surface in a self-consistent manner and calculate the electric fields in space due to the surface charge. Trajectories of charged particles in this electric field can be computed to determine if these particles enhance surface contamination. A preliminary model of the Spacecraft Charging At The High Altitudes (SCATHA) satellite was developed in the NASCAP code and subjected to a geomagnetic substorm environment to investigate the possibility of electrostatic contamination. The results indicate that differential voltages will exist between the spacecraft ground surfaces and the insulator surfaces. The electric fields from this differential charging can enhance the contamination of spacecraft surfaces. Author

N78-21373*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INVESTIGATION OF HIGH VOLTAGE SPACECRAFT SYSTEM INTERACTIONS WITH PLASMA ENVIRONMENTS
N. John Stevens, Frank D. Berkopec, Carolyn K. Purvis, Norman Grier, and John V. Staskus Apr 1978 22 p refs Presented at the 13th Intern. Elec. Propulsion Conf., San Diego Calif., 26-27 Apr 1978; sponsored by AIAA and DGLR
(NASA-TM-78831; E-9536) Avail: NTIS HC A02/MF A01 CSCL 09C

An experimental investigation was undertaken for insulator and conductor test surfaces biased up to + or - 1kV in a simulated low earth orbit charged particle environment. It was found that these interactions are controlled by the insulator surfaces surrounding the biased conductors. For positive applied voltages the electron current collection can be enhanced by the insulators. For negative applied voltages the insulator surface confines the voltage to the conductor region. Understanding these interactions and the technology to control their impact on system operation is essential to the design of solar cell arrays for ion drive propulsion applications that use direct drive power processing. Author

N78-25323*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LIQUID METAL SLIP RING Patent Application
Frank D. Berkopec, Robert R. Lovell, and David H. Culp, inventors (to NASA) Filed 17 Apr 1978 11 p
(NASA-Case-LEW-12277-2; US-Patent-Appl-SN-896955) Avail: NTIS HC A02/MF A01 CSCL 09C

The liquid metal electrical device includes a rotor with a channel for retaining the liquid by tension. The device also includes a stator in the form of a brush partially immersed in the metal. The brush is bidirectionally symmetrical so that whichever direction the rotor turns, the probe presents the same physical resistance and affords the same electrical conductivity as a connection between the probe and the rotor. NASA

N78-27367* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DIRECT HEATING SURFACE COMBUSTOR Patent
Donald G. Beremand, Lloyd I. Shire, and Thaddeus S. Mroz, inventors (to NASA) Issued 9 May 1978 6 p Filed 26 Jul 1976 Supersedes N76-28646 (14 - 19, p 2478)
(NASA-Case-LEW-11877-1; US-Patent-4,087,962; US-Patent-Appl-SN-708660; US-Patent-Class-60-39.65; US-Patent-Class-431-7; US-Patent-Class-431-10; US-Patent-Class-431-328; US-Patent-Class-60-39.69R) Avail: US Patent Office CSCL 20D

The combustor utilizes a non adiabatic flame to provide low emission combustion for gas turbines. A fuel air mixture is directed through a porous wall, the other side of which serves as a combustion surface. A radiant heat sink disposed adjacent to and spaced from the combustion surface controls the combustor flame temperature in order to prevent the formation of oxides of nitrogen. A secondary air flow cools the heat sink. Additionally, up to 100% of secondary air flow is mixed with the combustion products at the direct heating surface combustor to dilute such products thereby reducing exit temperature. However, if less than 100% secondary air is mixed to the combustor, the remainder may be added to the combustion products further downstream.
Official Gazette of the U.S. Patent Office

N78-32241* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REGULATED HIGH EFFICIENCY, LIGHTWEIGHT CAPACITOR-DIODE MULTIPLIER dc TO dc CONVERTER Patent
William T. Harrigill, Jr., and Ira T. Myers, inventors (to NASA) Issued 30 May 1978 5 p Filed 27 May 1977 Supersedes N77-24385 (15 - 15, p 2011)
(NASA-Case-Lew-12791-1; US-Patent-4,092,712; US-Patent-Appl-SN-801432; US-Patent-Class-363-60; US-Patent-Class-363-16; US-Patent-Class-363-101) Avail: US Patent Office CSCL 09C

A voltage multiplier having a capacitor-diode voltage multiplying network is disclosed which is fed with voltage pulses from a dc source through a first switching means. Pulses of a second polarity are also supplied through a second switching means to the input of the capacitor-diode voltage multiplier from a second dc source whose voltage is adjustable to change the voltage of the pulses of second polarity. The switching means are alternately rendered conducting by signals from a control circuit. The second dc source may be controlled by a voltage comparator which compares the output voltage of the capacitor-diode voltage multiplier to the reference source.
Official Gazette of the U.S. Patent Office

A78-15823 * # Design and prototype fabrication of a 30 tesla cryogenic magnet. G. M. Prok, M. C. Swanson, and G. V. Brown (NASA, Lewis Research Center, Cleveland, Ohio). *National Bureau of Standards, Cryogenic Engineering Conference, University of Colorado, Boulder, Colo., Aug. 2-5, 1977, Paper.* 15 p.

A liquid-neon-cooled magnet has been designed to produce 30 teslas in steady operation. Its feasibility was established by a previously reported parametric study. To ensure the correctness of the heat transfer relationships used, supercritical neon heat transfer tests were made. Other tests made before the final design included tests on the effect of the magnetic field on pump motors; tensile-shear tests on the cryogenic adhesives; and simulated flow studies for the coolant. The magnet will be made of two pairs of coils, cooled by forced convection of supercritical neon. Heat from the supercritical neon will be rejected through heat exchangers which are made of roll-bonded copper panels and are submerged in a pool of saturated liquid neon. A partial mock-up coil was wound to identify the tooling required to wind the magnet. This was followed by winding a prototype pair of coils. The prototype winding established procedures for fabricating the final magnet and revealed slight changes needed in the final design. (Author)

A78-16922 * # Electric vehicle power train instrumentation - Some constraints and considerations. J. E. Triner and I. G. Hansen (NASA, Lewis Research Center, Cleveland, Ohio). *Electric Vehicle Council International Electric Vehicle Exposition and Conference, 1st, Chicago, Ill., Apr. 26-29, 1977, Paper 7744.* 21 p. 8 refs

The application of pulse modulation control (choppers) to dc motors creates unique instrumentation problems. In particular, the high harmonic components contained in the current waveforms require frequency response accommodations not normally considered in dc instrumentation. In addition to current sensing, accurate power measurement not only requires adequate frequency response but also must address phase errors caused by the finite bandwidths and component characteristics involved. This paper discusses the implications of these problems and reports on the degree to which they have been solved at Lewis Research Center.
(Author)

A78-18282 * Use of a simple external nonreciprocal attenuator in coupled-cavity TWT's. D. J. Connolly (NASA, Lewis Research Center, Cleveland, Ohio). *IEEE Transactions on Electron Devices*, vol. ED-24, Dec. 1977, p. 1351-1353. 7 refs.

A technique has been developed for introducing a nonreciprocal sever in a traveling-wave tube design. It employs an output coupler followed by a ferrite isolator, a variable phase shifter, and an input coupler. The input and output couplers are similar to those already needed at the ends of the tube. The isolator and phase shifter are similar to commercially available waveguide components. A computer simulation has suggested the technique may yield a significant improvement in efficiency. S.C.S.

A78-18287 * A possible pole problem in the formula for klystron gap fields. H. G. Kosmahl (NASA, Lewis Research Center, Cleveland, Ohio). *IEEE Transactions on Electron Devices*, vol. ED-24, Dec. 1977, p. 1368, 1369.

In isolated cases a pole may be encountered in a previously published solution for the fields in a klystron gap. Formulas, permitting the critical combinations of parameters to be defined, are presented. It is noted that the region of inaccuracy surrounding the pole is sufficiently small and that a 0.1% change in the field changing parameter is enough to avoid it. S.C.S.

A78-23635 * Secondary electron emission properties of conducting surfaces for use in multistage depressed collectors. R. Forman (NASA, Lewis Research Center, Cleveland, Ohio). *IEEE Transactions on Electron Devices*, vol. ED-25, Jan. 1978, p. 69, 70.

An Auger spectrometer in ultrahigh vacuum was used to measure the secondary emission properties of a number of candidate collector-materials including beryllium, carbon, (soot and pyrolytic graphite), copper, titanium carbide and tantalum. The advantage of the technique used is that the surface chemical constituents could be determined just before the secondary emission characteristics of the surface were measured. Pyrolytic graphite roughened by sputter etching showed the most favorable results for depressed collector use. B.J.

A78-24883 * # Performance of the 12 GHz, 200 watt Transmitter Experiment Package for the Hermes Satellite. R. E. Alexovich (NASA, Lewis Research Center, Cleveland, Ohio). *Royal Society of Canada, Symposium on Hermes (Communications Technology Satellite): Its Performance and Applications, Ottawa, Canada, Nov. 29-Dec. 1, 1977, Paper.* 33 p. 6 refs.

Performance characteristics from on-orbit tests of the Transmitter Experiment Package (TEP) for the Hermes Satellite are presented. The tests were conducted from February 8, 1976 through August 8, 1977. The TEP consists of a Power Processing System (PPS), an Output Stage Tube (OST) and a Variable Conductance Heat Pipe System (VCHPS), all of which are described. The OST is a coupled cavity traveling wave tube with a multistage depressed collector and a stepped velocity-tapered slow wave structure for efficiency enhancement. It has an RF output power of 233 W and overall efficiency of 50.75% at a center band frequency of 12.080 GHz. The PPS provides the required operating voltages, regulation, control and protection for the OST. The VCHPS consists of a fin radiator and three dual-artery stainless steel heat pipes using methanol and a mixture of inert gases. Test results presented include efficiencies, RF output power and body current. A discussion of thermal anomalies which occurred is presented. (Author)

A78-33208 * # Up-date of traveling wave tube improvements. E. Buck (NASA, Lewis Research Center, Cleveland, Ohio; USAF, Washington, D.C.). *Electronic Warfare Symposium, Warner Robins AFB, Ga., Mar. 20-24, 1978, Paper.* 14 p.

NASA research in the area of traveling wave tube technology is reviewed, with emphasis on the basic physics of guns and collectors and a computer model for the interaction between the electron beam and the RF circuit. The design of a multistage depressed collector, capable of multiplying tube efficiency by a factor of two or more, is presented; one such design has been adopted for commercial traveling wave tube production. A three-dimensional model of electron trajectories toward the collector also receives attention, as does the problem of RF circuit losses. J.M.B.

A78-39802 * Potential damage to dc superconducting magnets due to high frequency electromagnetic waves. G. J. Gabriel (Notre Dame, University, Notre Dame, Ind.) and J. A. Burkhart (NASA, Lewis Research Center, Cleveland, Ohio). In: Symposium on Engineering Problems of Fusion Research, 7th, Knoxville, Tenn., October 25-28, 1977, Proceedings. Volume 1. (A78-39783 17-75) Piscataway, N.J., Institute of Electrical and Electronics Engineers, Inc., 1977, p. 741-745. 7 refs. NASA-supported research.

Studies of a d.c. superconducting magnet coil indicate that the large coil behaves as a straight waveguide structure. Voltages between layers within the coil sometimes exceeded those recorded at terminals where protective resistors are located. Protection of magnet coils against these excessive voltages could be accomplished by impedance matching throughout the coil system. The wave phenomenon associated with superconducting magnetic coils may create an instability capable of converting the energy of a quiescent d.c. superconducting coil into dissipative a.c. energy, even in cases when dielectric breakdown does not take place. J.M.B.

A78-45435 * # Medium power voltage multipliers with a large number of stages. W. T. Harrigill and I. T. Myers (NASA, Lewis Research Center, Cleveland, Ohio). *Institute of Electrical and Electronics Engineers, Power Electronics Specialists Conference, Syracuse, N.Y., June 13-15, 1978, Paper.* 7 p. 13 refs.

Voltage multiplier techniques were extended at medium power levels to larger multiplication ratios. A series of DC-DC converters were built, with from 20 to 45 stages and with power levels up to 100 watts. Maximum output voltages were about 10,000 volts. (Author)

N78-11296*# Hughes Aircraft Co., Torrance, Calif. Electron Dynamics Div.
STUDY OF 42 AND 85 GHz COUPLED CAVITY TRAVELING-WAVE TUBES FOR SPACE USE
J. B. Kennedy, I. Tammaru, and P. S. Wolcott. Jun. 1977. 171 p. refs.
(Contract NAS3-19701)
(NASA-CR-134670, W-06553) Avail: NTIS HC A08/MF A01 CSCL 09A

Designs were formulated for four CW, millimeter wavelength traveling-wave tubes having high efficiency and long life. Three of these tubes in the 42 to 44 GHz frequency region develop power outputs of 100 to 300 watts with overall efficiencies of typically 45 percent. Another tube, which covers the frequency range of 84 to 86 GHz, provides a power output of 200 watts at 25 percent efficiency. The cathode current density in each design was 1A/sq cm. Each tube includes metal-ceramic construction, periodic permanent magnet focusing, a two step velocity taper, an electron beam refocusing section, and a radiation cooled three-stage depressed collector. The electrical and mechanical design for each tube type is discussed in detail. The results of thermal and mechanical analyses are presented. Author

N78-13328*# Maya Development Corp., San Diego, Calif.
THE EFFECT OF ENVIRONMENTAL PLASMA INTERACTIONS ON THE PERFORMANCE OF THE SOLAR SAIL SYSTEM Contractor Report, Jul. 1976 - Jul. 1977
Marvin Douglas, Robert Laquey, and Sherman DeForest. Aug. 1977. 104 p. refs.
(Contract NAS3-20119)
(NASA-CR-135258) Avail: NTIS HC A06/MF A01 CSCL 09C

Interaction between the solar sail and the natural plasma environment were examined for deleterious impacts upon the operation of the sail and its associated payload. Electrostatic charging of the sail in the solar wind and in near earth environment were examined. Deployment problems were studied. An analysis of electromechanical oscillations coupling the sail to the natural plasma was performed. As a result of these studies, it was concluded that none of these effects will have a significant negative impact upon the sail operation. The natural environment will be significantly perturbed and this will preclude measurements of electric and magnetic fields from an attached payload. Author

N78-13328*# Systems Science and Software, La Jolla, Calif.
A THREE DIMENSIONAL DYNAMIC STUDY OF ELECTROSTATIC CHARGING IN MATERIALS Contractor Report, Jul. 1976 - Jul. 1977
I. Katz, D. E. Parks, M. J. Mandell, J. M. Harvey, D. H. Brownell, Jr., S. S. Wang, and M. Rotenberg Aug. 1977 334 p refs
(Contract NAS3-20119)
(NASA-CR-135256; SSS-R-77-3367) Avail: NTIS HC A15/MF A01 CSCL 09C

A description is given of the physical models employed in the NASCAP (NASA Charging Analyzer Program) code, and several test cases are presented. NASCAP dynamically simulates the charging of an object made of conducting segments which may be entirely or partially covered with thin dielectric films. The object may be subject to either ground test or space user-specified environments. The simulation alternately treats (1) the tendency of materials to accumulate and emit charge when subject to plasma environment, and (2) the consequent response of the charged particle environment to an object's electrostatic field. Parameterized formulations of the emission properties of materials subject to bombardment by electrons, protons, and sunlight are presented. Values of the parameters are suggested for clean aluminum, Al2O3, clean magnesium, MgO, SiO2 kapton, and teflon. A discussion of conductivity in thin dielectrics subject to radiation and high fields is given, together with a sample calculation. Author

N78-13329*# Systems Science and Software, La Jolla, Calif.
NASCAP USER'S MANUAL Contractor Report, Jul. 1976 - Jul. 1977
M. J. Mandell, J. M. Harvey, and I. Katz Aug. 1977 354 p refs
(Contract NAS3-20119)
(NASA-CR-135259; SSS-R-77-3368) Avail: NTIS HC A16/MF A01 CSCL 09C

The NASCAP (NASA Charging Analyzer Program) code simulates the charging process for a complex object in either tenuous plasma or ground test environment. Detailed specifications needed to run the code are presented. The object definition section, OBJDEF, allows the test object to be easily defined in the cubic mesh. The test object is composed of conducting sections which may be wholly or partially covered with thin dielectric coatings. The potential section, POTENT, obtains the electrostatic potential in the space surrounding the object. It uses the conjugate gradient method to solve the finite element formulation of Poisson's equation. The CHARGE section of NASCAP treats charge redistribution among the surface cells of the object as well as charging through radiation bombardment. NASCAP has facilities for extensive graphical output, including several types of object display plots, potential contour plots, space charge density contour plots, current density plots, and particle trajectory plots. Author

N78-15397*# Case Western Reserve Univ., Cleveland, Ohio Engineering Design Center
ADAPTATION OF ION BEAM TECHNOLOGY TO MICROFABRICATION OF SOLID STATE DEVICES AND TRANSDUCERS
James A. Topich Nov. 1977 43 p refs
(Grant NsG 3131)
(NASA-CR-135314) Avail: NTIS HC A03/MF A01 CSCL 09C

It was found that ion beam texturing of silicon surfaces can be used to increase the effective surface area of MOS capacitors. There is, however, a problem with low dielectric breakdown. Preliminary work was begun on the fabrication of ion implanted resistors on textured surfaces and the potential improvement of wire bond strength by bonding to a textured surface. In the area of ion beam sputtering, the techniques for sputtering PVC were developed. A PVC target containing valinomycin was used to sputter an ion selective membrane on a field effect transistor to form a potassium ion sensor. Author

N78-16400*# Hughes Aircraft Co., Culver City, Calif.
HIGH FREQUENCY CAPACITOR-DIODE VOLTAGE MULTIPLIER dc-dc CONVERTER DEVELOPMENT Progress Report, 14 Jun. - 14 Jul. 1977
Jack J. Kisch and Robert M. Martinelli Sep. 1977 72 p refs
(Contract NAS3-20111)
(NASA-CR-135309; P77-437) Avail: NTIS HC A04/MF A01 CSCL 09C

A power conditioner was developed which used a capacitor diode voltage multiplier to provide a high voltage without the use of a step-up transformer. The power conditioner delivered 1200 Vdc at 100 watts and was operated from a 120 Vdc line. The efficiency was in excess of 90 percent. The component weight was 197 grams. A modified boost-add circuit was used for the regulation. A short circuit protection circuit was used which turns off the drive circuit upon a fault condition, and recovers within 5 ms after removal of the short. High energy density polysulfone capacitors and high speed diodes were used in the multiplier circuit. Author

N78-19392*# Westinghouse Electric Corp., Pittsburgh, Pa. Research and Development Center.
NIOBIUM-GERMANIUM SUPERCONDUCTING TAPES FOR HIGH-FIELD MAGNET APPLICATIONS Final Report, 19 Apr. 1976 - 19 Nov. 1977
A. I. Braginski, G. W. Roland, M. R. Daniel, and J. A. Woolam Nov. 1977 116 p refs
(Contract NAS3-20233)
(NASA-CR-135364; Rept-77-9F1-HYSUC-R9) Avail: NTIS HC A06/MF A01 CSCL 09C

A process of fabricating superconducting Nb3Ge tapes by chemical vapor deposition (CVD) has been developed and tapes up to 10 meters long fabricated. The typical properties achieved were: critical temperature T sub c ~ 20 K, upper critical field H sub c2 ~ 29 tesla at 4.2 K, and J sub c ~ 3 to 4 x 10 to the 5th power A m(-2) at 4.2 K, 18 tesla. The relative depression of T sub c and H sub c2 compared with the best thin film samples sputtered on sapphire was due to the presence of Nb5Ge3 second-phase particles used as flux pinning centers and to strains induced by thermal mismatch with Hastelloy B tape substrates. A peculiar field dependence of flux pinning force that was observed in both CVD and sputtered Nb3Ge indicated a premature pin-breaking mechanism or a phase inhomogeneity. Directions of further optimization work were defined. Author

N78-24488*# Hughes Aircraft Co., Culver City, Calif.
TECHNOLOGICAL DEVELOPMENT OF CYLINDRICAL AND FLAT SHAPED HIGH ENERGY DENSITY CAPACITORS Final Technical Report, 22 Apr. 1976 - 15 Sep. 1977
Joseph A. Zelik and Robert D. Parker Dec. 1977 100 p
(Contract NAS3-20090)
(NASA-CR-135286; P77-594) Avail: NTIS HC A05/MF A01 CSCL 09A

Cylindrical wound metallized film capacitors rated 2 micron F 500 VDC that had an energy density greater than 0.3 J/g and flat flexible metallized film capacitors rated at 2 micron F 500 VDC that had an energy density greater than 0.1 J/g were developed. Polysulfone polycarbonate and polyvinylidene fluoride (PVF2) were investigated as dielectrics for the cylindrical units. PVF2 in 6.0 micron m thickness was employed in the final components of both types. Capacitance and dissipation factor measurements were made over the range 25 C to 100 C and 10 Hz to 10 kHz. No pre-life-test burning was performed, and

six of ten cylindrical units survived a 2500 hour AC plus DC life test. Three of the four failures were infant mortality. All but two of the flat components survived 400 hours. Finished energy densities were 0.104 J/g at 500 V and 0.200 J/g at 700 V, the energy density being limited by the availability of thin PVF2 films. Author

N78-28350*# TRW Defense and Space Systems Group, Redondo Beach, Calif. Power Conversion Electronics Dept.
MODELING AND ANALYSIS OF POWER PROCESSING SYSTEMS (MAPPS), INITIAL PHASE 2 Final Report
Yuan Yu, Fred C. Lee, Herb Wangenheim, and Dan Warren 22 Dec. 1977 427 p refs
(Contract NAS3-19690)
(NASA-CR-135173; TRW-27744.000) Avail: NTIS HC A19/MF A01 CSCL 09C

The overall objective of the program is to provide the engineering tools to reduce the analysis, design, and development effort, and thus the cost, in achieving the required performances for switching regulators and dc-dc converter systems. The program was both tutorial and application oriented. Various analytical methods were described in detail and supplemented with examples, and those with standardization appeals were reduced into computer-based subprograms. Major program efforts included those concerning small and large signal control-dependent performance analysis and simulation, control circuit design, power circuit design and optimization, system configuration study, and system performance simulation. Techniques including discrete time domain, conventional frequency domain, Lagrange multiplier, nonlinear programming, and control design synthesis were employed in these efforts. To enhance interactive conversation between the modeling and analysis subprograms and the user, a working prototype of the Data Management Program was also developed to facilitate expansion as future subprogram capabilities increase. Author

N78-28351*# California Inst. of Tech., Pasadena. Dept of Electrical Engineering
MODELLING, ANALYSES AND DESIGN OF SWITCHING CONVERTERS
Slobodan Cuk and R. D. Middlebrook [1978] 320 p refs Prepared for TRW Defense and Space Systems Group, Redondo Beach, Calif.
(Contracts NAS3-19690, NAS3-20102)
(NASA-CR-135174; TRW-A72042-RHBE; TRW-D04803-CFCM) Avail: NTIS HC A14/MF A01 CSCL 09C

A state-space averaging method for modeling switching dc-to-dc converters for both continuous and discontinuous conduction mode is developed. In each case the starting point is the unified state-space representation, and the end result is a complete linear circuit model, for each conduction mode, which correctly represents all essential features, namely, the input, output, and transfer properties (static dc as well as dynamic ac small-signal). While the method is generally applicable to any switching converter, it is extensively illustrated for the three common power stages (buck, boost, and buck-boost). The results for these converters are then easily tabulated owing to the fixed equivalent circuit topology of their canonical circuit model. The insights that emerge from the general state-space modelling approach lead to the design of new converter topologies through the study of generic properties of the cascade connection of basic buck and boost converters. F.O.S.

A78-18574* **Solid State Remote Power Controllers for high voltage DC distribution systems.** W. W. Billings (Westinghouse Electric Corp., Lima, Ohio) and G. R. Sundberg (NASA, Lewis Research Center, Cleveland, Ohio). In: NAECON '77; Proceedings of the National Aerospace and Electronics Conference, Dayton, Ohio, May 17-19, 1977. (A78-18551 04-33) New York, Institute of Electrical and Electronics Engineers, Inc., 1977, p. 186-192. 5 refs. Contract No. NAS3-20183.

Presently, hybrid Remote Power Controllers (RPC's) are in production and prototype units are available for systems utilizing 28VDC, 120VDC, 115VAC/400 Hz and 230VAC/400 Hz. This paper describes RPC development in a new area of application: HVDC distribution systems utilizing 270/300VDC. Two RPC current ratings, 1 amp and 2 amps, were selected for development as they are adequate to control 90% of projected system loads. The various aspects and trade-offs encountered in circuit development are discussed with special focus placed on the circuits that see the duress of the high dc potentials. The comprehensive evaluation tests are summarized which confirmed the RPC compliance with the specification and with system/load compatibility requirements. In addition, present technology status and new applications are summarized. (Author)

A78-18796*# **Discrete time domain modelling and analysis of dc-dc converters with continuous and discontinuous inductor current.** R. P. Iwens, F. C. Lee (TRW Defense and Space Systems Group, Redondo Beach, Calif.), and J. E. Triner (NASA, Lewis Research Center, Cleveland, Ohio). *International Federation of Automatic Control, Symposium on Control in Power Electronics and Electrical Drives, 2nd, Düsseldorf, West Germany, Oct. 3-5, 1977, Preprint.* 15 p. 9 refs. Contract No. NAS3-18918.

Using discrete time state variable representation, a generalized computer-aided modeling and analysis of dc-dc converters is presented. The methodology provides exact modeling and is applicable to all types of power stages and duty-cycle control, including continuous and discontinuous inductor current operation. Converter stability, transient behavior and audio susceptibility can be analytically evaluated and predicted. The generalized theory of the proposed approach to converter modeling and analysis is presented first, followed by a demonstrative example applying the theory to a constant frequency buck converter operating in continuous and discontinuous inductor current mode. Excellent agreement with laboratory test data has been observed. (Author)

34 FLUID MECHANICS AND HEAT TRANSFER

Includes boundary layers; hydrodynamics; fluidics; mass transfer; and ablation cooling.

For related information see also *02 Aerodynamics* and *77 Thermodynamics and Statistical Physics*.

N78-10415*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE DESIGN OF HYDRAULIC PRESSURE REGULATORS THAT ARE STABLE WITHOUT THE USE OF SENSING LINE RESTRICTORS OR FRICTIONAL DAMPERS

Harold Gold 1977 22 p refs Presented at Natl. Conf. on Fluid Power, Chicago, 25-27 Oct. 1977; sponsored by IIT
(NASA-TM-X-73687; E-9220) Avail: NTIS HC A02/MF A01 CSCL 20D

Parameters controlled in design determine the stability of hydraulic pressure regulators in service. The non-linear sensing line restrictor can provide stability, but degrades the transient response. Linear damping is not always physically realizeable and is sensitive to clearance and viscosity. Design relationships are analytically derived through which regulators can be made to be stable without the use of either of these damping means. The analytical distinctions between the parameters derived and those in prior literature are discussed. An analytically derived circuit component that stabilizes an otherwise unstable regulator and its experimental verification is described. Author

N78-10416*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RELEASE OF DISSOLVED NITROGEN FROM WATER DURING DEPRESSURIZATION TRANSIENTS: PRELIMINARY REPORT

Robert J. Simoneau 1977 25 p refs Presented at 5th Water Reactor Safety Res. Inform. Meeting, Gaithersburg, Md., 7-11 Nov. 1977, sponsored by Nucl. Regulatory Comm.
(NASA-TM-73822; E-9411) Avail: NTIS HC A02/MF A01 CSCL 20D

An experiment was run to study depressurization of water containing various concentrations of dissolved nitrogen gas, the primary case being room temperature water saturated with nitrogen at 4 MPa. The experiment had two major components both visual: a static depressurization experiment and a flow through a pressure gradient experiment. In the static depressurization experiment, water which had been bubbled with nitrogen for from 1 to 28 days, was depressurized at from 0.09 to 0.50 MPa/second. The transient was photographed with high speed movies. The pictures showed that the bubble population increased strongly with decreasing depressurization rate and weakly with increased bubble time. The water was always very nearly saturated with nitrogen. Bubbles rarely appeared before the pressured reached P sub zero/2 and in some instances levels of P sub zero/5 would show no bubbles. Flow experiments were performed in two nozzles, an axisymmetric converging-diverging nozzle and a two-dimensional converging nozzle with glass sidewalls. Depressurization rates were roughly 0.5 x 1000 to 1.2 x 1000 MPa/second. Both nozzles exhibited choked flow behavior even at nitrogen concentration levels as low as 4 percent of saturation. Author

N78-13361*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ON THE LOCALNESS OF THE SPECTRAL ENERGY TRANSFER IN TURBULENCE

R. G. Deissler 1977 20 p refs Presented at 13th Annv. Meeting of the Fluid Mec. Div. of the Amer. Phys. Soc., Bethlehem, Penn., 21-23 Nov. 1977
(NASA-TM-73824; E-9376) Avail: NTIS HC A02/MF A01 CSCL 20D

By utilizing available experimental data for net energy transfer spectra for homogeneous turbulence, contributions P(k,k prime 1) to the energy transfer at a wavenumber k from various other wavenumbers k prime 1 are calculated. This is done by fitting a truncated power - exponential series in k and k prime 1 to the experimental data for the net energy transfer T(k), and using known properties of P(k,k prime 1). Although the contributions P(k,k prime 1) obtained by using this procedure are not unique, the results obtained by using various assumptions do not differ significantly. It seems clear from the results that for a region where the energy entering a wavenumber band dominates that leaving, much of the energy entering the band comes from wavenumbers which are about an order of magnitude smaller. That is, the energy transfer is rather nonlocal. This result is not significantly dependent on Reynolds number. For lower wavenumbers, where more energy leaves than enters a wavenumber band, the energy transfer into the band is more local, but much of the energy then leaves at distant wavenumbers. Author

N78-13369*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECT OF AIRSTREAM VELOCITY ON MEAN DROP DIAMETERS OF WATER SPRAYS PRODUCED BY PRESSURE AND AIR ATOMIZING NOZZLES

Robert D. Ingebo 1977 9 p refs Presented at Winter Ann. Meeting, Atlanta, Ga., 27 Nov. - 2 Dec. 1977
(NASA-TM-73740; E-9304) Avail: NTIS HC A02/MF A01 CSCL 20D

A scanning radiometer was used to determine the effect of airstream velocity on the mean drop diameter of water sprays produced by pressure atomizing and air atomizing fuel nozzles used in previous combustion studies. Increasing airstream velocity from 23 to 53.4 meters per second reduced the Sauter mean diameter by approximately 50 percent with both types of fuel nozzles. The use of a sonic cup attached to the tip of an air assist nozzle reduced the Sauter mean diameter by approximately 40 percent. Test conditions included airstream velocities of 23 to 53.4 meters per second at 293 K and atmospheric pressure. Author

N78-13379*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EFFECTS OF FILM INJECTION ANGLE ON TURBINE VANE COOLING

James W. Gauntner Dec 1977 24 p refs
(NASA-TP-1095; E-9254) Avail: NTIS HC A02/MF A01 CSCL 20D

Film ejection from discrete holes in the suction surface of a turbine vane was studied for hole axes (1) slanted 30 deg to the surface in the streamwise direction and (2) slanted 30 deg to the surface and 45 deg from the streamwise direction toward the hub. The holes were near the throat area in a five-row staggered array with 8-diameter spacing. Mass flux ratios were as high as 1.2. The data were obtained in an annular sector cascade at conditions where both the ratio of the boundary layer momentum thickness-to-hole diameter and the momentum thickness Reynolds number were typical of an advanced turbofan engine at both takeoff and cruise. Wall temperatures were measured downstream of each of the rows of holes. Results of this study are expressed as a comparison of cooling effectiveness between the in-line angle injection and the compound-angle injection as a function of mass flux ratio. These heat transfer results are also compared with the results of a referenced flow visualization study. Also included is a closed-form analytical solution for temperature within the film cooled wall. Author

N78-14313*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EXPERIMENTAL EVALUATION OF PREMIXING-PREVAPORIZING FUEL INJECTION CONCEPTS FOR A GAS TURBINE CATALYTIC COMBUSTOR

Robert Tacina Aug 1977 19 p refs Presented at ASME Winter Ann. Meeting, Atlanta, 27 Nov. - 2 Dec. 1977
(Contract EC-77-A-31-1011)
(NASA-TM-73755; E-9301; CONS/1011-18) Avail: NTIS HC A02/MF A01 CSCL 20A

Experiments were performed to evolve and evaluate a premixing-prevaporizing fuel system to be used with a catalytic

combustor for possible application in an automotive gas turbine. Spatial fuel distribution and degree of vaporization were measured using Jet A fuel. Three types of air blast injectors, an air assist nozzle and a simplex pressure atomizer were tested. Air swirlers with vane angles up to 30 deg were used to improve the spatial fuel distribution. The work was done in a 12-cm (4.75-in.) diameter tubular rig. Test conditions were: a pressure of 0.3 and 0.5 MPa (3 and 5 atm), inlet air temperatures up to 800 K (980 F), velocity of 20 m/sec (66 ft/sec) and fuel-air ratios of 0.01 and 0.025. Uniform spatial fuel distributions that were within plus or minus 10 percent of the mean were obtained. Complete vaporization of the fuel was achieved with air blast configurations at inlet air temperatures of 550 K (530 F) and higher. The total pressure loss was less than 0.5 percent for configurations without air swirlers and less than 1 percent for configurations with a 30 deg vane angle air swirler. Author

N78-17336* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
MAGNETIC HEAT PUMPING Patent
Gerald V. Brown, inventor (to NASA) Issued 17 Jan. 1978 9 p. Filed 30 Nov. 1976 Supersedes N77-15343 (15 - 06, p. 0750)
(NASA-Case-LEW-12508-1; US-Patent-4,069,026; US-Patent-Appl-SN-746580; US-Patent-Class-62-3) Avail: US Patent Office CSCL 20D

A ferromagnetic or ferrimagnetic element is used to control the temperature and applied magnetic field of the element to cause the state of the element as represented on a temperature-magnetic entropy diagram to repeatedly traverse a loop. The loop may have a first portion of concurrent substantially isothermal or constant temperature and increasing applied magnetic field, a second portion of lowering temperature and constant applied magnetic field, a third portion of isothermal and decreasing applied magnetic field, and a fourth portion of increasing temperature and constant applied magnetic field. Other loops may be four-sided, with two isotherms and two adiabats. Preferably, a regenerator is used to enhance desired cooling or heating effects, with varied magnetic fields, or varying temperatures including three-sided figures traversed by the representative point.
Official Gazette of the U.S. Patent Office

N78-17338*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
METHOD FOR CALCULATING CONVECTIVE HEAT-TRANSFER COEFFICIENTS OVER TURBINE VANE SURFACES
Daniel J. Gauntner and James Sucec Jan. 1978 18 p. refs
(NASA-TP-1134; E-9324) Avail: NTIS HC A02/MF A01 CSCL 20D

A method for calculating laminar, transitional, and turbulent convective heat-transfer coefficients for turbine vane surfaces is described. An approximate integral solution method produced results in good agreement with a finite-difference solution. Comparisons between the two are presented. The integral solution results agreed well with the finite-difference solution results in the laminar and turbulent regions. Differences in calculating the start of transition produced a later starting point for the approximate integral solution's transitional flow regime. Author

N78-17340*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
HIGH TEMPERATURE SURFACE PROTECTION
Stanley R. Levine 1978 17 p. refs Presented at Spring Review Conf. of the Inst. of Metallurgists, Cardiff, Wales, 7-10 Apr. 1978
(NASA-TM-73877; E-9477) Avail: NTIS HC A02/MF A01 CSCL 20D

Alloys of the MCrAlX type are the basis for high temperature surface protection systems in gas turbines. M can be one or more of Ni, Co, or Fe and X denotes a reactive metal added to enhance oxide scale adherence. The selection and formation as well as the oxidation, hot corrosion and thermal fatigue performance of MCrAlX coatings are discussed. Coatings covered range from simple aluminides formed by pack cementation to the more advanced physical vapor deposition overlay coatings and developmental plasma spray deposited thermal barrier coatings. Author

N78-17341*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
ACCELERATED LIFE TESTS OF SPECIMEN HEAT PIPE FROM COMMUNICATION TECHNOLOGY SATELLITE (CTS) PROJECT
Leonard K. Tower and Warner B. Kaufman Dec. 1977 27 p. refs
(NASA-TM-73848; E-9433) Avail: NTIS HC A03/MF A01 CSCL 20D

A gas-loaded variable conductance heat pipe of stainless steel with methanol working fluid identical to one now on the CTS satellite was life tested in the laboratory at accelerated conditions for 14,200 hours, equivalent to about 70,000 hours at flight conditions. The noncondensible gas inventory increased about 20 percent over the original charge. The observed gas increase is estimated to increase operating temperature by about 2.2 C, insufficient to harm the electronic gear cooled by the heat pipes in the satellite. Tests of maximum heat input against evaporator elevation agree well with the manufacturer's predictions. Author

N78-18356* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
THERMAL BARRIER COATING SYSTEM Patent
Stephan Stecura and Curt H. Leibert, inventors (to NASA) Issued 25 Oct. 1977 3 p. Filed 14 May 1976 Supersedes N76-23359 (14 - 14, p. 1773)
(NASA-Case-LEW-12554-1; US-Patent-4,055,705; US-Patent-Appl-SN-686449; US-Patent-Class-428-633; US-Patent-Class-428-652; US-Patent-Class-428-667; US-Patent-Class-427-405; US-Patent-Class-427-419A; US-Patent-Class-427-34; US-Patent-Class-427-423) Avail: US Patent Office CSCL 20D

A coating system which contains a bond coating and a thermal barrier coating is applied to metal surfaces such as turbine blades and provides both low thermal conductivity and improved adherence when exposed to high temperature gases or liquids. The bond coating contains NiCrAlY and the thermal barrier coating contains a reflective oxide. The reflective oxides ZrO_2-Y_2O_3 and ZrO_2-MgO have demonstrated significant utility in high temperature turbine applications.
Official Gazette of the U.S. Patent Office

N78-20458*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
THE ROLE OF DROP VELOCITY IN STATISTICAL SPRAY DESCRIPTION
J. F. Groeneweg, M. M. El-Wakil (Wisc. Univ., Madison), P. S. Myers (Wisc. Univ., Madison), and O. A. Uyehara (Wisc. Univ., Madison) 1978 14 p. refs Presented at 1st Intern. Conf. on Liquid Atomization and Spray Systems, Tokyo, 29-31 Aug. 1978
(NASA-TM-73887; E-9502) Avail: NTIS HC A02/MF A01 CSCL 20D

The justification for describing a spray by treating drop velocity as a random variable on an equal statistical basis with drop size was studied experimentally. A double exposure technique using fluorescent drop photography was used to make size and velocity measurements at selected locations in a steady ethanol spray formed by a swirl atomizer. The size velocity data were categorized to construct bivariate spray density functions to describe the spray immediately after formation and during downstream propagation. Bimodal density functions were formed by environmental interaction during downstream propagation. Large differences were also found between spatial mass density and mass flux size distribution at the same location. Author

N78-20488*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

EVALUATION OF COMMERCIALLY-AVAILABLE SPACECRAFT-TYPE HEAT PIPER

W. B. Kaufman and L. K. Tower 1978 16 p refs Proposed for Presentation at the 3d Intern. Heat Pipes Conf., Palo Alto, Calif., 22-24 May 1978; Sponsored by AIAA

(NASA-TM-78826) Avail: NTIS HC A02/MF A01 CSCL 20D

As part of an effort to develop reliable, cost effective spacecraft thermal control heat pipes, life tests on 30 commercially available heat pipes in 10 groups of different design and material combinations were conducted. Results for seven groups were reported herein. Materials are aluminum and stainless steel, and working fluids are methanol and ammonia. The formation of noncondensible gas was observed for times exceeding 11,000 hours. The heat transport capacities of the pipes were also determined. Author

N78-21403*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CONSTRAINED SLOSHING OF LIQUID MERCURY IN A FLEXIBLE SPHERICAL TANK

Joseph Lestingi (Akron Univ., Ohio) and Ralph Zavesky Apr. 1978 12 p refs Presented at the 13th Intern. Elec. Propulsion Conf., San Diego, Calif., 25-27 Apr. 1978; sponsored by AIAA and DGLR

(NASA-TM-78833; E-9540) Avail: NTIS HC A02/MF A01 CSCL 20D

The mercury propellant tank system developed for use with solar electric propulsion was studied to analytically determine the resonant frequencies of the tank system and compare them with the anticipated control natural frequency of the spacecraft. The system consisted of a stainless steel spherical shell and a hemispherical elastometric diaphragm. The major analytical tool used was the NASTRAN program. Six mathematical models were developed. Resonant frequencies for six harmonics were obtained for each of the six models considered. The results show that the lowest resonant frequency for the tank system is about an order of magnitude greater than the anticipated control frequency of the spacecraft. Author

N78-21404*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

BOUNDARY LAYER ANALYSIS OF A CENTAUR STANDARD SHROUD

W. R. Hingst and C. E. Towne Mar. 1978 19 p refs

(NASA-TM-78843; E-9557) Avail: NTIS HC A02/MF A01 CSCL 20D

An analytical boundary layer investigation was carried out in conjunction with an experimental wind tunnel test to determine the discharge characteristics of the Centaur shroud escent vent system on the Titan/Centaur launch vehicle. This involved estimating the effect of the local boundary layers on the vent discharge for vehicle Mach numbers ranging from 0.8 to 1.58. The growth of the boundary layer along the vehicle was influenced by the interaction with flanges protruding into the flow and by the longitudinal corrugations in the vehicle surface. The effects of the flange and corrugations were treated by approximate techniques. In addition, boundary layer calculations were made for a 3 percent model of the launch vehicle compared with experimental results. Author

N78-22329*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NUMERICAL SPATIAL MARCHING TECHNIQUES FOR ESTIMATING DUCT ATTENUATION AND SOURCE PRESSURE PROFILES

K. J. Baumeister 1978 38 p refs Presented at the 95th Meeting of the Acoust. Soc. of Am., Providence, 16-19 May 1978

(NASA-TM-78857; E-9586) Avail: NTIS HC A03/MF A01 CSCL 20D

A numerical method was developed that could predict the pressure distribution of a ducted source from far field pressure inputs. Using an initial value formulation, the two-dimensional homogeneous Helmholtz wave equation (no steady flow) was solved using implicit marching techniques. The Von Neumann method was used to develop relationships which describe how sound frequency and grid spacing affect numerical stability. At the present time, stability considerations limit the approach to high frequency sound. Sample calculations for both hard and soft wall ducts compare favorably to known boundary value solutions. In addition, assuming that reflections in the duct are small, this initial value approach was successfully used to determine the attenuation of a straight soft wall duct. Compared to conventional finite difference or finite element boundary value approaches, the numerical marching technique is orders of magnitude shorter in computation time and required computer storage and can be easily employed in problems involving high frequency sound. Author

N78-22364*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

HIGH TEMPERATURE HEAT PIPE RESEARCH AT NASA LEWIS RESEARCH CENTER

L. K. Tower and W. B. Kaufman 1978 15 p refs Presented at the 3d Intern. Heat Pipe Conf., Palo Alto, Calif., 22-24 May 1978; sponsored by AIAA

(NASA-TM-78832; E-9537) Avail: NTIS HC A02/MF A01 CSCL 20D

High temperature refractory metal heat pipes with alkali metal working fluids, for use in thermionic space power systems, were studied. The main effort involved a concept for an out-of-core thermionic nuclear reactor power system. For this a lithium filled heat pipe of 335 cm length with 18 kW capacity was built in several modifications, one of them ultimately tested. Fabrication studies included the manufacture of a heat pipe tube of wire reinforced tantalum by chemical vapor deposition (CVD) and the extension to a reinforced pipe with integral arteries made by the CVD process. A lithium-filled CVD tungsten heat pipe of about 3 kW capacity ran several thousand hours above 1800 K. Materials compatibility studies of several liquid metals in tantalum alloy pipes were performed. Author

N78-23385*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

STIFFNESS OF STRAIGHT AND TAPERED ANNULAR GAS PATH SEALS

David P. Fleming 1978 23 p refs Proposed for presentation at Lubrication Conf., Minneapolis, 24-26 Oct. 1978; cosponsored by ASME and Am. Soc. Mech. Engr.

(NASA-TM-78872; E-9576) Avail: NTIS HC A02/MF A01 CSCL 20D

Radial stiffness of annular (ring-type) gas path seals are calculated for both constant-clearance designs and tapered designs for which the inlet clearance is larger than the outlet clearance. Under some conditions a constant-clearance seal can have a negative stiffness; this undesirable property is completely eliminated by use of tapered seals. Leakage rates are only moderately higher in tapered seals. Author

N78-24484*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

DEGREE OF VAPORIZATION USING AN AIRBLAST TYPE INJECTOR FOR A PREMIXED-PREVAPORIZED COMBUSTOR

Robert R. Tacina Apr. 1978 12 p refs To be presented at the 1st Intern. Conf. on Liquid Atomization and Spray Systems, Tokyo, 28-31 Aug. 1978, sponsored by the Fuel Soc. of Japan

(Contract EC-77-A-31-1011)

(NASA-TM-78836; E-9546) Avail: NTIS HC A02/MF A01 CSCL 20D

Vaporization data that could be useful in designing premixed prevaporized fuel preparation systems for gas turbine combustors are presented. The effect of the experimental parameters on vaporization was found to be E = T sub in tau 0.18 (V sub ref + 38) (P sub in + 35)/203000 where E is the degree of vaporization in percent, T sub in the inlet air temperature in K

over the range 450 to 700 K, the residence time in ms over the range 4.3 to 23.8 ms, V sub ref the reference velocity in m/s over the range 5 to 22 m/s, and P sub in the inlet pressure in MPa over the range 0.18 to 0.59 MPa. Jet A and Diesel no. 2 fuels were tested for the effect of inlet air temperature and were found to have nearly identical results. Author

N78-28381* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

FLOW COMPENSATING PRESSURE REGULATOR Patent

Edward F. Bashr, inventor (to NASA) Issued 18 Apr. 1978 5 p Filed 21 Mar. 1977 Supersedes N77-20408 (15 - 11, p 1453)

(NASA-Case-LEW-12718-1; US-Patent-4,084,612; US-Patent-Appl-SN-779428; US-Patent-Class-137-484.2; US-Patent-Class-137-501; US-Patent-Class-137-505.18) Avail: US Patent Office CSCL 20D

An apparatus for regulating pressure of treatment fluid during ophthalmic procedures is described. Flow sensing and pressure regulating diaphragms are used to modulate a flow control valve. The pressure regulating diaphragm is connected to the flow control valve to urge the valve to an open position due to pressure being applied to the diaphragm by bias means such as a spring. The flow sensing diaphragm is mechanically connected to the flow control valve and urges it to an opened position because of the differential pressure on the diaphragm generated by a flow of incoming treatment fluid through an orifice in the diaphragm. A bypass connection with a variable restriction is connected in parallel relationship to the orifice to provide for adjusting the sensitivity of the flow sensing diaphragm. A multiple lever linkage system is utilized between the center of the second diaphragm and the flow control valve to multiply the force applied to the valve by the other diaphragm and reverse the direction of the force. Official Gazette of the U.S. Patent Office

N78-28380*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

LITHIUM AND POTASSIUM HEAT PIPES FOR THERMIONIC CONVERTERS

Gabor Miskolczy (Thermo Electron Corp., Waltham, Mass.) and Erich Kroeger 1978 7 p refs Proposed for presentation at the 13th Intersociety Energy Conversion Engr. Conf., San Diego, Calif., 20-25 Aug. 1978, sponsored by SAE, ACS, AIAA, ASME, IEEE, AIChE, and ANS

(Contract NAS3-20270)

(NASA-TM-78946; E-9695) Avail: NTIS HC A02/MF A01 CSCL 20D

A prototypic heat pipe system for an out-of-core thermionic reactor was built and tested. The emitter of the concentric thermionic converter consists of the condenser of a tungsten heat pipe utilizing a lithium working fluid. The evaporator section of the emitter heat pipe is radiation heated to simulate the thermal input from the nuclear reactor. The emitter heat pipe thermal transport is matched to the thermionic converter input requirement. The collector heat pipe of niobium 1% zirconium alloy uses potassium as the working fluid. The thermionic collector is coupled to the heat pipe by a tapered conical joint designed to minimize the temperature drop. The collector heat flux matches the design requirements of the thermionic converter. Author

N78-27367*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

SOME FLOW PHENOMENA IN A CONSTANT AREA DUCT WITH A BORDA TYPE INLET INCLUDING THE CRITICAL REGION

R. C. Hendricks and R. J. Simoneau 1978 14 p refs Proposed for Presentation at the Winter Ann. Meeting, San Francisco, 10-15 Dec. 1978 Sponsored by ASME

(NASA-TM-78943; E-9690) Avail: NTIS HC A02/MF A01 CSCL 20D

Mass limiting flow characteristics for a 55 L/D tube with a borda type inlet were assessed over large ranges of temperature and pressure using fluid nitrogen. Under certain conditions separation and pressure drop at the inlet was sufficiently strong to permit partial vaporization and the remaining fluid flowed through the tube as if it were a free jet. An empirical relation was determined which defines conditions under which this type of flow can occur. A flow coefficient is presented which enables estimations of flow rates over the experimental range. A flow rate stagnation pressure map for selected stagnation isotherms and pressure profiles document these flow phenomena. J.A.M.

N78-27388*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

MEASUREMENT OF CONTROL SYSTEM RESPONSE USING AN ANALOG OPERATIONAL CIRCUIT

Vincent R. Lalli 1978 14 p refs Presented at the Elec./Electron. Conf. and Exposition, Cleveland, 9-11 May 1978; Sponsored by IEEE

(NASA-TM-78937; E-9580) Avail: NTIS HC A02/MF A01 CSCL 14B

Ten basic steps are established for an analog method that measures control system response parameters. An example shows how these steps were used on a speed control portion of an auxiliary power unit. The equations and calculations necessary to describe this subsystem are given. The mechanization schematic and simulation diagram for obtaining the measured response parameters of the control system using an analog circuit are explained. Methods for investigating the various effects of the control parameters are described. It is concluded that the optimum system should be underdamped enough to be slightly oscillatory during transients. Author

N78-28372*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

VELOCITY, TEMPERATURE, AND ELECTRICAL CONDUCTIVITY PROFILES IN HYDROGEN-OXYGEN MHD DUCT FLOWS

Mahesh S. Greywall and Carleon C. P. Pian 1978 11 p refs To be presented at the Winter Ann. Meeting of the ASME, San Francisco, 10-15 Dec. 1978 Prepared in cooperation with Wichita State Univ.

(Grant NsG-3186; Contract EF-77-A-01-2647)

(NASA-TM-78968; E-9717) Avail: NTIS HC A02/MF A01 CSCL 20D

Two-dimensional duct flow computations for radial distributions of velocity, temperature, and electrical conductivity are reported. Calculations were carried out for the flow conditions representative of a hydrogen-oxygen combustion driven MHD duct. Results are presented for profiles of developing flow in a smooth duct, and for profiles of fully developed pipe flow with a specified streamwise shear stress distribution. The predicted temperature and electrical conductivity profiles for the developing flows compare well with available experimental data. G.G.

N78-28374*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TACT1, A COMPUTER PROGRAM FOR THE TRANSIENT THERMAL ANALYSIS OF A COOLED TURBINE BLADE OR VANE EQUIPPED WITH A COOLANT INSERT. 1. USERS MANUAL

Raymond E. Gaugler Aug. 1978 78 p refs

(NASA-TP-1271; E-9554) Avail: NTIS HC A05/MF A01 CSCL 21E

A computer program to calculate transient and steady state temperatures, pressures, and coolant flows in a cooled, axial flow turbine blade or vane with an impingement insert is described. Coolant side heat transfer coefficients are calculated internally in the program, with the user specifying either impingement or convection heat transfer at each internal flow station. Spent impingement air flows in a chordwise direction and is discharged through the trailing edge and through film cooling holes. The ability of the program to handle film cooling is limited by the internal flow model. Sample problems, with tables of input and output are included in the report. Input to the program includes a description of the blade geometry, coolant supply conditions,

outside thermal boundary conditions, and wheel speed. The blade wall can have two layers of different materials, such as a ceramic thermal barrier coating over a metallic substrate. Program output includes the temperature at each node, the coolant pressures and flow rates, and the inside heat-transfer coefficients. Author

N78-28407*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
LIQUID PROPELLANT REORIENTATION IN A LOW-GRAVITY ENVIRONMENT
Irving E Sumner Jul 1978 52 p
(NASA-TM-78969; E-9716) Avail NTIS HC A04/MF A01 CSCL 20D

An existing empirical analysis relating to the reorientation of liquids in cylindrical tanks due to propulsive settling in a low gravity environment was extended to include the effects of geyser formation in the Weber number range from 4 to 10. Estimates of the minimum velocity increment required to be imposed on the propellant tank to achieve liquid reorientation were made. The resulting Bond numbers, based on tank radius, were found to be in the range from 3 to 5, depending upon the initial liquid fill level, with higher Bond number required for high initial fill levels. The resulting Weber numbers, based on tank radius and the velocity of the liquid leading edge, were calculated to be in the range from 6.5 to 8.5 for cylindrical tanks having a fineness ratio of 2.0, with Weber numbers of somewhat greater values for longer cylindrical tanks. It, therefore, appeared to be advantageous to allow small geysers to form and then dissipate into the surface of the collected liquid in order to achieve the minimum velocity increment. The Bond numbers which defined the separation between regions in which geyser formation did and did not occur due to propulsive settling in a spherical tank configuration ranged from 2 to 9 depending upon the liquid fill level. 38

N78-33388*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
ENGINEERING IN THE 21ST CENTURY
John F McCarthy, Jr 1978 15 p refs Presented at the 25th Anniv Conf of the Am. Astronautical Soc., Houston, Tex., 30 Oct 1978 - 2 Nov 1978
(NASA-TM-79010; E-9714) Avail NTIS HC A02/MF A01 CSCL 12B

Reasonable evolutionary trends in federal outlays for aerospace research and development predict a continuing decline in real resources (1970 dollars) until the mid eighties, and a growth thereafter to the 1970 level by 2000, still well below the 1966 peak. Employment levels will parallel this trend with no shortage of available personnel foreseen. These trends characterize a maturing industry. Shifts in outlook toward the economic use of resources, rather than minimum risk at any cost, and toward missions aligned with societal needs and broad national goals will accompany these trends. These shifts in outlook will arise in part in academia, and will, in turn, influence engineering education. By 2000 space technology will have achieved major advances in the management of information, in space transportation, in space structures, and in energy. The economics of space systems must be the primary consideration if the space program foreseen for the 21st century is to become an actuality. Author

A78-15725* Revised international representations for the viscosity of water and steam and new representations for the surface tension of water. R. C. Hendricks (NASA, Lewis Research Center, Cleveland, Ohio), R. B. McClintock (General Electric Co., Schenectady, N.Y.), and G. J. Silvestri (Westinghouse Electric Corp., Philadelphia, Pa.). *ASME, Transactions, Series A - Journal of Engineering for Power*, vol. 99, Oct. 1977, p. 664-678. 11 refs.

A78-15820*# Boiling incipience and convective boiling of neon and nitrogen. S. S. Papell and R. C. Hendricks (NASA, Lewis Research Center, Cleveland, Ohio). *National Bureau of Standards, Cryogenic Engineering Conference, University of Colorado, Boulder, Colo., Aug. 2-5, 1977, Paper.* 17 p. 6 refs.

Forced convection and subcooled boiling heat transfer data for liquid nitrogen and liquid neon were obtained in support of a design study for a 30 tesla cryomagnet cooled by forced convection of liquid neon. This design precludes nucleate boiling in the flow channels as they are too small to handle vapor flow. Consequently, it was necessary to determine boiling incipience under the operating conditions of the magnet system. The cryogen data obtained over a range of system pressures, fluid flow rates, and applied heat fluxes were used to develop correlations for predicting boiling incipience and convective boiling heat transfer coefficients in uniformly heated flow channels. The accuracy of the correlating equations was then evaluated. A technique was also developed to calculate the position of boiling incipience in a uniformly heated flow channel. Comparisons made with the experimental data showed a prediction accuracy of plus or minus 15 percent. (Author)

A78-15821*# Effect of ice contamination on liquid-nitrogen drops in film boiling. G. J. Schoessow (NASA, Lewis Research Center, Cleveland, Ohio; Florida, University, Gainesville, Fla.), C. E. Chmielewski (NASA, Lewis Research Center, Cleveland, Ohio; Indiana Public Service Co., Plainfield, Ind.), and K. J. Baumeister (NASA, Lewis Research Center, Cleveland, Ohio). *National Bureau of Standards, Cryogenic Engineering Conference, University of Colorado, Boulder, Colo., Aug. 2-5, 1977, Paper.* 11 p. 8 refs.

Previously reported vaporization time data of liquid nitrogen drops in film boiling on a flat plate are about 30 percent shorter than predicted from standard laminar film boiling theory. This theory, however, had been found to successfully correlate the data for conventional fluids such as water, ethanol, benzene, or carbon tetrachloride. This paper presents experimental evidence that some of the discrepancy for cryogenic fluids results from ice contamination due to condensation. The data indicate a fairly linear decrease in droplet evaporation time with the diameter of the ice crystal residue. After correcting the raw data for ice contamination along with convection, a comparison of theory with experiment shows good agreement. (Author)

A78-15822*# Estimating surface temperature in forced convection nucleate boiling - A simplified method. R. C. Hendricks and S. S. Papell (NASA, Lewis Research Center, Cleveland, Ohio). *National Bureau of Standards, Cryogenic Engineering Conference, University of Colorado, Boulder, Colo., Aug. 2-5, 1977, Paper.* 7 p. 9 refs.

A simplified expression to estimate surface temperatures in forced convection boiling was developed using a liquid nitrogen data base. Using the principal of corresponding states and the Kutateladze relation for maximum pool boiling heat flux, the expression was normalized for use with other fluids. The expression was applied also to neon and water. For the neon data base, the agreement was acceptable with the exclusion of one set suspected to be in the transition boiling regime. For the water data base at reduced pressure greater than 0.06 the agreement is generally good. At lower reduced pressures, the water data scatter and the calculated temperature becomes a function of flow rate. (Author)

A78-15824*# Two phase choke flow in tubes with very large L/D. R. C. Hendricks and R. J. Simoneau (NASA, Lewis Research Center, Cleveland, Ohio). *National Bureau of Standards, Cryogenic Engineering Conference, University of Colorado, Boulder, Colo., Aug. 2-5, 1977, Paper.* 21 p. 19 refs.

Two phase and gaseous choked flow data for fluid nitrogen were obtained for a test section which was a long constant area duct of 16 200 L/D with a diverging diffuser attached to the exit. Flow rate data were taken along five isotherms (reduced temperature of 0.81, 0.96, 1.06, 1.12, and 2.34) for reduced pressures to 3. The flow rate

data were mapped in the usual manner using stagnation conditions at the inlet mixing chamber upstream of the entrance length. The results are predictable by a two-phase homogeneous equilibrium choking flow model which includes wall friction. A simplified theory which in essence decouples the long tube region from the high acceleration choking region also appears to predict the data reasonably well, but about 15 percent low. (Author)

A78-17481 * # **Velocity and temperature profiles in near-critical nitrogen flowing past a horizontal flat plate.** R. J. Simoneau (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Chemical Engineers and American Society of Mechanical Engineers, Heat Transfer Conference, Salt Lake City, Utah, Aug. 15-17, 1977, ASME Paper 77-HT-7.* 8 p. 11 refs. Members, $1.50; nonmembers, $3.00.

Boundary layer velocity and temperature profiles were measured for nitrogen near its thermodynamic critical point flowing past a horizontal flat plate. The heated surface was oriented both facing upward and downward. The results were compared to earlier work in which measurements were made for vertically upward flow. The boundary layer temperatures ranged from below to above the thermodynamic critical temperature. For wall temperatures below the thermodynamic critical temperature there was little variation between the velocity and temperature profiles in the three orientations. In all three orientations the point of crossing into the critical temperature region is marked by a significant flattening of the velocity and temperature profiles and also a decrease in heat transfer coefficient. As the heat flux and, consequently, wall temperature are further increased significant changes occur in the velocity and temperature profiles. Examination of near-critical heat transfer in these three flow orientations offers insights into the relative role of buoyancy forces in this regime. (Author)

A78-17508 * # **Thermally driven oscillations and wave motion of a liquid drop.** K. J. Baumeister, R. C. Hendricks (NASA, Lewis Research Center, Cleveland, Ohio), and G. J. Schoessow (Florida, University, Gainesville, Fla.). *American Institute of Chemical Engineers and American Society of Mechanical Engineers, Heat Transfer Conference, Salt Lake City, Utah, Aug. 15-17, 1977, Paper.* 11 p. 16 refs. Members, $1.50, nonmembers, $3.00.

In the state of Leidenfrost boiling, liquid drops are observed to vibrate in a variety of modal patterns. Theories are presented which predict the frequency of oscillation and show that the observed modal patterns of drops correspond to the minimum energy oscillatory excitation state. High-speed photographic techniques were used to record these motions and substantiate the theories. An incipient temperature was also found for water drops in film boiling below which free oscillations do not exist. In addition to these oscillations, photographic sequences are presented which show that wave motion can exist along the circumference of the drop. Following the study of free oscillations, the system was mounted on a shaker table and the drop subjected to a range of forced frequencies and accelerations. (Author)

A78-20682 * # **A computer program for the transient thermal analysis of an impingement cooled turbine blade.** R. E. Gaugler (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 16th, Huntsville, Ala., Jan. 16-18, 1978, Paper 78-92.* 9 p. 8 refs.

A computer program to calculate transient and steady state temperatures, pressures, and coolant flows in a cooled turbine blade or vane with an impingement insert is described. Input to the program includes a description of the blade geometry, coolant supply conditions, outside thermal boundary conditions and wheel speed. Coolant side heat transfer coefficients are calculated internally in the program, with the user specifying the mode of heat transfer at each internal flow station. Program output includes the temperature at each node, the coolant pressures and flow rates and the inside heat transfer coefficients. A sample problem is discussed. (Author)

A78-23246 * # **Characteristics of the unsteady motion on transversely sheared mean flows.** M. E. Goldstein (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Fluid Mechanics*, vol. 84, Jan. 30, 1978, p. 305-329. 15 refs.

An explicit representation for the unsteady motion on a transversely sheared mean flow is obtained which corresponds to the gustline motion on a uniform mean flow. The important features of this motion are discussed. It is shown that its velocity, pressure and vorticity are all induced by a certain disturbance field that is a linear combination of the vorticity and particle-displacement fields and is everywhere frozen in the mean flow. The general ideas are illustrated by considering the scattering of a gust by a half-plane embedded in a shear flow. (Author)

A78-24909 * # **On the localness of the spectral energy transfer in turbulence.** R. G. Deissler (NASA, Lewis Research Center, Cleveland, Ohio). *American Physical Society, Anniversary Meeting of the Fluid Mechanics Division, 30th, Bethlehem, Pa., Nov. 21-23, 1977, Paper.* 19 p. 12 refs.

Data for the energy transfer function are used to estimate the degree of localness of energy transfer in homogeneous turbulence. It is found that in regions where the energy which enters a wavenumber band is greater than the energy leaving, much of the energy entering the band is produced by wavenumbers an order of magnitude smaller. Thus for both low and high Reynolds numbers, spectral energy transfer is nonlocal. The tendency of the energy to jump between separated wavenumber regions agrees with the theory that turbulence forms concentrated regions of large velocity gradients. It is also felt that the universal equilibrium theory may be applicable if the Reynolds number of the turbulence is very high. S.C.S.

A78-32749 * # **Constrained sloshing of liquid mercury in a flexible spherical tank.** J. Lestingi (Akron, University, Akron, Ohio) and R. Zavesky (NASA, Lewis Research Center, Mechanical Engineering Section, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft fur Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA Paper 78-670.* 8 p. 7 refs.

The mercury propellant tank system developed for use with solar electric propulsion was studied to analytically determine the resonant frequencies of the tank system and compare them with the anticipated control natural frequency of the spacecraft. The system consisted of a stainless steel spherical shell and a hemispherical elastomeric diaphram which separates the mercury propellant and the gaseous nitrogen pressurant. The major analytical tool used was the NASTRAN program. Six mathematical models, which represent various amounts of mercury in the tank system were developed. Resonant frequencies for six harmonics were obtained for each of the six models considered. The results show that the lowest resonant frequency for the tank system is about an order of magnitude greater than the anticipated control frequency of the spacecraft. (Author)

A78-35618 * # **High temperature heat pipe research at NASA Lewis Research Center.** L. K. Tower and W. B. Kaufman (NASA, Lewis Research Center, Cleveland, Ohio). In: International Heat Pipe Conference, 3rd, Palo Alto, Calif., May 22-24, 1978, Technical Papers. (A78-35576 14-34) New York, American Institute of Aeronautics and Astronautics, Inc., 1978, p. 303-311. (AIAA 78-438)

In the course of studies of thermionic power plants for space applications, high temperature refractory metal heat pipes have been designed and built for alkali metal working fluids. Fabrication of tungsten wire-reinforced tantalum pipes by chemical vapor deposition is discussed, the development of reinforced pipes with integral arteries produced by chemical vapor deposition is also mentioned. The feasibility of using lithium, sodium, potassium, cesium or mercury as the working fluid in the heat pipes is also reviewed. Operation of a lithium-filled heat pipe of about 3 kW capacity for several thousand hours is reported. J.M.B.

A78-40983 * Turbulence processes and simple closure schemes. R. G. Deissler (NASA, Lewis Research Center, Cleveland, Ohio). In: Handbook of turbulence. Volume 1 Fundamentals and applications. (A78-40976 17-34) New York, Plenum Press, 1977, p. 165-186. 23 refs.

The problem of closure in turbulence in the case of two-point correlations resides in the existence of two unknowns E and W, the energy spectrum function and the transfer function, respectively, in the spectrum equation. In the case of weak turbulence, W is negligible. In case of higher correlations, closure can be effective by neglecting the inertia term in the highest order term used. Specifying a certain number of spectra at an initial time is also a way of getting around the closure problem. A simple case of turbulent shear flow is then considered, where two-point correlation equations are used and the velocity is broken into mean and fluctuating components. This yields a differential equation for the energy spectrum, the three terms of which are the energy spectrum, production term and dissipation term. They are plotted for a particular time. Similar analyses and comparisons with experiment are made for pipe and boundary layer flows. P.T.H.

A78-41154 * # Liquid jet impingement normal to a disk in zero gravity. T. L. Labus (NASA, Lewis Research Center, Cleveland, Ohio) and K. J. DeWitt (Toledo, University, Toledo, Ohio). *(American Society of Mechanical Engineers, Paper 78-WA/FE-1,* 1978.) *ASME, Transactions, Journal of Fluids Engineering,* vol. 100, June 1978, p. 204-209. 27 refs.

An experimental and analytical investigation was conducted to determine the free surface shapes of circular jets impinging normal to sharp-edged disks in zero gravity. Experiments conducted in a zero gravity drop tower yielded three distinct flow patterns which were classified in terms of the relative effects of surface tension and inertial forces. An order of magnitude analysis was conducted indicating regions where viscous forces were not significant when computing free surface shapes. The free surface analysis was simplified by transforming the governing potential flow equations and boundary conditions into the inverse plane. The resulting nonlinear equations were solved numerically and comparisons were made with the experimental data for the inertia dominated regime. (Author)

A78-45431 * # Performance characteristics of two annular dump diffusers using suction-stabilized vortex flow control. A. J. Juhasz and J. M. Smith (NASA, Lewis Research Center, Cleveland, Ohio). *International Association for Hydraulic Research, ASME, and ASCE, Joint Symposium on Design and Operation of Fluid Machinery, Fort Collins, Colo., June 12-14, 1978, Paper.* 13 p. 7 refs.

The two diffusers employed in the investigation had the same overall area ratio but different prediffuser area ratios and suction slot geometries. Velocity profile and diffuser pressure recovery performance data were obtained at ambient pressure and temperature, with inlet Mach numbers ranging from 0.18 to 0.41 and suction rate varying from zero to 18% of total inlet mass flow rate. On the basis of the reported investigation it is concluded that suction stabilized vortex flow diffusers show promise for application in combustors because of relatively high static pressure recovery and low total pressure loss obtained in a short length. Performance obtained using a narrow angle (7 degree) prediffuser was superior to that obtained with a prediffuser having a 14 degree included angle. G.R.

A78-50322 * # Degree of vaporization using an airblast type fuel injector for a premixed-prevaporized combustor. R. R. Tacina (NASA, Lewis Research Center, Cleveland, Ohio). *Fuel Society of Japan, International Conference on Liquid Atomization and Spray Systems, 1st, Tokyo, Japan, Aug. 28-31, 1978, Paper.* 11 p. 9 refs. Contract No. EC-77-A-31-1011.

Vaporization data are presented which could be useful in designing premixed-prevaporized fuel preparation systems for gas turbine combustors. Lean, premixed-prevaporized combustion systems are being developed because they operate with low flame temperatures and, therefore, produce low levels of nitrogen oxides. Parametric tests of the effect of inlet air temperature, length (residence time), reference velocity, pressure and fuel-air ratio on the degree of vaporization are reported. Jet A and Diesel no. 2 fuel were tested. A formula is provided which shows the effect of inlet air temperature, residence time, reference velocity, and pressure on the degree of vaporization for a constant fuel-air ratio of 0.020. The results of the effect of inlet air temperature on the degree of vaporization using Jet A and Diesel no. 2 are nearly identical. G.R.

A78-50323 * # The role of drop velocity in statistical spray description. J. F. Groeneweg (NASA, Lewis Research Center, Cleveland, Ohio), M. M. El-Wakil, P. S. Myers, and O. A. Uyehara (Wisconsin, University, Madison, Wis.). *Fuel Society of Japan, International Conference on Liquid Atomization and Spray Systems, 1st, Tokyo, Japan, Aug. 28-31, 1978, Paper.* 16 p. 15 refs.

The justification for describing a spray by treating drop velocity as a random variable on an equal statistical basis with drop size was studied experimentally. A double-exposure technique using fluorescent drop photography was used to make size and velocity measurements at selected locations in a steady ethanol spray formed by a swirl atomizer. The size-velocity data were categorized to construct bivariate spray density functions to describe the spray immediately after formation and during downstream propagation. It was found that a statistical treatment of drop velocity was supported by the data. Spray density function shapes and modal characteristics depended strongly on position and the amount of droplet-gas interaction that had occurred. Bimodal density functions were formed by environmental interaction during downstream propagation. Large differences were also found between spatial mass density and mass flux size distributions at the same location. (Author)

N78-12384*# Martin Marietta Corp., Denver, Colo.
EFFECT OF VIBRATION ON RETENTION CHARACTERISTICS OF SCREEN ACQUISITION SYSTEMS Final Report, May 1976 - Jun. 1977
J. R. Tegart and A. C. Park Oct. 1977 167 p refs
(Contract NAS3-20097)
(NASA-CR-135264; MCR-77-253) Avail: NTIS HC A08/MF A01 CSCL 20D

An analytical and experimental investigation of the effect of vibration on the retention characteristics of screen acquisition systems was performed. The functioning of surface tension devices using fine-mesh screens requires that the pressure differential acting on the screen be less than its pressure retention capability. When exceeded, screen breakdown will occur and gas-free expulsion of propellant will no longer be possible. An analytical approach to predicting the effect of vibration was developed. This approach considers the transmission of the vibration to the screens of the device and the coupling of the liquid and the screen in establishing the screen response. A method of evaluating the transient response of the gas/liquid interface within the screen was also developed. Author

N78-16329*# Sigma Research, Inc., Richland, Wash.
TWO-PHASE WORKING FLUIDS FOR THE TEMPERATURE RANGE 60 TO 350 C Final Report
Elric W. Saaski and Peter C. Owzarski Jun. 1977 103 p refs
(Contract NAS3-20222)
(NASA-CR-135255) Avail: NTIS HC A06/MF A01 CSCL 20D

The decomposition and corrosion of two-phase heat transfer liquids and metal envelopes have been investigated on the basis of molecular bond strengths and chemical thermodynamics. Potentially stable heat transfer fluids for the temperature range 100 C to 350 C have been identified, and reflux heat pipes tests initiated with 10 fluids and carbon steel and aluminum envelopes to experimentally establish corrosion behavior and noncondensable gas generation rates. Author

N78-17342*# Aerojet Liquid Rocket Co., Sacramento, Calif.
SUPERCRITICAL OXYGEN HEAT TRANSFER Final Report
R. G. Spencer and D. C. Rouser Nov. 1977 95 p refs
(Contract NAS3-20384)
(NASA-CR-135339) Avail: NTIS HC A05/MF A01 CSCL 20D

Heat transfer to supercritical oxygen was experimentally measured in electrical heated tubes. Experimental data were obtained for pressures ranging from 17 to 34.5 MPa (2460 to 5000 psia), and heat fluxes from 2 to 90 million w/sq cm (1.2 to 55 Btu/(sq in. sec)). Bulk temperatures ranged from 96 to 217 K (173 to 391 R). Experimental data obtained by other investigators were added to this to increase the range of pressure down to 2 MPa (290 psia) and increase the range of bulk temperature up to 566 K (1019 R). From this compilation of experimental data a correlating equation was developed which predicts over 95% of the experimental data within + or - 30%.
Author

N78-29410*# TRW Defense and Space Systems Group, Redondo Beach, Calif.
CTS TEP THERMAL ANOMALIES: HEAT PIPE SYSTEM PERFORMANCE Final Report
B. D. Marcus 30 Nov. 1977 61 p refs
(Contract NAS3-21012)
(NASA-CR-159413) Avail: NTIS HC A04/MF A01 CSCL 20D

A part of the investigation is summarized of the thermal anomalies of the transmitter experiment package (TEP) on the Communications Technology Satellite (CTS) which were observed on four occasions in 197 . Specifically, the possible failure modes of the variable conductance heat pipe system (VCHPS) used for principal thermal control of the high-power traveling wave tube in the TEP are considered. Further, the investigation examines how those malfunctions may have given rise to the TEP thermal anomalies. Using CTS flight data information, ground test results, analysis conclusions, and other relevant information, the investigation concentrated on artery depriming as the most likely VCHPS failure mode. Included in the study as possible depriming mechanisms were freezing of the working fluid, Marangoni flow, and gas evolution within the arteries. The report concludes that while depriming of the heat pipe arteries is consistent with the bulk of the observed data, the factors which cause the arteries to deprime have yet to be identified.
L.S.

N78-31380*# General Dynamics/Convair, San Diego, Calif.
FILLING OF ORBITAL FLUID MANAGEMENT SYSTEMS
F. Merino, M. H. Blatt, and N. C. Thies Jul. 1978 117 p refs
(Contract NAS3-21021)
(NASA-CR-159404; CASD-NAS-78-010) Avail: NTIS HC A06/MF A01 CSCL 20D

A study was performed with three objectives: (1) analyze fluid management system fill under orbital conditions, (2) determine what experimentation is needed, and (3) develop an experimental program. The fluid management system was a 1.06m (41.7 in) diameter pressure vessel with screen channel device. Analyses were conducted using liquid hydrogen and N2O4. The influence of helium and autogenous pressurization systems was considered. Analyses showed that fluid management system fill will be more difficult with a cryogen than with an earth storable. The key to a successful fill with cryogens is in devising techniques for filling without vent liquid, and removing trapped vapor from the screen device at tank fill completion. This will be accomplished with prechill, fill, and vapor condensation processes. Refill will require a vent and purge process, to dilute the residual helium, prior to introducing liquid. Neither prechill, chill, nor purge processes will be required for earth storables.
Author

N78-33380*# Colorado State Univ., Fort Collins. Fluid Mechanics and Wind Engineering Program.
A VISUAL INVESTIGATION OF TURBULENCE IN STAGNATION FLOW ABOUT A CIRCULAR CYLINDER Final Report
Willy Z. Sadeh and Hervert J. Brauer Oct. 1978 82 p refs
Film supplement Number C-288 to this report is available on loan from Chief Management Services Division (6-5), National Aeronautics and Space Administration, Lewis Research Center, 2100 Brookpark Road, Cleveland, Ohio 44135
(Grant NsG-3127)
(NASA-CR-3019; CSU-FMWEP-NASLRC-1; CER-77-78WZS-HG1322) Avail: NTIS HC A04/MF A01 CSCL 20D

A visual investigation of turbulence in stagnation flow around a circular cylinder was carried out in order to gain a physical insight into the model advocated by the corticity-amplification theory. Motion pictures were taken from three different viewpoints, and a frame by frame examination of selected movie strips was conducted. Qualitative and quantitative analyses of the flow events focused on tracing the temporal and spatial evolution of a cross-vortex tube outlined by the entrained smoke filaments. The visualization supplied evidence verifying: (1) the selective stretching of cross-vortex tubes which is responsible for the amplification of cross vorticity and, hence, of streamwise turbulence; (2) the streamwise tilting of stretched cross-vortex tubes; (3) the existence of a coherent array of vortices near the stagnation zone; (4) the interaction of the amplified vorticity with the body laminar boundary layer; and, (5) the growth of a turbulent boundary layer.
Author

A78-42877 * # Flow of liquid jets through closely woven screens. F. T. Dodge and R. E. Ricker (Southwest Research Institute, San Antonio, Tex.). *Journal of Spacecraft and Rockets*, vol. 15, July-Aug. 1978, p. 213-218. 9 refs. Contract No. NAS3-20086.

Previously developed analytical models relate pressure drop across a fine-mesh screen to throughflow velocity for duct systems. These models are shown to be unreliable for an unconfined flow, such as a free jet, impinging on a screen. A new model is developed for these kinds of systems, incorporating the important influence of liquid deflection by the screen. A new parameter, the boundary-layer blockage coefficient, is introduced. This coefficient, which depends on the screen weave geometry and the jet impingement angle, accounts for the increase in fluid path length through the screen resulting from the flow deflection. Comparisons are made with previous experimental studies to determine empirical values of the blockage coefficient. It is concluded that the new model reliably predicts the bulk flow and penetration characteristics of an impinging liquid jet interacting with a screen.
(Author)

A78-48716 * # Convection due to surface-tension gradients. S. Ostrach (Case Western Reserve University, Cleveland, Ohio). *COSPAR Plenary Meeting, 21st, Innsbruck, Austria, May 29-June 10, 1978, Paper.* 9 p. 19 refs. Contract No. NAS3-21046.

The use of dimensionless parameters to study fluid motions that could occur in a reduced gravity environment is discussed. The significance of the Marangoni instability is considered, and the use of dimensionless parameters to investigate problems such as thermo and diffusocapillary flows is described. Characteristics of fluid flow in space are described, and the relation and interaction of motions due to capillarity and buoyancy is examined.
M.L.

35 INSTRUMENTATION AND PHOTOGRAPHY

Includes remote sensors; measuring instruments and gages; detectors; cameras and photographic supplies; and holography.

For aerial photography see *43 Earth Resources*. For related information see also *06 Aircraft Instrumentation* and *15 Spacecraft Instrumentation*.

N78-13407*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RELIABILITY ANALYSIS OF FORTY-FIVE STRAIN-GAGE SYSTEMS MOUNTED ON THE FIRST FAN STAGE OF A YF-100 ENGINE

Raymond Holanda and Lloyd M. Frause Sep. 1977 20 p refs

(NASA-TM-73724; E-9274) Avail: NTIS HC A02/MF A01 CSCL 14B

The reliability of 45 state-of-the-art strain gage systems under full scale engine testing was investigated. The flame spray process was used to install 23 systems on the first fan rotor of a YF-100 engine, the others were epoxy cemented. A total of 56 percent of the systems failed in 11 hours of engine operation. Flame spray system failures were primarily due to high gage resistance, probably caused by high stress levels. Epoxy system failures were principally erosion failures, but only on the concave side of the blade. Lead-wire failures between the blade-to-disk jump and the control room could not be analyzed. Author

N78-15463*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RECOVERY AND RADIATION CORRECTIONS AND TIME CONSTANTS OF SEVERAL SIZES OF SHIELDED AND UNSHIELDED THERMOCOUPLE PROBES FOR MEASURING GAS TEMPERATURE

George E. Glawe, Raymond Holanda, and Lloyd N. Krause Jan 1978 30 p refs

(NASA-TP-1099; E-9289) Avail: NTIS HC A03/MF A01 CSCL 14B

Performance characteristics were experimentally determined for several sizes of a shielded and unshielded thermocouple probe design. The probes are of swaged construction and were made of type K wire with a stainless steel sheath and shield and MgO insulation. The wire sizes ranged from 0.03- to 1.02-mm diameter for the unshielded design and from 0.16- to 0.81-mm diameter for the shielded design. The probes were tested through a Mach number range of 0.2 to 0.9, through a temperature range of room ambient to 1420 K, and through a total-pressure range of 0.03 to 0.22 MPa (0.3 to 2.2 atm). Tables and graphs are presented to aid in selecting a particular type and size. Recovery corrections, radiation corrections, and time constants were determined. Author

N78-23028*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

APPLICATION OF FLUIDICS TO NEW CONTROL COMPONENTS

Miles O. Dustin, Vernon D. Gebben, and Robert E. Wallhagen *In* NASA, Washington Fourth Inter-Center Control Systems Conf. Jan. 1978 p 365-386 refs (For availability see N78-23010 13-99)

Avail: NTIS HC A22/MF A01 CSCL 20D

A78-11392*# **A low cost, portable instrument for measuring emittance.** G. McDonald (NASA, Lewis Research Center, Cleveland, Ohio). *International Solar Energy Society, Annual Meeting, Orlando, Fla., June 6-10, 1977, Paper.* 10 p.

A low cost, portable instrument has been developed with which emittance can be measured by comparison to a standard. A reflector collects infra-red radiation from a heated sample onto a low mass, black detector and the temperature rise of the black detector is measured with a thermocouple and meter. Graphical examples are presented for determination of emittance from measurements made on a sample at any known temperature. (Author)

A78-17397* **Miniature drag force anemometer.** L. N. Krause and G. C. Fralick (NASA, Lewis Research Center, Cleveland, Ohio). In: International Instrumentation Symposium, 23rd, Las Vegas, Nev., May 1-5, 1977, Proceedings. (A78-17351 05-35) Pittsburgh, Pa., Instrument Society of America, 1977, p. 461-467. 7 refs.

A miniature drag force anemometer is described which is capable of measuring dynamic velocity head and flow direction. The anemometer consists of a silicon cantilevered beam 2.5 mm long, 1.5 mm wide, and 0.25 mm thick with an integrated diffused strain gage bridge, located at the base of the beam, as the force measuring element. The dynamics of the beam are like that of a second order system with a natural frequency of about 42 kHz and a damping coefficient of 0.007. The anemometer can be used in both forward and reversed flow. Measured flow characteristics up to Mach 0.6 are presented along with application examples including turbulence measurements. (Author)

A78-23525* **Development of a drift-correction procedure for a photoelectric spectrometer.** G. B. Chapman, II and W. A. Gordon (NASA, Lewis Research Center, Cleveland, Ohio). *Applied Spectroscopy*, vol. 32, Jan.-Feb. 1978, p. 46-53. 6 refs.

A technique has been developed to automatically correct for drifts in the radiometric sensitivity of the detector channels in a direct-reading emission spectrometer. The method utilizes a 1000 W tungsten-halogen reference lamp to illuminate the detectors through the same optical path as that traversed during the analysis of the sample. Detector channel responses to the light are compared to those for the same light intensity at the time of analytical calibration. This corrects for the drift. It is noted that with the exception of positioning the lamp, the procedure is fully automatic. S.C.S.

A78-33365* **Instrumentation for propulsion systems development.** I. Warshawsky (NASA, Lewis Research Center, Cleveland, Ohio). *Society of Automotive Engineers, Congress and Exposition, Detroit, Mich., Feb. 27-Mar. 3, 1978, Paper 780076.* 11 p. 20 refs.

Various types of instrumentation for the development of propulsion systems are discussed. For the steady-state measurement of local temperature, pressure and flow velocity in gases the devices include: a multielement probe, calibrated thermocouple probes, thermocouple probes designed for low gas velocities, pressure measuring devices for high-speed rotors, and instruments for data pickup from rotating members. For the dynamic measurements of the same factors attention is given to 2-mm diameter pressure transducers, flush-diaphragm transducers, resistance thermometers or thermocouples, and miniature transducers for velocity measurements. Instruments for compressor and turbine blade instrumentation are described with reference to a pyrometer for mapping turbine blade surface temperature, a capacitance method for making rotor clearance measurements, and optical detection procedures for blade vibration amplitude. S.C.S.

A78-38826 * Ultraviolet spectrophotometer for measuring columnar atmospheric ozone from aircraft. F. A. Hanser, B. Sellers (Panametrics, Inc., Waltham, Mass.), and D. C. Brichl (NASA, Lewis Research Center, Cleveland, Ohio). *Applied Optics*, vol. 17, May 15, 1978, p. 1649-1656. 40 refs.

An ultraviolet spectrophotometer (UVS) to measure downward solar fluxes from an aircraft or other high altitude platform is described. The UVS uses an ultraviolet diffuser to obtain large angular response with no aiming requirement, a twelve-position filter wheel with narrow (2-nm) and broad (20-nm) bandpass filters, and an ultraviolet photodiode. The columnar atmospheric ozone above the UVS (aircraft) is calculated from the ratios of the measured ultraviolet fluxes. Comparison with some Dobson station measurements gives agreement to 2%. Some UVS measured ozone profiles over the Pacific Ocean for November 1976 are shown to illustrate the instrument's performance. (Author)

N78-11368*# Teledyne Systems Co., Northridge, Calif.
STRAPDOWN GYRO TEST PROGRAM Final Report, 1 Jun. 1976 - 1 Sep. 1977
R. B. Irvine and R. VanAlstine Oct. 1977 59 p refs
(Contract NAS3-31909)
(NASA-CR-150458) Avail: NTIS HC A04/MF A01 CSCL 14B

The power spectral noise characteristic performance of the Teledyne two-degree-of-freedom dry tuned gimbal gyroscope was determined. Tests were conducted using a current configuration SDG-5 gyro in conjunction with test equipment with minor modification. Long term bias stability tests were conducted as well as some first difference performance tests. The gyro, test equipment, and the tests performed are described. Results are presented. Author

A78-41464 * Compact electron-beam source for formation of neutral beams of very low vapor pressure materials. J. A. Rutherford and D. A. Vroom (IRT Corp., San Diego, Calif.). *Review of Scientific Instruments*, vol. 49, July 1978, p. 1008-1010. Contract No. NAS3-17759.

In order to form metal vapors for neutral beam studies, an electron-beam heater and a power supply have been designed. The source, which measures about 30 x 50 x 70 mm, consists of a filament, accelerating plate (defined by pole pieces), and a supported target. The electrons from the filament are focused by the field penetration through a 2 mm slit in the high-voltage cage. They are then accelerated to about 5 kV to a ground plate. The electrons then follow a path in the magnetic field and strike the sample to be heated on its front surface. The assembly is attached to a water-cooled base plate. The electron beam source has produced beams of Ta and C particles with densities of about 10 to the 8th power/cu cm. S.C.S.

36 LASERS AND MASERS

Includes parametric amplifiers.

N78-13421*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SMALL-SIGNAL GAIN DIAGNOSTIC MEASUREMENTS IN A FLOWING CO2 PIN DISCHARGE LASER
R. A. Blech, E. J. Manista, and J. W. Dunning, Jr. Nov. 1977 17 p refs
(NASA-TM-73843; E-9430) Avail: NTIS HC A02/MF A01 CSCL 20E

Small-signal gain diagnostic measurements were conducted on closed loop, high power, carbon dioxide laser to assess the coupling between gas flow velocity and resonator saturation. Parameters investigated included optical cavity and discharge power. Results of gain measurements within and downstream of the excitation volume are presented for a laser gas composition He:N2:CO2 of 10:7:1 at 90 torr. The gain at constant discharge power was observed to be dependent upon discharge power level and time. An important result of this study is that the effects of gain swept downstream of the discharge region must be considered in the resonator design if efficient extraction of stored optical energy is desired. Author

N78-14386*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DISTRIBUTION OF E/N AND N SUB e IN A CROSS-FLOW ELECTRIC DISCHARGE LASER
John W. Dunning, Jr., Richard B. Lancashire, and Eugene J. Manista 1976 17 p refs Presented at 29th Ann. Gaseous Electron. Conf., Cleveland, 19-22 Oct. 1976; sponsored by GE and Am. Phys. Soc.
(NASA-TM-73807; E-9390) Avail: NTIS HC A02/MF A01 CSCL 20E

The spatial distribution of the ratio of electric field to neutral gas density on a flowing gas, multiple pin-to-plane discharge was measured in a high-power, closed loop laser. The laser was operated at a pressure of 140 torr (1:7:20, CO2, N2, He) with typically a 100 meter/second velocity in the 5 x 8 x 135 centimeter discharge volume. E/N ratios ranged from 2.7 x 10 to the minus 16th power to 1.4 x 10 to the minus 16th power volts/cu cm along the discharge while the electron density ranged from 2.8 x 10 to the 10th power to 1.2 x 10 to the 10th power cm/3. Author

N78-21441*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A REVIEW OF THE THERMOELECTRONIC LASER ENERGY CONVERTER (TELEC) PROGRAM AT LEWIS RESEARCH CENTER
D. L. Alger, E. J. Manista, and R. W. Thompson 1978 19 p refs Presented at 3d Conf. on Radiation Energy Conversion, Moffett Field, Calif., 26-27 Jan. 1978; sponsored by NASA
(NASA-TM-73888; E-9503) Avail: NTIS HC A02/MF A01 CSCL 20E

The investigation of the Thermoelectronic Laser Energy Converter (TELEC) concept began with a feasibility study of a 1 megawatt sized TELEC system. The TELEC was to use either cesium vapor or hydrogen as the plasma medium. The cesium vapor TELEC appears to be the more practical device studied with an overall calculated conversion efficiency of greater than 48%. Following this study, a small TELEC cell was fabricated which demonstrated the conversion of a small amount of laser power to electrical power. The cell developed a short circuit current of 0.7 amperes and an open circuit voltage, as extrapolated from volt-ampere curves, of about 1.5 volts. Author

A78-24896*# Distribution of E/N and N/e/ in a cross-flow electric discharge laser. J. W. Dunning, Jr., R. B. Lancashire, and E. J. Manista (NASA, Lewis Research Center, Cleveland, Ohio). *General Electric Co. and American Physical Society, Annual Gaseous Electronics Conference, 29th, Cleveland, Ohio, Oct. 19-22, 1976, Paper.* 16 p. 5 refs.

Measurements have been conducted of the effect of the convection of ions and electrons on the discharge characteristics in a large scale laser. The results are presented for one particular distribution of ballast resistance. Values of electric field, current density, input power density, ratio of electric field to neutral gas density (E/N), and electron number density were calculated on the basis of measurements of the discharge properties. In a number of graphs, the E/N ratio, current density, power density, and electron density are plotted as a function of row number (downstream position) with total discharge current and gas velocity as parameters. From the dependence of the current distribution on the total current, it appears that the electron production in the first two rows significantly affects the current flowing in the succeeding rows. G.R.

N78-13420*# Rockwell International Corp., Anaheim, Calif.
ANALYSIS AND DESIGN OF A HIGH POWER LASER ADAPTIVE PHASED ARRAY TRANSMITTER Final Report
G. E. Mevers, J. F. Suohoo, J. Winocur, N. A. Massie, W. H. Southwell, R. A. Brandewie, and C. L. Hayes Dec. 1977 190 p refs
(Contract NAS3-18937)
(NASA-CR-134952; C75-537/501) Avail: NTIS HC A13/MF A01 CSCL 20E

The feasibility of delivering substantial quantities of optical power to a satellite in low earth orbit from a ground based high energy laser (HEL) coupled to an adaptive antenna was investigated. Diffraction effects, atmospheric transmission efficiency, adaptive compensation for atmospheric turbulence effects, including the servo bandwidth requirements for this correction, and the adaptive compensation for thermal blooming were examined. To evaluate possible HEL sources, atmospheric investigations were performed for the CO2, (C-12)(O-18)2 isotope, CO and DF wavelengths using output antenna locations of both sea level and mountain top. Results indicate that both excellent atmospheric and adaption efficiency can be obtained for mountain top operation with a micron isotope laser operating at 9.1 um, or a CO laser operating single line (P10) at about 5.0 (C-12)(O-18)2um, which was a close second in the evaluation. Four adaptive power transmitter system concepts were generated and evaluated, based on overall system efficiency, reliability, size and weight, advanced technology requirements and potential cost. A multiple source phased array was selected for detailed conceptual design. The system uses a unique adaption technique of phase locking independent laser oscillators which allows it to be both relatively inexpensive and most reliable with a predicted overall power transfer efficiency of 53%. Author

N78-19411*# Avco-Everett Research Lab., Everett, Mass.
LASER ABSORPTION PHENOMENA IN FLOWING GAS DEVICES Final Technical Report
P. K. Chapman and J. H. Otis Jun. 1978 125 p refs
(Contract NAS3-19859)
(NASA-CR-135129) Avail: NTIS HC A06/MF A01 CSCL 20E

A theoretical and experimental investigation is presented of inverse Bremsstrahlung absorption of CW CO2 laser radiation in flowing gases seeded with alkali metals. In order to motivate this development, some simple models are described of several space missions which could use laser powered rocket vehicles. Design considerations are given for a test cell to be used with a welding laser, using a diamond window for admission of laser radiation at power levels in excess of 10 kW. A detailed analysis of absorption conditions in the test cell is included. The experimental apparatus and test setup are described and the results of experiments presented. Injection of alkali seedant and steady state absorption of the laser radiation were successfully demonstrated, but problems with the durability of the diamond windows at higher powers prevented operation of the test cell as an effective laser powered thruster. Author

N78-19480*# Hughes Research Labs., Malibu, Calif.
EXCIMER LASERS Final Report, 30 May 1976 - 10 Jun. 1978
A. J. Palmer, L. D. Hess, R. R. Stephens, and D. M. Pepper Nov. 1977 129 p refs
(Contract NAS3-19707)
(NASA-CR-156949) Avail: NTIS HC A07/MF A01 CSCL 20E

The results of a two-year investigation into the possibility of developing continuous wave excimer lasers are reported. The program included the evaluation and selection of candidate molecular systems and discharge pumping techniques. The K Ar/K2 excimer dimer molecules and the xenon fluoride excimer molecule were selected for study; each used a transverse and capillary discharges pumping technique. Experimental and theoretical studies of each of the two discharge techniques applied to each of the two molecular systems are reported. Discharge stability and fluorine consumption were found to be the principle impediments to extending the XeF excimer laser into the continuous wave regime. Potassium vapor handling problems were the principal difficulty in achieving laser action on the K Ar/K2 system. Of the four molecular systems and pumping techniques explored, the capillary discharge pumped K Ar/K2 system appears to be the most likely candidate for demonstrating continuous wave excimer laser action primarily because of its predicted lower pumping threshold and a demonstrated discharge stability advantage. Author

N78-20469*# Physical Sciences, Inc., Woburn, Mass.
ANALYTICAL STUDY OF LASER SUPPORTED COMBUSTION WAVES IN HYDROGEN Final Report, 10 Dec. 1976 - 4 Dec. 1977
N. H. Kemp and R. G. Root Aug. 1977 119 p refs
(Contract NAS3-20381)
(NASA-CR-135349; PSI-TR-97) Avail: NTIS HC A06/MF A01 CSCL 20E

A one-dimensional energy equation, with constant pressure and area, was used to model the LSC wave. This equation balances convection, conduction, laser energy absorption, radiation energy loss and radiation energy transport. Solutions of this energy equation were obtained to give profiles of temperature and other properties, as well as the relation between laser intensity and mass flux through the wave. The flow through the LSC wave was then conducted through a variable pressure, variable area streamtube to accelerate it to high speed, with the propulsion application in mind. A numerical method for coupling the LSC wave model to the streamtube flow was developed and a sample calculation was performed. The result shows that 42% of the laser power has been radiated away by the time the gas reaches the throat. It was concluded that in the radially confined flows of interest for propulsion applications, transverse velocities would be less important than in the unconfined flows where air experiments have been conducted. Author

N78-25407*# Hughes Aircraft Co., Culver City, Calif.
CLOSED CYCLE ELECTRIC DISCHARGE LASER DESIGN INVESTIGATION Final Report
Philip K. Baily and Richard C. Smith Mar. 1978 95 p refs
(Contract NAS3-20100)
(NASA-CR-135408; P78-128) Avail: NTIS HC A05/MF A01 CSCL 20E

Closed cycle CO2 and CO electric discharge lasers were studied. An analytical investigation assessed scale-up parameters and design features for CO2, closed cycle, continuous wave, unstable resonator, electric discharge lasing systems operating in space and airborne environments. A space based CO system was also examined. The program objectives were the conceptual designs of six CO2 systems and one CO system. Three airborne CO2 designs, with one, five, and ten megawatt outputs, were produced. These designs were based upon five minute run times. Three space based CO2 designs, with the same output levels, were also produced, but based upon one year run times. In addition, a conceptual design for a one megawatt space based CO laser system was also produced. These designs include the flow loop, compressor, and heat exchanger, as well as the laser cavity itself. The designs resulted in a laser loop weight for the space based five megawatt system that is within the space shuttle capacity. For the one megawatt systems, the estimated weight of the entire system including laser loop, solar power generator, and heat radiator is less than the shuttle capacity.
Author

N78-26870*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
CONSIDERATIONS TO ACHIEVE DIRECTIONALITY FOR GAMMA RAY LASERS e36
S. Jha (Cincinnati Univ.) and J. Blue *In* Princeton Univ. Partially Ionized Plasmas, Including the 3rd Symp. on Uranium Plasmas Sep. 1976 p 275-279 refs (For availability see N78-26837 17-70)
(Grant NsG-3091)
Avail: NTIS HC A13/MF A01 CSCL 20E

A method of alignment of nuclei for a gamma ray laser and a means of achieving preferential emission of radiation along the crystal axis are studied. Atomic alignment was achieved by materials researchers who made composite structures composed of needle-like single crystals all with the same orientation and all pointing in the same direction contained in a matrix of cobalt or nickel. The proposed method of preferential emission of radiation along the aligned needles is to have a symmetric field gradient at the nucleus and a sequence of excited levels of spin and parity 2(+) and 0(+). The proposed scheme reduces the density of excited states required for lasing and reduces the linewidth due to inhomogenous broadening. Mossbauer absorption experiments intended to test these ideas are outlined. Author

37 MECHANICAL ENGINEERING

Includes auxiliary systems (non-power); machine elements and processes; and mechanical equipment.

N78-10467* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OIL COOLING SYSTEM FOR A GAS TURBINE ENGINE Patent
George A. Coffinberry (GE, Cincinnati) and Howard B. Kast, inventors (to NASA) (GE, Cincinnati) Issued 16 Aug. 1977 10 p Filed 17 Jul. 1975 Sponsored by NASA
(NASA-Case-LEW-12321-1; US-Patent-4,041,697; US-Patent-Appl-SN-596641; US-Patent-Class-60-39.28R; US-Patent-Class-60-39.66; US-Patent-Class-415-180; US-Patent-Class-123-41.33; US-Patent-Class-123-122E; US-Patent-Class-137-104) Avail: US Patent Office CSCL 21E

A gas turbine engine fuel delivery and control system is provided with means to recirculate all fuel in excess of fuel control requirements back to aircraft fuel tank, thereby increasing the fuel pump heat sink and decreasing the pump temperature rise without the addition of valving other than that normally employed. A fuel/oil heat exchanger and associated circuitry is provided to maintain the hot engine oil in heat exchange relationship with the cool engine fuel. Where anti-icing of the fuel filter is required, means are provided to maintain the fuel temperature entering the filter at or above a minimum level to prevent freezing thereof. Fluid circuitry is provided to route hot engine oil through a plurality of heat exchangers disposed within the system to provide for selective cooling of the oil.
Official Gazette of the U.S. Patent Office

N78-10468* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IMPACT ABSORBING BLADE MOUNTS FOR VARIABLE PITCH BLADES Patent
Richard Ravenhall (GE, Cincinnati), Charles T. Salemme (GE, Cincinnati), and Arthur P. Adamson, inventors (to NASA) (GE, Cincinnati) Issued 13 Sep. 1977 6 p Filed 29 May 1975 Sponsored by NASA
(NASA-Case-LEW-12313-1; US-Patent-4,047,840; US-Patent-Appl-SN-581751; US-Patent-Class-416-135; US-Patent-Class-416-141; US-Patent-Class-416-220R; US-Patent-Class-416-248) Avail: US Patent Office CSCL 13I

A variable pitch blade and blade mount are reported that are suitable for propellers, fans and the like and which have improved impact resistance. Composite fan blades and blade mounting arrangements permit the blades to pivot relative to a turbine hub about an axis generally parallel to the centerline of the engine upon impact of a large foreign object, such as a bird. Centrifugal force recovery becomes the principal energy absorbing mechanism and a blade having improved impact strength is obtained. Official Gazette of the U.S. Patent Office

N78-10474*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STABILITY OF NUMERICAL INTEGRATION TECHNIQUES FOR TRANSIENT ROTOR DYNAMICS
Albert F. Kascak. 1977 22 p refs
(NASA-TP-1092; E-9252) Avail: NTIS HC A02/MF A01 CSCL 21E

A finite element model of a rotor bearing system was analyzed to determine the stability limits of the forward, backward, and centered Euler, Runge-Kutta, Milne, and Adams numerical integration techniques. The analysis concludes that the highest frequency mode determines the maximum time step for a stable solution. Thus, the number of mass elements should be minimized. Increasing the damping can sometimes cause numerical instability. For a uniform shaft, with 10 mass elements, operating at approximately the first critical speed, the maximum time step for the Runge-Kutta, Milne, and Adams methods is that which corresponds to approximately 1 degree of shaft movement. This is independent of rotor dimensions. Author

N78-10636* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
METHOD OF FORMING METAL HYDRIDE FILMS Patent
Robert Steinberg, Donald L. Alger, and Dale W. Cooper, inventors (to NASA) Issued 25 Oct. 1977 5 p Filed 20 Feb. Supersedes N76-18262 (14 - 09, p 1100)
(NASA-Case-LEW-12083-1; US-Patent-4,055,686; US-Patent-Appl-SN-659882; US-Patent-Class-427-124; US-Patent-Class-427-126; US-Patent-Class-427-255; US-Patent-Class-427-248E; US-Patent-Class-427-250; US-Patent-Class-250-499; US-Patent-Class-313-61S) Avail: US Patent Office CSCL 13H

The substrate to be coated (which may be of metal, glass or the like) is cleaned, both chemically and by off-sputtering in a vacuum chamber. In an ultra-high vacuum system, vapor deposition by a sublimator or vaporizer coats a cooled shroud disposed around the substrate with a thin film of hydride forming metal which getters any contaminant gas molecules. A shutter is then opened to allow hydride forming metal to be deposited as a film or coating on the substrate. After the hydride forming metal coating is formed, deuterium or other hydrogen isotopes are bled into the vacuum system and diffused into the metal film or coating to form a hydride of metal film. Higher substrate temperatures and pressures may be used if various parameters are appropriately adjusted.
Official Gazette of the U.S. Patent Office

N78-13439*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESIGN CONSIDERATIONS IN MECHANICAL FACE SEALS FOR IMPROVED PERFORMANCE. 1: BASIC CONFIGURATIONS
Lawrence P. Ludwig and Harold F. Greiner (Sealol, Inc., Providence, R. I.) 1977 20 p refs Presented at Winter Annual Meeting, Atlanta, Ga., 27 Nov. - 2 Dec. 1977
(NASA-TM-73735; E-9298-1) Avail: NTIS HC A02/MF A01 CSCL 11A

Basic assembly configurations of the mechanical face seal are described and some advantages associated with each are listed. The various forms of seal components are illustrated, and functions pointed out. The technique of seal pressure balancing and its application are described; and the concept of the PV factor, its different forms and limitations are discussed. Brief attention is given to seal lubrication since it is covered in detail in a companion paper. Finally, the operating conditions for various applications of low pressure seals (aircraft transmissions) are listed, and the seal failure mode of a particular application is discussed. Author

N78-17384* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
VARIABLE CYCLE GAS TURBINE ENGINES Patent
James Edward Johnson (GE, Cincinnati) and Tom Foster, inventors (to NASA) (GE, Cincinnati) Issued 27 Dec. 1977 10 p Filed 2 Jun. 1975 Sponsored by NASA
(NASA-Case-LEW-12916-1; US-Patent-4,064,692; US-Patent-Appl-SN-583066; US-Patent-Class-60-261; US-Patent-Class-60-262; US-Patent-Class-60-271) Avail: US Patent Office CSCL 21E

A technique, method, and apparatus were designed for varying the bypass ratio and modulating the flow of a gas turbine engine in order to achieve improved mixed mission performance. Embodiments include gas flow control system for management of core and bypass stream pressure comprising diverter valve means downstream of the core engine to selectively mix or separate the core and bypass exhaust streams. The flow control system may also include variable geometry means for maintaining the engine inlet airflow at a matched design level at all flight velocities. Earth preferred embodiment thus may be converted from a high specific thrust mixed flow cycle at supersonic velocities to a lower specific thrust separated flow turbofan system at subsonic velocities with a high degree of flow variability in each mode of operation. Official Gazette of the U.S. Patent Office

N78-17389*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BEARING, GEARING, AND LUBRICATION TECHNOLOGY
William J. Anderson 1978 24 p refs Presented at the 1978 Automotive Eng. Congr. and Exposition, Detroit, 27 Feb. - 3 Mar. 1978; sponsored by SAE
(NASA-TM-73851) Avail: NTIS HC A02/MF A01 CSCL 13I

Results of selected NASA research programs on rolling-element and fluid-film bearings, gears, and elastohydrodynamic lubrication are reported. Advances in rolling-element bearing material technology, which have resulted in a significant improvement in fatigue life, and which make possible new applications for rolling bearings, are discussed. Research on whirl-resistant, fluid-film bearings, suitable for very high-speed applications, is discussed. An improved method for predicting gear pitting life is reported. An improved formula for calculating the thickness of elastohydrodynamic films (the existence of which help to define the operating regime of concentrated contact mechanisms such as bearings, gears, and cams) is described.
Author

N78-18429*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STATISTICAL MODEL FOR ASPERITY-CONTACT TIME FRACTION IN ELASTOHYDRODYNAMIC LUBRICATION
Steven M. Sidik and John J. Coy (US Army R and T Labs., Cleveland) Feb. 1978 41 p refs
(NASA-TP-1130; E-9265) Avail: NTIS HC A03/MF A01 CSCL 13I

Relations for the asperity contact time fraction during elastohydrodynamic (EHD) lubrication of a typical ball bearing are presented. The analysis is based on a two-dimensional random surface model, and actual profile traces of the bearing surfaces were used as statistical sample records. The results of the analysis show that transition from 90 percent contact to 1 percent contact occurs within a dimensionless film thickness range of approximately 4 to 5. This thickness ratio is several times larger than reported in the literature where one-dimensional random surface models were used.
Author

N78-19512*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FRICTION AND WEAR BEHAVIOR OF SINGLE-CRYSTAL SILICON CARBIDE IN SLIDING CONTACT WITH VARIOUS METALS
Kazuhisa Miyoshi and Donald H. Buckley 1978 28 p refs Presented at Ann. Meeting of Am. Soc. of Lubrication Engineers, Dearborn, Mich., 17-20 Apr. 1978
(NASA-TM-73782; E-9337) Avail: NTIS HC A03/MF A01 CSCL 11D

Sliding friction experiments were conducted with single-crystal silicon carbide in contact with various metals. Results indicate the coefficient of friction is related to the relative chemical activity of the metals. The more active the metal, the higher the coefficient of friction. All the metals examined transferred to silicon carbide. The chemical activity of the metal and its shear modulus may play important roles in metal transfer, the form of the wear debris and the surface roughness of the metal wear scar. The more active the metal, and the less resistance to shear, the greater the transfer to silicon carbide and the rougher the wear scar on the surface of the metal. Hexagon shaped cracking and fracturing formed by cleavage of both prismatic and basal planes is observed on the silicon carbide surface.
Author

N78-19513*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SELF-ACTING SHAFT SEALS
Lawrence P. Ludwig 1978 36 p refs Presented at AGARD Power, Energetics, and Propulsion Panel Meeting on Seal Technol. in Gas Turbine Engines, London, 6-7 Apr. 1978
(NASA-TM-73856) Avail: NTIS HC A03/MF A01 CSCL 11A

Self-acting seals are described in detail. The mathematical models for obtaining a seal force balance and the equilibrium operating film thickness are outlined. Particular attention is given to primary ring response (seal vibration) to rotating seat face runout. This response analysis reveals three different vibration models with secondary seal friction being an important parameter. Leakage flow, inlet pressure drop, and effects of axisymmetric sealing face deformations are discussed. Experimental data on self-acting face seals operating under simulated gas turbine conditions are given. Also a spiral groove seal design operated to 244 m/sec (800 ft/sec) is described.
Author

N78-20511*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TRIBOLOGICAL PROPERTIES OF SURFACES
Donald H. Buckley 1978 25 p refs Presented at the Intern. Conf. on Met. Coatings, San Francisco, 3-7 Apr. 1978; sponsored by Am. Vacuum Soc.
(NASA-TM-73896) Avail: NTIS HC A02/MF A01 CSCL 20K

The real area of contact between two solid surfaces is only a small portion of the apparent area. Deformation of these areas can result in solid state contact through surface films. For clean solid to solid contact strong adhesive bonding occurs across the interface. Under these conditions many properties of the solid such as the metallurgical and chemical nature of metals can influence adhesion, friction, and wear behavior. The presence of gases, liquids, and solid films on the surface of solids alter markedly tribological characteristics. These surface films can also considerably change the mechanical effects of solid state contact on bulk material behavior.
Author

N78-20512*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FRICTION AND WEAR OF SELECTED METALS AND ALLOYS IN SLIDING CONTACT WITH AISI 440 C STAINLESS STEEL IN LIQUID METHANE AND IN LIQUID NATURAL GAS
Donald W. Wisander Feb. 1978 18 p refs
(NASA-TP-1150; E-9195) Avail: NTIS HC A02/MF A01 CSCL 20K

Aluminum, titanium, beryllium, nickel, iron, copper, and several copper alloys were run in sliding contact with AISI 440C in liquid methane and natural gas. All of the metals run except copper and the copper alloys of tin and tin lead showed severely galled wear scars. Friction coefficients varied from 0.2 to 1.0, the lowest being for copper, copper-17 wt. % tin, and copper-8 wt. % tin-22 wt. % lead. The wear rate for copper was two orders of magnitude lower than that of the other metals run. An additional order of magnitude of wear reduction was achieved by the addition of tin and/or lead to copper.
Author

N78-20513*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PREDICTED AND EXPERIMENTAL PERFORMANCE OF JET-LUBRICATED 120-MILLIMETER-BORE BALL BEARINGS OPERATING TO 2.5 MILLION DN
Harold H. Coe and Erwin V. Zaretsky Apr. 1978 28 p refs
(NASA-TP-1196, E-9288) Avail: NTIS HC A03/MF A01 CSCL 13I

Bearing inner- and outer-race temperatures and friction power losses were calculated using two computer programs. The values obtained were compared with previously reported experimental data for 120 mm bore bearings which operated at thrust loads to 22 240 N (5000 lb), shaft speeds to 20 800 rpm, and with two lubricant flow rates. One program severely underestimated the power loss, while the other, called SHABERTH, provided a good prediction of both race temperatures and power losses.
Author

N78-21470*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CHARACTERIZATION OF WEAR DEBRIS GENERATED IN ACCELERATED ROLLING-ELEMENT FATIGUE TESTS

William R. Jones, Jr. and Richard J. Parker Apr. 1978 28 p refs

(NASA-TP-1203; E-9260) Avail: NTIS HC A03/MF A01 CSCL 13I

A ferrographic analysis was used to determine the types and quantities of wear debris generated during accelerated rolling contact fatigue tests. The five-ball rolling contact fatigue tester was used. Ball specimens were made of a corrosion resistant, high-temperature bearing steel. The lubricant was a superrefined naphthenic mineral oil. Conditions included a maximum Hertz stress of 5.52 10 to the 9th power Pa and a shaft speed of 10,000 rpm. Four types of wear debris were observed: (1) normal rubbing wear particles, (2) fatigue microspall particles, (3) spheres, and (4) friction polymer deposits. The characterization of wear debris as a function of time was of limited use in predicting fatigue failures in these accelerated tests. Author

N78-21473*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ROLLING-ELEMENT FATIGUE LIFE OF AISI M-50 AND 18-4-1 BALLS

Richard J. Parker and Erwin V. Zaretsky Apr. 1978 19 p refs

(NASA-TP-1202; E-9350) Avail: NTIS HC A02/MF A01 CSCL 13I

Rolling element fatigue studies were conducted with AISI M-50, EFR 18-4-1, and VAR 18-4-1. Groups of 12.7 mm (1/2-in) diameter balls of each material were tested in the five ball fatigue tester. Test conditions included a load of 1540 N (347 lbf) giving a maximum Hertz stress of 5520 MPa (800 000 psi), a shaft speed of 10,700 rpm, and a contact angle of 30 deg. Tests were run at a race temperature of 339 K (150 F) with a type 2 ester lubricant. The rolling element fatigue life of AISI M-50 was not significantly different from that of EFR 18-4-1 or VAR 18-4-1 based on a statistical comparison of the test results. Author

N78-22377*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FERROGRAPHIC ANALYSIS OF WEAR PARTICLES FROM SLIDING ELASTOHYDRODYNAMIC EXPERIMENTS

William R. Jones, Jr., H. S. Nagaraj (Mechanical Technology, Inc., Latham, N. Y.), and Ward O. Winer (Georgia Inst. of Tech., Atlanta) Apr. 1978 31 p refs

(NASA-TP-1230; E-9300) Avail: NTIS HC A03/MF A01 CSCL 20K

The Ferrograph was used to analyze wear debris generated in a sliding elastohydrodynamic contact. The amount of wear debris correlates well with the ratio of film thickness to composite surface roughness (A ratio). The general wear level parameter and the wear severity index yielded similar correlations with average A ratios. Essentially all the generated wear particles were of the normal rubbing wear type. The Ferrograph was more sensitive in detecting the wear debris than was the commonly used emission spectrograph. Author

N78-24545* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AUTOMOTIVE GAS TURBINE FUEL CONTROL Patent

Harold Gold, inventor (to NASA) Issued 14 Mar. 1978 14 p Filed 8 Nov. 1976 Supersedes N77-13426 (15 - 04, p 0477)

(NASA-Case-LEW-12785-1; US-Patent-4,078,378; US-Patent-Appl-SN-739909; US-Patent-Class-60-39.28R) Avail: US Patent Office CSCL 21A

A fuel control system is reported for automotive-type gas turbines and particulary advanced gas turbines utilizing variable geometry components to improve mileage and reduce pollution emission. The fuel control system compensates for fuel density variations, inlet temperature variations, turbine vane actuation, acceleration and turbine braking. These parameters are utilized to control various orifices, spool valves and pistons.

Official Gazette of the U.S. Patent Office

N78-26429*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SOME EFFECTS OF COMPOSITION ON FRICTION AND WEAR OF GRAPHITE-FIBER-REINFORCED POLYIMIDE LINERS IN PLAIN SPHERICAL BEARINGS

Harold E. Sliney and Thomas P. Jacobson May 1978 23 p refs

(NASA-TP-1229; E-9296) Avail: NTIS HC A02/MF A01 CSCL 13I

Oscillating, plain spherical bearings with graphite-fiber-reinforced polyimide (GFRPI) liners were tested for friction and wear from 25 to 315 C. A condensation polymer was compared with an addition polymer, and a high-modulus fiber was compared with a lower cost, low-modulus fiber. All polymer fiber combinations gave friction coefficients from 0.05 to 0.18 and low wear. Adding CdO and CdI2 reduced the wear of degassed bearings in dry air. These additives were not needed when the bearing liners contained adsorbed moisture. Although, at 25 C, MoS2 reduced the friction and wear of the base composite at unit loads above 70,000,000 N/m squared (10,000 psi), it had no beneficial effect at lighter loads. Author

N78-26442*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESIGN APPROACHES TO MORE ENERGY EFFICIENT ENGINES

Neal T. Saunders, Raymond S. Colladay, and Lawrence E. Macioce Jul. 1978 13 p refs Presented at the 14th Propulsion Conf., Las Vegas, Nev., 25-27 Jul. 1978; cosponsored by AIAA and SAE

(NASA-TM-78893) Avail: NTIS HC A02/MF A01 CSCL 10B

The status of NASA's Energy Efficient Engine Project, a comparative government-industry effort aimed at advancing the technology base for the next generation of large turbofan engines for civil aircraft transports is summarized. Results of recently completed studies are reviewed. These studies involved selection of engine cycles and configurations that offer potential for at least 12% lower fuel consumption than current engines and also are economically attractive and environmentally acceptable. Emphasis is on the advancements required in component technologies and systems design concepts to permit future development of these more energy efficient engines. G.Y.

N78-26443*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

ADDITIONAL ASPECTS OF ELASTOHYDRODYNAMIC LUBRICATION

Bernard J. Hamrock Jun. 1978 15 p refs Presented at the Intern. Conf. Fundamentals of Tribology, Cambridge, Mass., 19-22 Jun. 1978, sponsored by ARO, DARPA, MIT, and ONR

(NASA-TM-78898; E-9634) Avail: NTIS HC A02/MF A01 CSCL 11H

An up-to-date review of the varying aspects of elastohydrodynamic lubrication is presented. Some recent work on elastohydrodynamic lubrication of materials of low elastic modulus as well as on hydrodynamic lubrication is included. Both these topics are applicable for contacts with any ellipticity parameter (ranging from a circular contact to a line contact). G.G.

N78-26444*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PROPOSED DESIGN PROCEDURE FOR TRANSMISSION SHAFTING UNDER FATIGUE LOADING

Stuart H. Loewenthal 1978 10 p refs To be presented at the 5th Ann. Meeting of the Natl. Conf. on Power Transmission, Philadelphia, 7-9 Nov. 1978, sponsored by the Ill. Inst. of Technol.

(NASA-TM-78927, E-9667) Avail: NTIS HC A02/MF A01 CSCL 13I

A new standard for the design of transmission shafting is reported. Computed was the diameter of rotating solid steel shafts under combined cyclic bending and steady torsion is presented. The formula is based on an elliptical variation of endurance strength with torque exhibited by combined stress fatigue data. Fatigue factors are cited to correct specimen bending endurance strength data for use in the shaft formula. A design example illustrates how the method is to be applied. G.G.

N78-28446*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SOME LOAD LIMITS AND SELF-LUBRICATING PROPERTIES OF PLAIN SPHERICAL BEARINGS WITH MOLDED GRAPHITE FIBER REINFORCED POLYIMIDE LINERS TO 320 C
Harold E. Sliney 1978 13 p refs To be presented at the Joint Lubrication Conf., Minneapolis, 24-26 Oct. 1978; cosponsored by the Am. Soc. of Lubrication Engr. and the Am. Soc. of Mech. Engr.
(NASA-TM-78936; E-9678) Avail: NTIS HC A02/MF A01 CSCL 13I

Plain spherical bearings with molded liners of self-lubricating graphite fiber-polyimide composite were developed and their dynamic load capacities were determined. Liners were prepared by transfer molding a prepolymer resin-fiber mix into the space between the ball and outer race, the completing polymerization under heat and pressure. Bearing dynamic load capacities were in excess of 140 MPa (20,000 psi) from room temperature to 260 C and about 70 MPa (10,000 psi) at 320 C. Friction coefficients were about 0.20 at room temperatures and light loads and tended to decrease with increasing temperatures and loads to about 0.15. Thermal expansion of the liner at uniform bearing temperatures of 200 C or higher produced a bearing preload which could be alleviated by providing an initial internal diametral clearance of 0.05 to 0.10 mm. Author

N78-28448*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FILTRATION EFFECTS ON BALL BEARING LIFE AND CONDITION IN A CONTAMINATED LUBRICANT
Stuart H. Loewenthal and Donald W. Moyer (Tribon Mfg. Co., Cleveland) Oct. 1978 26 p refs Proposed for presentation at the Joint Lubrication Conf., Minneapolis, 24-26 Oct. 1978; sponsored by the Am. Soc. of Mech. Engr. and the Am. Soc. of Lubrication Engr.
(NASA-TM-78907; E-9418) Avail: NTIS HC A03/MF A01 CSCL 13I

Ball bearings were fatigue tested with a noncontaminated lubricant and with a contaminated lubricant under four levels of filtration. The test filters had absolute particle removal ratings of 3, 30, 49, and 105 microns. Aircraft turbine engine contaminants were injected into the filter's supply line at a constant rate of 125 milligrams per bearing hour. Bearing life and running track condition generally improved with finer filtration. The experimental lives of 3 and 30 micron filter bearings were statistically equivalent, approaching those obtained with the noncontaminated lubricant bearings. Compared to these bearings, the lives of the 49 micron bearings were statistically lower. The 105 micron bearings experienced gross wear. The degree of surface distress, weight loss, and probable failure mode were dependent on filtration level, with finer filtration being clearly beneficial. Author

N78-28447*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
GRAPHITE-FIBER-REINFORCED POLYIMIDE LINERS OF VARIOUS COMPOSITIONS IN PLAIN SPHERICAL BEARINGS
Harold E. Sliney and Thomas P. Jacobson Aug. 1978 19 p refs Proposed for presentation at the 2d Intern. Conf. on Solid Lubrication, Denver, 14-18 Aug. 1978; sponsored by the Am. Soc. of Lubrication Engr.
(NASA-TM-78908; E-9296) Avail: NTIS HC A02/MF A01 CSCL 13I

A plain spherical bearing design with a ball diameter of 28.6 mm, a race length of 12.7 mm, and a 1.7-mm-thick, molded composite liner was evaluated. The liner material is a self-lubricating composite of graphite-fiber-reinforced polyimide resin (GFRPI). The liner is prepared by transfer molding a mixture of one part chopped graphite fiber and one part partially polymerized resin into the space between the bearing ball and the outer race and then completing the polymerization under heat and pressure. Several liner compositions were evaluated: two types of polyimide, condensation and addition, two types of graphite fiber, low and high modulus, and four powder additives - cadmium oxide, cadmium iodide, graphite fluoride, and molybdenum disulfide. The bearings were oscillated + or - 15 deg at 1 Hz for 20 kilocycles under a radial unit load of 28 MN sq m (4200 psi) in dry air at 28, 200, or 315 C. Both types of fiber and polyimide gave low friction and wear. A simple equation was developed to fit the wear-time data and adequately predicted wear to 100 kilocycles. Author

N78-27428*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
ELASTOHYDRODYNAMIC FILM THICKNESS MEASUREMENTS OF ARTIFICIALLY PRODUCED SURFACE DENTS AND GROOVES
L. D. Wedeven and C. Cusano (Illinois Univ., Urbana) 1978 38 p refs Proposed for presentation at the Joint Lubrication Conf., Minneapolis, Minn., 24-26 Oct. 1978; Sponsored by ASME and Am. Soc. of Lubrication Engineers
(NASA-TM-78949; E-9693) Avail: NTIS HC A03/MF A01 CSCL 13I

Elastohydrodynamic (EHD) film thickness measurements using optical interferometry were made of artificially produced dents and grooves under rolling and sliding conditions. These measurements are compared to stylus traces of the dent and groove profiles to determine the local deformation associated with micro-EHD pressure generation. The surface geometry associated with the dents and grooves became intimately involved in the lubrication process itself, creating local pressure variations that substantially deformed the local surface geometry, particularly under sliding conditions. The rolling results implied surface initiated fatigue, and the sliding results showed clearly the EHD surface interactions that must occur prior to scuffing failure. J.A.M.

N78-28457*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF FILTRATION ON ROLLING-ELEMENT-BEARING LIFE IN CONTAMINATED LUBRICANT ENVIRONMENT
Stuart H. Loewenthal, Donald W. Moyer (Tribon Bearing Co., Cleveland), and John J. Sherlock (Tribon Bearing Co., Cleveland) Jul. 1978 34 p refs
(NASA-TP-1272; E-9418) Avail: NTIS HC A03/MF A01 CSCL 13I

Fatigue tests were conducted on groups of 65 millimeter-bore ball bearings under four levels of filtration with and without a contaminated MIL-L-23699 lubricant. The baseline series used noncontaminated oil with 49 micron absolute filtration. In the remaining tests contaminants of the composition found in aircraft engine filters were injected into the filter's supply line at a constant rate of 125 milligrams per bearing-hour. The test filters had absolute particle removal ratings of 3, 30, 49, and 105 microns (0.45, 10, 30, and 70 microns nominal), respectively. Bearings were tested at 15,000 rpm under 4580 newtons radial load. Bearing life and running tract condition generally improved with finer filtration. The 3 and 30 micron filter bearings in a contaminated lubricant had statistically equivalent lives, approaching those from the baseline tests. The experimental lives of 49 micron bearings were approximately half the baseline bearing's lives. Bearings tested with the 105 micron filter experienced wear failures. The degree of surface distress, weight loss, and probable failure mode were found to be dependent on filtration level, with finer filtration being clearly beneficial. Author

N78-28468*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ELASTOHYDRODYNAMIC LUBRICATION OF ELLIPTICAL CONTACTS FOR MATERIALS OF LOW ELASTIC MODULUS. 2: STARVED CONJUNCTION
Bernard J. Hamrock and Duncan Dowson (Leeds Univ., England) Jul. 1978 26 p refs Proposed for presentation at the Joint Lubrication Conf., Minneapolis, 24-26 Oct. 1978; sponsored by the Am. Soc. of Lubrication Engr. and the Am. Soc. of Mech. Engr.
(NASA-TP-1273; E-9558) Avail: NTIS HC A03/MF A01 CSCL 11H

Lubricant starvation effects on minimum film thickness for low-elastic modulus materials are studied by moving the inlet boundary closer to the contact center. Contour plots of the pressure and film thickness in and around the contact were obtained for fully flooded and starved lubrication conditions. These contour plots show that the inlet pressure contours become less circular and that the film thickness decreases substantially as the severity of starvation increases. G.G.

N78-28469*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
METHOD OF COLD WELDING USING ION BEAM TECHNOLOGY Patent Application
Bernard L. Sater, inventor (to NASA) Filed 28 Jul. 1978 10 p
(NASA-Case-LEW-12982-1; US-Patent-Appl-SN-929084) Avail: NTIS HC A02/MF A01 CSCL 13H

A method is described for cold welding metals in a vacuum using ion beams to prepare the surfaces of metals to be joined. The figure is a schematic diagram of an ion beam apparatus for carrying out the method. An expellant gas is stored in a high pressure tank and delivered to the ion source assembly. The ion source produces a unidirectional beam of gas molecules with uniform energies which, in a vacuum environment, is directed onto each surface to be cleaned and effectively sputters away the contamination oxide layer to expose clean underlying metal. When the surfaces to be jointed are sufficiently clean, they are pressed together with pressure adequate to assure that their asperities are brought into intimate contact throughout the area to be joined. This process provides a solid state cold weld with metal-to-metal bonding without causing gross deformation due to plastic flow and thinning of the material at the joint. NASA

N78-30305*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LEWIS RESEARCH CENTER SUPPORT OF CHRYSLER UPGRADED ENGINE PROGRAM
E. L. Warren *In* DOE Highway Vehicle Systems Mar. 1978 p 143-149 (For primary document see N78-30293 21-31)
Avail: NTIS HC A20/MF A01 CSCL 21A

N78-30314*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STIRLING ENGINE PROJECT STATUS
R. G. Ragsdale *In* DOE Highway Vehicle Systems Mar. 1978 p 241-243 (For primary document see N78-30293 21-31)
Avail: NTIS HC A20/MF A01 CSCL 21A

N78-30316*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INITIAL TEST RESULTS WITH SINGLE CYLINDER RHOMBIC DRIVE STIRLING ENGINE
James E. Cairelli *In* DOE Highway Vehicle Systems Mar. 1978 p 254-258 (For primary document see N78-30293 21-31)
Avail: NTIS HC A20/MF A01 CSCL 13I

N78-30318*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MATERIALS TECHNOLOGY ASSESSMENT FOR STIRLING ENGINES
Joseph R. Stephens *In* DOE Highway Vehicle Systems Mar. 1978 p 267-274 (For primary document see N78-30293 21-31)
Avail: NTIS HC A20/MF A01 CSCL 21A

N78-30684*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LIQUID ROCKET ENGINE TURBOPUMP ROTATING-SHAFT SEALS NASA Space Vehicle Design Criteria, Chemical Propulsion
R. E. Burcham and Russell B. Keller, Jr., ed. Feb. 1978 160 p refs Prepared in cooperation with Rocketdyne, Canoga Park, Calif.
(NASA-SP-8121) Avail: NTIS HC A08/MF A01 CSCL 11A

A monograph is organized and presents, for effective use in design, the significant experience and knowledge accumulated in development and operational programs to date. It reviews and assesses current practices, and from them establishes firm guidance for achieving greater consistency in design, increased reliability in the end product, and greater efficiency in the design effort. The monograph is divided into two major sections: state of the art and design criteria. G.Y.

N78-30686*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF GEOMETRY ON HYDRODYNAMIC FILM THICKNESS
David E. Brewe (AVRADCOM Res. and Technol. Labs.), Bernard J. Hamrock, and Christopher M. Taylor (Leeds Univ., England) Aug. 1978 36 p refs Proposed for presentation at ASLE-ASME Joint Lubrication Conf., Minneapolis, 24-26 Oct. 1978
(NASA-TP-1287; E-9347; AVRADCOM-TR-78-18) Avail: NTIS HC A03/MF A01 CSCL 20K

The influence of geometry on the isothermal hydrodynamic film separating two rigid solids was investigated. Pressure-viscosity effects were not considered. The minimum film thickness is derived for fully flooded conjunctions by using the Reynolds conditions. It was found that the minimum film thickness had the same speed, viscosity, and load dependence as Kapitza's classical solution. However, the incorporation of Reynolds boundary conditions resulted in an additional geometry effect. Solutions using the parabolic film approximation are compared with those using the exact expression for the film in the analysis. Contour plots are shown that indicate in detail the pressure developed between the solids. Author

N78-33445*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE PRACTICAL IMPACT OF ELASTOHYDRODYNAMIC LUBRICATION
William J. Anderson 1978 14 p refs Presented at the 5th Leeds-Lyon Symp. on Tribology, Leeds, Engl., 19-22 Sep. 1978
(NASA-TM-78987; E-9766) Avail: NTIS HC A02/MF A01 CSCL 13I

The use of elastohydrodynamics in the analysis of rolling element bearings is discussed. Relationships for minimum film thickness and tractive force were incorporated into computer codes and used for bearing performance prediction. The lambda parameter (ratio of film thickness to composite surface roughness) was shown to be important in predicting bearing life and failure mode. Results indicate that at values of lambda below 3 failure modes other than the classic subsurface initiated fatigue can occur. S.S.

N78-33447*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MINIMUM FILM THICKNESS IN ELLIPTICAL CONTACTS FOR DIFFERENT REGIMES OF FLUID-FILM LUBRICATION
Bernard J. Hamrock and Duncan Dowson (Leeds Univ., Engl.)

Oct. 1978 26 p refs
(NASA-TP-1342; E-9687) Avail: NTIS HC A02/MF A01 CSCL 11H

The film parameter equations are provided for four fluid-film lubrication regimes found in elliptical contacts. These regimes are isoviscous-rigid; viscous-rigid; elastohydrodynamic of low-elastic-modulus materials, or isoviscous-elastic; and elastohydrodynamic, or viscous-elastic. The influence or lack of influence of elastic and viscous effects is the factor that distinguishes these regimes. The film-parameter equations for the respective regimes come from earlier theoretical studies by the authors on elastohydrodynamic and hydrodynamic lubrication of elliptical conjunctions. These equations are restated and the results are presented as a map of the lubrication regimes, with film-thickness contours on a log-log grid of the viscosity and elasticity parameters for five values of the ellipticity parameter. The results present a complete theoretical film-parameter solution for elliptical contacts in the four lubrication regimes. L.S.

A78-12737 * # **Simplified solution for elliptical-contact deformation between two elastic solids.** D. E. Brewe (U.S. Army, Air Mobility Research and Development Laboratory, Cleveland, Ohio) and B. J. Hamrock (NASA, Lewis Research Center, Cleveland, Ohio). *ASME, Transactions, Series F - Journal of Lubrication Technology*, vol. 99, Oct. 1977, p. 485-487. 10 refs.

A linear regression by the method of least squares is made on the geometric variables that occur in the equation for elliptical-contact deformation. The ellipticity and the complete elliptic integrals of the first and second kind are expressed as a function of the x,y-plane principal radii. The ellipticity was varied from 1 (circular contact) to 10 (a configuration approaching line contact). The procedure for solving these variables without the use of charts or a high-speed computer would be quite tedious. These simplified equations enable one to calculate easily the elliptical-contact deformation to within 3 percent accuracy without resorting to charts or numerical methods. (Author)

A78-20591 * # **High stiffness seals for rotor critical speed control.** D. P. Fleming (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Design Engineering Technical Conference, Chicago, Ill., Sept. 26-30, 1977, Paper 77-DET-10.* 9 p. 8 refs. Members, $1.50; nonmembers, $3.00.

An annular seal is analyzed in which the inlet clearance is larger than the outlet clearance; the flow path may be either stepped or tapered. This design produces radial stiffnesses 1.7 to 14 times that of a constant clearance seal having the same minimum clearance. When sealing high pressure fluids, such as a seal can improve rotor stability and can be used to shift troublesome critical speeds to a more suitable location. (Author)

A78-20608 * # **Study of lubricant jet flow phenomena in spur gears - Out of mesh condition.** D. P. Townsend (NASA, Lewis Research Center, Cleveland, Ohio) and L. S. Akin (NASA, Lewis Research Center, Cleveland, Ohio; Western Gear Corp., Lynnwood, Calif.). *American Society of Mechanical Engineers, Design Engineering Technical Conference, Chicago, Ill., Sept. 26-30, 1977, Paper 77-DET-104.* 8 p. 5 refs. Members, $1.50; nonmembers, $3.00.

An analysis was conducted for oil jet lubrication on the disengaging side of a gear mesh. Results of the analysis were computerized and used to determine the oil jet impingement depth for several gear ratios and oil jet to pitch line velocity ratios. An experimental program was conducted on the NASA gear test rig using high speed photography to experimentally determine the oil jet impingement depth on the disengaging side of mesh. Impingement depth reaches a maximum at gear ratio near 1.5 where chopping by the leading gear tooth limits the impingement depth. The pinion impingement depth is zero above a gear ratio of 1.172 for a jet velocity to pitch line velocity ratio of 1.0 and is similar for other velocity ratios. The impingement depth for gear and pinion are equal and approximately one-half the maximum at a gear ratio of 1.0. Impingement depth on either the gear or pinion many be improved by relocation of the jet from the pitch line or by changing the jet angle. Results of the analysis were verified by experimental results using a high-speed camera and a well lighted oil jet. (Author)

A78-20609 * # **Experimental and analytical load-life relation for AISI 9310 steel spur gears.** D. P. Townsend, J. J. Coy, and E. V. Zaretsky (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Design Engineering Technical Conference, Chicago, Ill., Sept. 26-30, 1977, Paper 77-DET-121.* 7 p. 16 refs. Members, $1.50; nonmembers, $3.00.

Life tests were conducted at three different loads with three groups of 8.9 cm, pitch diameter spur gears made of vacuum arc remelted AISI 9310 steel. Life was found to vary inversely with load to the 4.3 and 5.1 power at the L-10 and L-50 life levels, respectively. The Weibull slope varied linearly with maximum Hertz contact stress, having an average value of 2.5. The test data when compared to AGMA standards showed a steeper slope for the load-life diagram. (Author)

A78-20683 * # **Temperature distributions and thermal stresses in a graded zirconia/metal gas path seal system for aircraft gas turbine engines.** C. M. Taylor (NASA, Lewis Research Center, Cleveland, Ohio; Leeds University, Leeds, England) and R. C. Bill (NASA, Lewis Research Center; U.S. Army, Propulsion Laboratory, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 16th, Huntsville, Ala., Jan. 16-18, 1978, Paper 78-93.* 11 p. 5 refs.

A78-23352 * # **The elastic distortion of the flanged inner ring of a high-speed cylindrical roller bearing.** C. M. Taylor (NASA Lewis Research Center, Cleveland, Ohio; Leeds University, Leeds, England). *(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Joint Lubrication Conference, Kansas City, Mo., Oct. 3-5, 1977, ASME Paper 77-Lub-8.) ASME, Transactions, Journal of Lubrication Technology*, vol. 100, Jan. 1978, p. 18-24. 5 refs.

The elastic distortion of the inner ring of an experimental 3,000,000 DN roller bearing is investigated analytically. The geometry of this bearing is unusually complex and for this reason a bearing with an axially symmetric inner ring and shaft is also analyzed. Only the inner ring and shaft are considered using a two-dimensional finite element computer program which enables interference between these components to be accommodated. The results for the experimental bearing suggest that elastic distortions are modest in relation to the design clearances. However, the variation of the radial deflection of the raceway may be significant for some circumstances and the interference fit adopted between the ring and shaft appears to be questionably low. (Author)

A78-23364 * # **Lubrication of high-speed, large bore tapered roller bearings.** R. J. Parker (NASA, Lewis Research Center, Cleveland, Ohio) and H. R. Signer (Industrial Tectonics, Inc., Compton, Calif.). *(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Joint Lubrication Conference, Kansas City, Mo., Oct. 3-5, 1977, ASME Paper 77-Lub-13.) ASME, Transactions, Journal of Lubrication Technology*, vol. 100, Jan. 1978, p. 31-38. 9 refs.

The performance of 120 65-mm bore tapered-roller bearings was investigated at shaft speeds up to 15,000 rpm. Temperature distribution and bearing heat generation were determined as a function of shaft speed, radial and thrust loads, lubricant flow rate, and lubricant inlet temperature. Lubricant was supplied either by jets or by a combination of holes through the cone directly to the cone rib contact and jets at the roller small end side. Cone-rib lubrication significantly improved high-speed tapered-roller bearing

performance, yielding lower cone-face temperatures and lower power loss and allowing lower lubricant flow rates for a given speed condition. Bearing temperatures increased with increased shaft speed and decreased with increased lubricant flow rate. Bearing power loss increased with increased shaft speed and increased lubricant flow rate. (Author)

A78-23426 * **The use of analytical surface tools in the fundamental study of wear.** D. H. Buckley (NASA, Lewis Research Center, Lubrication Fundamentals Section, Cleveland, Ohio). In: Wear of materials - 1977; Proceedings of the International Conference, St. Louis, Mo., April 25-28, 1977. (A78-23426 08-37) New York, American Society of Mechanical Engineers, 1977, p. 12-29. 77 refs.

This paper reviews the various techniques and surface tools available for the study of the atomic nature of the wear of materials. These include chemical etching, X-ray diffraction, electron diffraction, scanning electron microscopy, low-energy electron diffraction, Auger emission spectroscopy analysis, electron spectroscopy for chemical analysis, field ion microscopy, and the atom probe. Properties of the surface and wear surface regions which effect wear such as surface energy, crystal structure, crystallographic orientation, mode of dislocation behavior, and cohesive binding are discussed. A number of mechanisms involved in the generation of wear particles are identified with the aid of the aforementioned tools. (Author)

A78-24497 * # **The design of hydraulic pressure regulators that are stable without the use of sensing line restrictors or frictional dampers.** H. Gold (NASA, Lewis Research Center, Cleveland, Ohio). *Illinois Institute of Technology, National Conference on Fluid Power, Chicago, Ill., Oct 25-27, 1977, Paper.* 21 p. 6 refs.

A direct acting hydraulic pressure regulator design which incorporates stability margin, response and droop margin is developed. The pressure regulator system does not involve a nonlinear sensing line restrictor (which may degrade transient response) or linear damping (which is sensitive to clearance and viscosity). The direct-acting hydraulic pressure regulator makes use of the technique of lead network stabilization (i.e., the tuned stabilizer concept). An analytically derived circuit pressure regulator is tested to study the stability limit under a parallel capacitive plus resistive load and the stabilizing effect of the tuned stabilizer. J.M.B.

A78-26414 * # **Elastohydrodynamic lubrication of elliptical contacts for materials of low elastic modulus. I - Fully flooded conjunction.** B. J. Hamrock (NASA, Lewis Research Center, Cleveland, Ohio) and D. Dowson (NASA, Lewis Research Center, Cleveland, Ohio; Leeds University, Leeds, England). *American Society of Lubrication Engineers and American Society of Mechanical Engineers, Joint Lubrication Conference, Kansas City, Mo., Oct. 3-5, 1977, ASME Paper 77-Lub-10* 10 p. 12 refs. Members, $1.50; nonmembers, $3.00.

A complete numerical solution is presented to the problem of isothermal elastohydrodynamic lubrication of elliptical contacts for low-elastic-modulus materials operating under fully loaded conditions. No assumption is made for the pressure or film thickness within the contact, and compressibility and viscous effects are taken into account. Because of the dimensionless representation of the coordinates, the actual Hertzian contact ellipse becomes a circle regardless of the value of the ellipticity parameter. A minimum film thickness relation and a central film thickness relation are derived from examining 17 different cases. Contour plots for detailed illustration of the pressure distribution and film thickness in the conjunction are provided. S.D.

A78-28425 * # **Ferrographic analysis of wear debris generated in accelerated rolling element fatigue tests.** W. R. Jones, Jr. and R. J. Parker (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Lubrication Engineers and American Society of Mechanical Engineers, Joint Lubrication Conference, Kansas City, Mo., Oct. 3-5, 1977, Paper.* 21 p. 21 refs.

Ferrographic analysis was used to determine the types and quantities of wear particles generated during accelerated rolling contact fatigue tests. The NASA five-ball rolling contact fatigue tester was used. Ball specimens were made of AMS 5749, a corrosion-resistant high-temperature bearing steel. The lubricant was a super-refined naphthenic mineral oil. Conditions included a maximum Hertz stress of 5.52 billion Pa and a shaft speed of 10,000 rpm. Four types of wear particles were observed: normal rubbing wear particles, fatigue spall particles, spheres, and friction polymer. (Author)

A78-29328 * # **Steady-state unbalance response of a three-disk flexible rotor on flexible, damped supports.** R. E. Cunningham (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Design Engineering Technical Conference, Chicago, Ill., Sept. 26-29, 1977, Paper.* 41 p. 15 refs.

Experimental data are presented for the unbalance response of a flexible, ball bearing supported rotor to speeds above the third lateral bending critical. Values of squeeze film damping coefficients obtained from measured data are compared to theoretical values obtained from short bearing approximation over a frequency range from 5000 to 31,000 cycles/min. Experimental response for an undamped rotor is compared to that of one having oil squeeze film dampers at the bearings. Unbalances applied varied from 0.62 to 15.1 gm-cm. (Author)

A78-31829 * # **Shape of two-dimensional solidification interface during directional solidification by continuous casting.** R. Siegel (NASA, Lewis Research Center, Cleveland, Ohio). *ASME, Transactions, Journal of Heat Transfer*, vol. 100, Feb. 1978, p. 3-10. 11 refs.

An analysis was made of the two-dimensional solidification of an ingot being cooled and withdrawn vertically downward from a mold consisting of parallel walls of finite length. Heat transfer analysis shows how the flatness of the interface is related to the ingot thickness, the withdrawal rate, the heat addition from the superheated liquid metal, and the temperature difference available for cooling. This provides an understanding of the conditions that will yield a maximum rate of casting while achieving the desired flatness of the interface. The results are interpreted with respect to the conditions for obtaining an aligned eutectic structure by directional solidification. In this process an additional constraint must be included that relates the ingot withdrawal rate and the heat transfer rate from the liquid metal to the solidification interface. (Author)

A78-33183 * # **Design considerations in mechanical face seals for improved performance. I - Basic configurations.** L. P. Ludwig (NASA, Lewis Research Center, Cleveland, Ohio) and H. F. Greiner (Sealol, Inc., Providence, R.I.). *American Society of Mechanical Engineers, Winter Annual Meeting, Atlanta, Ga., Nov. 27-Dec. 2, 1977, Paper 77-WA/Lub-3* 10 p. 8 refs. Members, $1.50; nonmembers, $3.00.

Basic assembly configurations of the mechanical face seal are described and some advantages associated with each are listed. The various forms of seal components (the primary seal, secondary seal, etc.) are illustrated, and functions pointed out. The technique of seal pressure balancing and its application is described, and the concept of the PV factor, its different forms and limitations are discussed. Brief attention is given to seal lubrication since it is covered in detail in a companion paper. Finally, the operating conditions for various applications of low pressure seals (aircraft transmissions) are listed, and the seal failure modes of a particular application is discussed. (Author)

A78-33194 * # Design considerations in mechanical face seals for improved performance. II - Lubrication. L. P. Ludwig (NASA, Lewis Research Center, Cleveland, Ohio) and H. F. Greiner (Sealol, Inc., Providence, R.I.). *American Society of Mechanical Engineers, Winter Annual Meeting, Atlanta, Ga., Nov. 27-Dec. 2, 1977, Paper 77-WA/Lub-4.* 12 p. 21 refs. Members, $1.50; nonmembers, $3.00.

The importance of sealing technology in the U.S. industrial chemical-orientated society in regard to maintenance and environmental contamination is pointed out. It is stated that seal performance (leakage, life) is directly related to seal lubrication, which is a mechanism not well understood. Current thinking in regard to seal lubrication is reviewed, the effect of energy dissipation in the thin lubricating film separating the sealing faces is pointed out, and the results of vaporization due to heating are illustrated. Also, hydrodynamic lubrication is reviewed, and an inherent tendency for the seal to operate with angular misalignment is pointed out. Recent work on hydrostatic effects is summarized and the conditions for seal instability are discussed. Four different modes of seal lubrication are postulated with the mode type being a strong function of speed and pressure. (Author)

A78-33211 * # Tribological properties of surfaces. D. H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio). *American Vacuum Society, International Conference on Metallurgical Coatings, San Francisco, Calif., Apr. 3-7, 1978, Paper.* 24 p. 21 refs.

The real area of contact between two solid surfaces is only a small portion of the apparent area. Deformation of these areas can result in solid state contact through surface films. For clean solid to solid contact strong adhesive bonding occurs across the interface. Under these conditions many properties of the solid such as the metallurgical and chemical nature of metals can influence adhesion, friction, and wear behavior. The presence of gases, liquids, and solid films on the surface of solids alter markedly tribological characteristics. These surface films can also considerably change the mechanical effects of solid state contact on bulk material behavior. (Author)

A78-33219 * # Self-acting shaft seals. L. P. Ludwig (NASA, Lewis Research Center, Cleveland, Ohio). *NATO, AGARD, Power, Energetics, and Propulsion Panel Meeting on Seal Technology in Gas Turbine Engines, London, England, Apr. 6, 7, 1978, Paper.* 36 p. 17 refs.

Self-acting seals are described in detail. The mathematical models for obtaining a seal force balance and the equilibrium operating film thickness are outlined. Particular attention is given to primary ring response (seal vibration) to rotating seat face runout. This response analysis reveals three different vibration modes with secondary seal friction being an important parameter. Leakage flow inlet pressure drop and effects of axisymmetric and nonaxisymmetric sealing face deformations are discussed. Experimental data on self-acting face seals operating under simulated gas turbine conditions are given, these data show the feasibility of operating the seal at conditions of 345 N/sq cm and 152 m sec sliding speed. Also a spiral groove seal design operated to 244 m/sec is described. (Author)

A78-33364 * An overview of aerospace gas turbine technology of relevance to the development of the automotive gas turbine engine. D. G. Evans and T. J. Miller (NASA, Lewis Research Center, Cleveland, Ohio). *Society of Automotive Engineers, Congress and Exposition, Detroit, Mich., Feb. 27-Mar. 3, 1978, Paper 780075.* 23 p. 65 refs.

The NASA-Lewis Research Center (LeRC) has conducted, and has sponsored with industry and universities, extensive research into many of the technology areas related to gas turbine propulsion systems. This aerospace-related technology has been developed at both the component and systems level, and may have significant potential for application to the automotive gas turbine engine. This paper summarizes this technology and lists the associated references. The technology areas are system steady-state and transient performance prediction techniques, compressor and turbine design and performance prediction programs and effects of geometry, combustor technology and advanced concepts, and ceramic coatings and materials technology. (Author)

A78-33368 * Bearing, gearing, and lubrication technology. W. J. Anderson (NASA, Lewis Research Center, Cleveland, Ohio). *Society of Automotive Engineers, Congress and Exposition, Detroit, Mich., Feb. 27-Mar. 3, 1978, Paper 780077.* 11 p. 28 refs.

Results of selected NASA research programs on rolling-element and fluid-film bearings, gears, and elastohydrodynamic lubrication are reported. Advances in rolling-element bearing material technology, which have resulted in a significant improvement in fatigue life, and which make possible new applications for rolling bearings, are discussed. Research on whirl-resistant, fluid-film bearings, suitable for very high-speed applications, is discussed. An improved method for predicting gear pitting life is reported. An improved formula for calculating the thickness of elastohydrodynamic films (the existence of which help to define the operating regime of concentrated contact mechanisms such as bearings, gears, and cams) is described. (Author)

A78-37677 * # Experimental evaluation of fuel preparation systems for an automotive gas turbine catalytic combustor. R. R. Tacina (NASA, Lewis Research Center, Cleveland, Ohio). *U.S. Environmental Protection Agency, Workshop on Catalytic Combustion, 2nd, Raleigh, N.C., June 21, 22, 1977, Paper.* 21 p. 6 refs.

Premixing-prevaporizing fuel systems were evaluated for use with a catalytic reactor for possible automotive gas turbine application. Spatial fuel-air distributions, degree of vaporization, pressure drop and air velocity profiles were measured. Three airblast injectors and an air-assist nozzle were tested. Air swirlers were used to improve the spatial fuel-air distribution. The work was done in a 12 cm tubular duct. Test conditions were: a pressure of 0.3 and 0.5 MPa, inlet air temperatures up to 800 K, air velocities of 10 and 20 m/s and fuel air ratios up to 0.020. The fuel was Jet A. The best results were obtained with an air-blast configuration that used multiple cones to provide high velocity air for atomization and also straightened the inlet airflow. With this configuration, uniform spatial fuel-air distributions were obtained with mixing lengths greater than 17.8 cm. In this length, vaporization of the fuel was 98.5 percent complete at an inlet air temperature of 700 K. The total pressure loss was 1.0 percent with a reference velocity of 20 m/s and 0.25 percent at 10 m/s. The air velocity was uniform across the duct and no autoignition reactions were observed. (Author)

A78-45430 * # Additional aspects of elastohydrodynamic lubrication. B. J. Hamrock (NASA, Lewis Research Center, Cleveland, Ohio). *U.S. Army, DARPA, MIT, and U.S. Navy, International Conference on Fundamentals of Tribology, Cambridge, Mass., June 19-22, 1978, Paper.* 14 p. 14 refs.

Elastohydrodynamic lubrication (EHL) for materials of low elastic modulus is considered. Engineering applications in which EHL is important for low-elastic-modulus materials include seals, human joints, tires, and elastomeric material machine elements. Theoretical solutions of the problem of fully flooded line contacts in the case of low elastic materials are discussed. The equation regarding dimensionless minimum film thickness for fully flooded elliptical contacts for low elastic modulus is compared with the corresponding equation for materials of high elastic modulus. The powers of the dimensionless speed parameter U are quite similar in both equations, but the power of the dimensionless load parameter W is much more significant for low elastic modulus materials. Attention is given to aspects of dimensionless grouping, the isoviscous rigid regime, the viscous rigid regime, the isoviscous elastic regime, and the viscous elastic regime. G.R.

A78-45436 * # **Definition and effect of chemical properties of surfaces in friction, wear, and lubrication.** D. H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio). *U.S. Navy, U.S. Army, DARPA, and MIT, International Conference on Fundamentals of Tribology, Cambridge, Mass., June 19-22, 1978, Paper.* 39 p. 75 refs.

Much of the data relative to the properties of surfaces that have been used in the past in analyzing, interpreting and predicting adhesion, friction and wear behavior for solid surfaces is now suspect. With the advent of analytical surface tools, careful and complete characterization of surfaces indicate that very frequently the outermost layers of solid surfaces are markedly different in chemistry than had been previously thought. These layers, as will be shown, are extremely important in adhesion, friction and wear behavior. Some of the properties to be discussed in the paper relative to their role in adhesion, friction, wear and lubrication will include: (1) adsorption, both physical and chemical; (2) orientation of the solid as well as the lubricant; (3) surface energy; (4) surface segregation; (5) surface versus bulk metallurgical effects; (6) electronic nature of the surface; and (7) bonding mechanisms. (Author)

N78-10472*# Chrysler Corp., Detroit, Mich.
SPLITTER-BLADED CENTRIFUGAL COMPRESSOR IMPELLER DESIGNED FOR AUTOMOTIVE GAS TURBINE APPLICATION Final Report, 1 Sep. 1976 - 30 Jun. 1977
R. C. Pampreen Jun. 1977 44 p refs
(Contract NAS3-20059)
(NASA-CR-135237) Avail: NTIS HC A03/MF A01 CSCL 21A

Mechanical design and fabrication of two splitter-bladed centrifugal compressor impellers were completed for rig testing at NASA Lewis Research Center. These impellers were designed for automotive gas turbine application. The mechanical design was based on NASA specifications for blade-shape and flowpath configurations. The contractor made engineering drawings and performed calculations for mass and center-of-gravity, for stress and vibration analyses, and for shaft critical speed analysis. One impeller was machined to print; the other had a blade height and exit radius of 2.54 mm larger than print dimensions. Author

N78-17387*# Avco Lycoming Engine Group, Stratford, Conn.
DEVELOPMENT OF SPIRAL-GROOVE SELF-ACTING FACE SEALS Final Report, 9 Feb. 1976 - 31 Mar. 1977
M. OBrien Jun. 1977 141 p refs Sponsored in part by Army Air Mobility R and D Lab
(Contract NAS3-19772)
(NASA-CR-135303; LYC-77-41) Avail: NTIS HC A07/MF A01 CSCL 11A

An experimental evaluation and a 100-hour endurance test were performed on a spiral groove geometry, self-acting face seal. The seal was tested and operated successfully at maximum conditions of 243.8 m/s surface speed, 199.9 N/sq cm air pressure, and 645.4K (702 F) air temperature. The maximum speed condition of 243.8 m/s was obtained at a shaft speed of 72,500 rpm. Seal wear, gas leakage, and sealing element temperature were monitored during the test. Condition of the seal at the completion of the test was documented and found acceptable for further use. The spiral groove wear rate measured during the endurance test indicates a minimum potential seal life of over 2700 hours. Seal air leakage measured during the test program is within the range considered acceptable for consideration for use in a small gas turbine engine. Author

N78-17390*# Stein Seal Co., Philadelphia, Pa.
FEASIBILITY STUDY OF NEGATIVE LIFT CIRCUMFERENTIAL TYPE SEAL FOR HELICOPTER TRANSMISSIONS
E. N. Goldring Oct. 1977 38 p
(Contract NAS3-20598)
(NASA-CR-135302) Avail: NTIS HC A03/MF A01 CSCL 11A

A new seal concept, the negative lift circumferential type seal, was evaluated under simulated helicopter transmission conditions. The bore of the circumferential seal contains step type geometry which produces a negative lift that urges the sealing segments towards the shaft surface. The seal size was a 2.6 inch bore and the test speeds were 7000 and 14,280 rpm. During the 300 hour test at typical transmission seal pressure (to 2 psig) the leakage was within acceptable limits and generally less than 0.1 cc/hour during the last 150 hours of testing. The wear to the carbon segments during the 300 hours was negligible. Author

N78-20514*# Mechanical Technology, Inc., Latham, N. Y.
BALANCING TECHNIQUES FOR HIGH-SPEED FLEXIBLE ROTORS Final Report
A. J. Smalley Apr. 1978 129 p refs
(Contract NAS3-18520)
(NASA-CR-2975; MTI-77TR2) Avail: NTIS HC A07/MF A01 CSCL 13I

Ideal and non-ideal conditions for multiplane balancing are addressed. Methodology and procedures for identifying optimum balancing configurations and for assessing, quantitatively, the penalties associated with non-optimum configurations were developed and demonstrated. The problems introduced when vibration sensors are supported on flexible mounts were assessed experimentally, and the effects of flexural asymmetry in the rotor on balancing were investigated. A general purpose method for predicting the threshold of instability of an asymmetric rotor was developed, and its predictions are compared with measurements under different degrees of asymmetry. Author

N78-21471*# Michigan Univ., Ann Arbor. Dept. of Aerospace Engineering.
LIGHTWEIGHT, LOW COMPRESSION AIRCRAFT DIESEL ENGINE
T. L. Gaynor, M. S. Bottrell, C. D. Eagle, and C. F. Bachle Jul. 1977 103 p refs
(Contract NAS3-20051)
(NASA-CR-135300) Avail: NTIS HC A06/MF A01 CSCL 21G

The feasibility of converting a spark ignition aircraft engine to the diesel cycle was investigated. Procedures necessary for converting a single cylinder GTS10-520 are described as well as a single cylinder diesel engine test program. The modification of the engine for the hot port cooling concept is discussed. A digital computer graphics simulation of a twin engine aircraft incorporating the diesel engine and Hot Fort concept is presented showing some potential gains in aircraft performance. Sample results of the computer program used in the simulation are included. Author

N78-21472*# Mechanical Technology, Inc., Latham, N. Y.
HYDRODYNAMIC AIR LUBRICATED COMPLIANT SURFACE BEARING FOR AN AUTOMOTIVE GAS TURBINE ENGINE. 1: JOURNAL BEARING PERFORMANCE Final Report
D. Ruscitto, J. McCormick, and S. Gray Apr. 1978 145 p refs Prepared for DOE
(Contracts NAS3-19427; EC-77-A-31-1040)
(NASA-CR-135368; CONS/9427-1) Avail: NTIS HC A07/MF A01 CSCL 20E

A 38.1 mm (1.5 inch) diameter Hydresil Compliant Surface Air Lubricated Journal Bearing was designed and tested to obtain bearing performance characteristics at both room temperature and 315 C (600 F). Testing was performed at various speeds up to 60,000 rpm with varying loads. Rotating sensors provided an opportunity to examine the film characteristics of the compliant surface bearing. In addition to providing minimum film thickness values and profiles, many other insights into bearing operation were gained such as the influence of bearing fabrication accuracy and the influence of smooth foil deflection between the bumps. Author

N78-27427*# Detroit Diesel Allison, Indianapolis, Ind.
AERODYNAMIC PERFORMANCE OF CONVENTIONAL AND ADVANCED DESIGN LABYRINTH SEALS WITH SOLID-SMOOTH ABRADABLE, AND HONEYCOMB LANDS Final Report, 21 Jul. 1976 - 21 Nov. 1977
H. L. Stocker, D. M. Cox, and G. F. Holle Nov. 1977 272 p refs
(Contract NAS3-20066)
(NASA-CR-135307; EDR-9339) Avail: NTIS HC A12/MF A01 CSCL 11A

Labyrinth air seal static and dynamic performance was evaluated using solid, abradable, and honeycomb lands with standard and advanced seal designs. The effects on leakage of land surface roughness, abradable land porosity, rub grooves in abradable lands, and honeycomb land cell size and depth were studied using a standard labyrinth seal. The effects of rotation on the optimum seal knife pitch were also investigated. Selected geometric and aerodynamic parameters for an advanced seal design were evaluated to derive an optimized performance configuration. The rotational energy requirements were also measured to determine the inherent friction and pumping energy absorbed by the various seal knife and land configurations tested in order to properly assess the net seal system performance level. Results indicate that: (1) seal leakage can be significantly affected with honeycomb or abradable lands, (2) rotational energy absorption does not vary significantly with the use of a solid-smooth, an abradable, or a honeycomb land, and (3) optimization of an advanced lab seal design produced a configuration that had leakage 25% below a conventional stepped seal. A.R.H.

N78-27429*# SKF Industries, Inc., King of Prussia, Pa. Research Lab
EMERGENCY AND MICROFOG LUBRICATION AND COOLING OF BEARINGS FOR ARMY HELICOPTERS Final Report, Dec. 1972 - Jun. 1977
J. W. Rosenlieb Jan. 1978 125 p refs
(Contract NAS3-17343)
(NASA-CR-135195; SKF-AL77T021) Avail: NTIS HC A06/MF A01 CSCL 13I

An analysis and system study was performed to provide design information regarding lubricant and coolant flow rates and flow paths for effective utilization of the lubricant and coolant in a once-through oil-mist (microfog) and coolant air system. A system was designed, manufactured, coupled with an existing rig and evaluation tests were performed using 46 mm bore split-inner angular-contact ball bearings under 1779N (400 lb) thrust load. An emergency lubrication aspirator system was also manufactured and tested under lost lubricant conditions. The testing demonstrated the feasibility of using a mist oil and cooling air system to lubricate and cool a high speed helicopter engine mainshaft bearing. The testing also demonstrated the feasibility of using an emergency aspirator lubrication system as a viable survivability concept for helicopter mainshaft engine bearing for periods as long as 30 minutes. Author

N78-28466*# General Motors Corp., Indianapolis, Ind. Detroit Diesel Allison Div.
STUDY AND PROGRAM PLAN FOR IMPROVED HEAVY DUTY GAS TURBINE ENGINE CERAMIC COMPONENT DEVELOPMENT Final Report
H. E. Helms May 1977 156 p refs
(Contract EX-76-A-31-1011; NAS3-20064)
(NASA-CR-135230; CONS/0064-1; DDA-EDR-9068) Avail: NTIS HC A08/MF A01 CSCL 21A

A fuel economy of 213 mg/W-h(0.35 lb/hp-hr) brake specific fuel consumption by 1981 through use of ceramic materials, with conformance to current and projected Federal noise and emission standards was demonstrated and a commercially viable engine is described. Study results show that increased turbine inlet and regenerator inlet temperatures, through the use of ceramic materials, contribute the greatest amount to achieving fuel economy goals. Further, improved component efficiencies (for the compressor, gasifier turbine, power turbine, and regenerator disks show significant additional gains in fuel economy. Fuel saved in a 500,000 mile engine life, risk levels involved in development, and engine related life cycle costs for fleets (100 units) of trucks and buses were used as criteria to select work goals for the planned program. ERA

N78-29449*# Mechanical Technology, Inc., Latham, N. Y.
HYDRODYNAMIC AIR LUBRICATED COMPLIANT SURFACE BEARING FOR AN AUTOMOTIVE GAS TURBINE ENGINE. 2: MATERIALS AND COATINGS Final Report
Bharat Bhushan, David Ruscitto, and Stanley Gray Jul. 1978 139 p refs
(Contracts NAS3-19427, EC-77-A-31-1040)
(NASA-CR-135402; CONS/9427-2) Avail: NTIS HC A07/MF A01 CSCL 11A

Material coatings for an air-lubricated, compliant journal bearing for an automotive gas turbine engine were exposed to service test temperatures of 540 C or 650 C for 300 hours, and to 10 temperature cycles from room temperatures to the service test temperatures. Selected coatings were then put on journal and partial-arc foils and tested in start-stop cycle tests at 14 kPa (2 psi) loading for 2000 cycles. Half of the test cycles were performed at a test chamber service temperature of 540 C (1000 F) or 650 C (1200 F), the other half were performed at room temperature. Based on test results, the following combinations and their service temperature limitations are recommended: HL-800 TM (CdO and graphite) on foil versus chrome carbide on journal up to 370 C (700 F); NASA PS 120 (Tribaloy 400, silver and CaF_2 on journal versus uncoated foil up to 540 C (1000 F); and Kaman DES on journal and foil up to 640 C (1200 F). Kaman DES coating system was further tested successfully at 35 kPa (5 psi) loading for 2000 start-stop cycles. A.R.H.

N78-31427*# General Electric Co., Cincinnati, Ohio
ROLLING ELEMENT FATIGUE TESTING OF GEAR MATERIALS
A. H. Nahm 1 Apr. 1978 110 p refs
(Contract NAS3-14302)
(NASA-CR-135411; Doc-R78AEG289) Avail: NTIS HC A06/MF A01 CSCL 13I

Rolling element fatigue lives of eleven alloys were evaluated. The eleven alloys studied were three nitriding alloys (Super Nitralloy, Nitralloy 135 and Nitralloy N), four case carburizing alloys (AISI 9310, CBS 600, CBS 1000M and Vasco X-2), and four throughhardening alloys (Vasco Matrix II,AISI W-1, AISI S-2 and AISI O-2). Several different heat treatments and/or melting processes were studied on the three carburizing alloy steels. Metallurgical analyses were made before and after the RC rig tests. Test data were statistically analyzed using the Weibull distribution function. B-10 lives were compared versus VIM-VAR AISI M-50 and carburized VAR AISI 9310, as reference alloys. L.S.

N78-32433*# Tennessee Univ. Space Inst., Tullahoma.
TRANSIENT DYNAMICS OF A FLEXIBLE ROTOR WITH SQUEEZE FILM DAMPERS Final Report
D. F. Buono, L. D. Schlitzer, R. G. Hall, III, and D. H. Hibner. Sep. 1978. 85 p. refs.
(Contract NAS3-18523)
(NASA-CR-3060; PWA-5548-9) Avail: NTIS HC A05/MF A01 CSCL 13I

A series of simulated blade loss tests are reported on a test rotor designed to operate above its second bending critical speed. A series of analyses were performed which predicted the transient behavior of the test rig for each of the blade loss tests. The scope of the program included the investigation of transient rotor dynamics of a flexible rotor system, similar to modern flexible jet engine rotors, both with and without squeeze film dampers. The results substantiate the effectiveness of squeeze film dampers and document the ability of available analytical methods to predict their effectiveness and behavior. G.G.

A78-20606 * # Dynamic tooth loads and stressing for high contact ratio spur gears. R. W. Cornell and W. W. Westervelt (United Technologies Corp., Hamilton Standard Div., Windsor Locks, Conn.). *American Society of Mechanical Engineers, Design Engineering Technical Conference, Chicago, Ill., Sept. 26-30, 1977, Paper 77-DET-101.* 8 p. 10 refs. Members, $1.50, nonmembers, $3.00. Contract No. NAS3-17859.

A time history, closed form solution is presented for a dynamic model of spur gear systems for all practical contact ratios. The analysis determines the dynamic response of the gear system and the associated tooth loads and stressing. The dynamic model assumes the two gears act as a rigid inertia and the teeth act as a variable spring of a dynamic system excited by the meshing action of the teeth. Included in the analysis are the effects of the nonlinearity of the tooth pair stiffness during mesh, the tooth errors, and the tooth profile modifications. Besides reviewing the features, solution, and program of this analysis, preliminary results from applying the analysis are presented, which show that tooth profile modification, system inertia and damping, and system critical speeds can affect the dynamic gear tooth loads and stressing significantly. (Author)

A78-23447 * Influence of adsorbed fluids on the rolling contact deformation of MgO single crystals. K. F. Dufrane (Battelle Columbus Laboratories, Columbus, Ohio). In: Wear of materials - 1977; Proceedings of the International Conference, St. Louis, Mo., April 25-28, 1977. (A78-23426 08-37) New York, American Society of Mechanical Engineers, 1977, p. 446-451. 5 refs. Contract No. NAS3-6263.

Basic phenomena associated with rolling contact deformation were studied using MgO as a model bearing material. A hardened steel ball was rolled on MgO single crystals in slow-speed reciprocating motion and in high-speed circular motion. The resulting deformation was studied by dislocation etch-pit techniques. The presence of adsorbed fluids, such as silicone oil, white mineral oil, and toluene, with slow-speed sliding caused a dramatic change in slip mode and premature surface spalling compared with similar experiments in air or under water. In contrast, dimethyl formamide inhibited these slip processes. The results are consistent with the dependence of dislocation mobility on adsorbed species. High-speed hydrodynamic rolling with mineral oil lubrication produced a different slip phenomena entirely from the slow-speed rolling. The slip bands resembled those produced in tensile tests, and all slip apparently initiated at subsurface sites. (Author)

A78-31600 * # Development and fabrication of a diffusion welded Columbium alloy heat exchanger. W. F. Zimmerman, E. C. Duderstadt, D. Wein (General Electric Co., Evendale, Ohio), and R. H. Titran (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Mining, Metallurgical, and Petroleum Engineers, Annual Meeting, 107th, Denver, Colo., Feb. 26-Mar. 2, 1978, Paper A78-61.* 18 p. Contract No. NAS3-18541.

A Mini Brayton space power generation system required the development of a Columbium alloy heat exchanger to transfer heat from a radioisotope heat source to a He/Xe working fluid. A light-weight design featured the simultaneous diffusion welding of 148 longitudinal fins in an annular heat exchanger about 9-1/2 in. in diameter, 13-1/2 in. in length and 1/4 in. in radial thickness. To complete the heat exchanger, additional gas ducting elements and attachment supports were added by GTA welding in a vacuum-purged inert atmosphere welding chamber. The development required the modification of an existing large size hot isostatic press to achieve HIP capabilities of 2800 F and 10,000 psi for at least 3 hr. Excellent diffusion welds were achieved in a high-quality component which met all system requirements. (Author)

38 QUALITY ASSURANCE AND RELIABILITY

Includes product sampling procedures and techniques; and quality control.

N78-17287*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
USE OF AN ULTRASONIC-ACOUSTIC TECHNIQUE FOR NONDESTRUCTIVE EVALUATION OF FIBER COMPOSITE STRENGTH
Alex Vary and Kennett J. Bowles 1978 12 p refs Presented at the 33rd Ann. Conf. of the Soc. of the Plastics Ind., Washington, D.C., 7-10 Feb. 1978
(NASA-TM-73813; E-9400) Avail: NTIS HC A02/MF A01 CSCL 14D

Details of the method used to measure the stress wave factor are described. Frequency spectra of the stress waves are analyzed in order to clarify the nature of the wave phenomena involved. The stress wave factor was measured with simple contact probes requiring only one-side access to a part. This is beneficial in nondestructive evaluations because the waves can run parallel to fiber directions and thus measure material properties in directions assumed by actual loads. The technique can be applied where conventional through transmission techniques are impractical or where more quantitative data are required. The stress wave factor was measured for a series of graphite/polyimide composite panels, and results obtained are compared with through transmission immersion ultrasonic scans. Author

N78-24585*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
QUANTITATIVE ULTRASONIC EVALUATION OF MECHANICAL PROPERTIES OF ENGINEERING MATERIALS
Alex Vary 1978 37 p refs Presented at 1st Intern. Symp. on Ultrasonic Mater Characterization, Gaithersburg, Md., 7-9 Jun 1978; cosponsored by NBS and Am. Soc. Nondestructive Testing.
(NASA-TM-78905; E-9640) Avail: NTIS HC A03/MF A01 CSCL 14D

Progress in the application of ultrasonic techniques to nondestructive measurement of mechanical strength of engineering materials is reviewed. A dormant concept in nondestructive evaluation (NDE) is invoked. The availability of ultrasonic methods that can be applied to actual parts to assess their potential susceptibility to failure under design conditions is discussed. It was shown that ultrasonic methods yield measurements of elastic moduli, microstructure, hardness, fracture toughness, tensile strength, yield strength, and shear strength for a wide range of materials (including many types of metals, ceramics, and fiber composites). It was also indicated that although most of these methods were shown feasible in laboratory studies, more work is needed before they can be used on actual parts in processing, assembly, inspection, and maintenance lines. Author

A78-45433*# Quantitative ultrasonic evaluation of mechanical properties of engineering materials. A. Vary (NASA, Lewis Research Center, Cleveland, Ohio). *National Bureau of Standards and American Society for Nondestructive Testing, International Symposium on Ultrasonic Materials Characterization, 1st, Gaithersburg, Md., June 7-9, 1978, Paper.* 37 p. 55 refs.

Current progress in the application of ultrasonic techniques to nondestructive measurement of mechanical strength properties of engineering materials is reviewed. Even where conventional NDE techniques have shown that a part is free of overt defects, advanced NDE techniques should be available to confirm the material properties assumed in the part's design. There are many instances where metallic, composite, or ceramic parts may be free of critical defects while still being susceptible to failure under design loads due to inadequate or degraded mechanical strength. This must be considered in any failure prevention scheme that relies on fracture analysis. This review will discuss the availability of ultrasonic methods that can be applied to actual parts to assess their potential susceptibility to failure under design conditions. (Author)

N78-18601*# Westinghouse Electric Corp., Pittsburgh, Pa.
FABRICATION AND CHARACTERISTICS OF EXPERIMENTAL RADIOGRAPHIC AMPLIFIER SCREENS Final Report
Zoltan Szepesi Jan. 1978 25 p refs
(Contract NAS3-20742)
(NASA-CR-2937; Rept-77-9F9-RAPEX-R1) Avail: NTIS HC A02/MF A01 CSCL 14D

The fabrication process and transfer characteristics for solid state radiographic image transducers (radiographic amplifier screens) are described. These screens are for use in real-time nondestructive evaluation procedures that require large format radiographic images with contrast and resolution capabilities unavailable with conventional fluoroscopic screens. The screens are suitable for in-motion, on-line radiographic inspection by means of closed circuit television. Experimental effort was made to improve image quality and response to low energy (5 kV and up) X-rays. Author

N78-33463*# General Electric Co., Cincinnati, Ohio. Material and Process Technology Labs.
ROLLING ELEMENT FATIGUE TESTING OF GEAR MATERIALS Final Report, Apr. 1977 - Jun. 1978
A. H. Nahm 26 Jul 1978 124 p refs
(Contract NAS3-14302)
(NASA-CR-135450; R78AEG476) Avail: NTIS HC A06/MF A01 CSCL 14D

Rolling element fatigue lives of nine alloys were evaluated in Rolling Contact (RC) rigs. Test conditions included a Hertzian stress at 4,826 MPa (700 ksi), a rolling speed of 6.23 m/sec (245 in/sec.). Tests were run with a Type I oil (MIL-L-7808G) at room temperature. B-10 lives (10% failure rate) of alloys were compared versus reference alloys, VIM-VAR AISI M-50 and VAR AISI 9310. Six case carburizing alloys (AISI 9310, CBS600, CBS1000M, EX00014, Vasco X-2 and EX00053) and three through-hardening alloys (AISI M-50, VascoMax 350 and Vasco Matrix 2 evaluated, showed RCF performance inferior or equivalent to that of AISI 9310 and AISI M-50. It was also found that the effects of vacuum melting processes, different tempering temperatures, freezing cycle during heat treating, shot peening, gold plating and chrome plating employed in the present investigation did not significantly affect RCF life. G.Y.

39 STRUCTURAL MECHANICS

Includes structural element design and weight analysis; fatigue; and thermal stress.

For applications see 05 Aircraft Design, Testing and Performance and 18 Spacecraft Design, Testing and Performance.

N78-12469*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NASTRAN USE FOR CYCLIC RESPONSE AND FATIGUE ANALYSIS OF WIND TURBINE TOWERS
C. C. Chamis, P. Manos, J. H. Sinclair, and J. R. Winemiller *In its* Sixth NASTRAN Users' Colloq 1977 p 213-233 refs (For availability see N78-12443 03-39)
(Contract E(49-26)-1004)
Avail: NTIS HC A20/MF A01 CSCL 20K

A procedure is described which uses NASTRAN coupled with fatigue criteria via a postprocessor to determine the cyclic response and to assess the fatigue resistance (fatigue life) of wind turbine generator towers. The cyclic loads to which the tower may be subjected are entered either in a quasi-static approach though static load subcases (Rigid Format 1) or through the direct dynamic response (Rigid Format 9) features of NASTRAN. The fatigue criteria are applied to NASTRAN output data from either rigid format through an externally written user program embedded in a postprocessor. Author

N78-13477*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN INTEGRATED THEORY FOR PREDICTING THE HYDROTHERMOMECHANICAL RESPONSE OF ADVANCED COMPOSITE STRUCTURAL COMPONENTS
C. C. Chamis, R. F. Lark, and J. H. Sinclair 1977 43 p refs Presented at Tech. Specialists Conf. on Environ. Effects on Advanced Composite Mater., Dayton, Ohio, 29-30 Sep. 1977; sponsored by Am. Soc. for Testing and Mater.
(NASA-TM-73812; E-9372) Avail: NTIS HC A03/MF A01 CSCL 20K

An integrated theory is developed for predicting the hydrothermomechanical (HDTM) response of fiber composite components. The integrated theory is based on a combined theoretical and experimental investigation. In addition to predicting the HDTM response of components, the theory is structured to assess the combined hydrothermal effects on the mechanical properties of unidirectional composites loaded along the material axis and off-axis, and those of angleplied laminates. The theory developed predicts values which are in good agreement with measured data at the micromechanics, macromechanics, laminate analysis and structural analysis levels. Author

N78-19638*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MODE I ANALYSIS OF A FACE CRACKED PLATE SUBJECTED TO ROTATIONALLY CONSTRAINED END DISPLACEMENTS
Bernard Gross 1978 14 p refs Proposed for Presentation at the 11th Natl. Symp. on Fracture Mech., Blacksburg Va., 12-14 Jun 1978
(NASA-TM-73777) Avail: NTIS HC A02/MF A01 CSCL 20K

Mode I stress intensity coefficients and crack mouth displacement coefficients were obtained by planar boundary collocation analysis of face cracked plates subjected to rotationally constrained end displacements. Results are presented for plates with height-to-width ratio varying from 1.0 to 5.0 and crack depth-to-plate width ratios in the range 0.1 to 0.8. Author

N78-19639*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SHEAR STRENGTH OF METAL - SiO2 CONTACTS
Stephen V. Pepper 24 Mar. 1978 8 p refs Presented at the Intern. Topical Conf. on the Physics of SiO2 and its Interfaces, Yorktown Heights, N. J., 22-24 Mar. 1978
(NASA-TM-78838) Avail: NTIS HC A02/MF A01 CSCL 20K

The strength of the bond between metals and SiO2 was studied by measuring the static coefficient of friction of metals contacting alpha-quartz in ultrahigh vacuum. It was found that copper with either chemisorbed oxygen, nitrogen, or sulphur exhibited higher contact strength on stoichiometric SiO2 than did clean copper. Since the surface density of states induced by these species on copper is similar, it appears that the strength of the interfacial bond can be related to the density of states on the metal surface. Author

N78-23471*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INTERPOLATION AND EXTRAPOLATION OF CREEP RUPTURE DATA BY THE MINIMUM COMMITMENT METHOD. PART 1: FOCAL-POINT CONVERGENCE
S. S. Manson (Case Western Reserve Univ.) and C. R. Ensign 1978 101 p refs Proposed for presentation at Symp. on Characterization of Mater. Intended for Serv. at Elevated Temp. at the Pressure Vessels and Piping Conf., Montreal, 26-29 Jun. 1978; cosponsored by ASME and Can. Soc. Mech. Engr. Sponsored in part by Elec. Power Res. Inst. 3 Vol.
(NASA-TM-78881; E-9614) Avail: NTIS HC A06/MF A01 CSCL 20K

A specialized variation of the *minimum commitment* method is obtained by expressing the relation logt + AP logt + P = G where t is the rupture time, P a function of temperature, and G a function of stress. The term A was considered a structural stability parameter because it was found that the more unstable the material the higher was the negative value of A required to fit the data. The functional forms of P and G were still left to be determined from the station values determined by analysis. The extensions that were made through the development of the above equation are discussed. The discussion provides descriptions of how to implement the method both manually or by computer code. The method is illustrated in detail for Astroloy - a nickel base alloy for which the particular lot available showed embrittling instability involving a phase precipitation. It is also applied to a number of other steels, nickel base alloys, and aluminum alloys. Author

N78-23472*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INTERPOLATION AND EXTRAPOLATION OF CREEP RUPTURE DATA BY THE MINIMUM COMMITMENT METHOD. PART 2: OBLIQUE TRANSLATION
S. S. Manson (Case Western Reserve Univ.) and C. R. Ensign 1978 29 p refs Proposed for presentation at Symp. on Characterization of Mater. Intended for Serv. at Elevated Temp. at the Pressure Vessels and Piping Conf., Montreal, 26-29 Jun. 1978; cosponsored by ASME and Can. Soc. Mech. Engr. Sponsored in part by Elec. Power Res. Inst. 3 Vol.
(NASA-TM-78882; E-9615) Avail: NTIS HC A03/MF A01 CSCL 20K

A new concept is introduced whereby the creep-rupture isothermals are generated by an oblique translation of the master curve plotted on the conventional coordinates. For most materials a constant translation angle of around 5 deg relative to the horizontal axis is satisfactory. However, for highly unstable materials, such as a heat of Astroloy subject to sigma phase precipitation, an angle as high as 15 deg may be required. For best results the translation angle should depend on temperature, the lower temperatures requiring a lower angle. The method is, in fact, a generalization of other approaches but it allows for the other types of temperature effects than only those displayed by elastic modulus E. Implementation of the method can be accomplished either by manual-graphical means, or completely by computer, the major advantage being the ease of manual analysis. The method is illustrated for the unstable heat of Astroloy. Good results were obtained. Author

N78-23473*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INTERPOLATION AND EXTRAPOLATION OF CREEP RUPTURE DATA BY THE MINIMUM COMMITMENT METHOD. PART 3: ANALYSIS OF MULTIHEATS

S S Manson (Case Western Reserve Univ.) and C. R. Ensign 1978 33 p refs Proposed for presentation at Symp. on Characterization of Mater. Intended for Serv. at Elevated Temp. at the Pressure Vessels and Piping Conf., Montreal, 26-29 Jun. 1978, cosponsored by ASME and Can. Soc. Mech. Engr. Sponsored in part by Elec. Power Res. Inst. 3 Vol

(NASA-TM-78883, E-9616) Avail: NTIS HC A03/MF A01 CSCL 20K

The Minimum Commitment Method was applied to two sets of data for which multiple heat information was available. For one alloy, a 304 stainless steel studied in Japan, data on nine well characterized heats were used, while for a proprietary low alloy carbon steel studied in the United Kingdom data were available on seven heats - in many cases to very long rupture times. For this preliminary study no instability factors were used. It was discovered that heat-to-heat variations would be accounted for by introducing heat identifiers in the form A + B log sigma where sigma is the stress and the constants A and B depend only on the heat. With these identifiers all the data could be collapsed onto a single master curve, even though there was considerable scatter among heats. Using these identifiers together with the average behavior of all heats made possible the determination of an accurate constitutive equation for each individual heat. Two basic approaches are discussed for applying the results of the analysis. Author

N78-27463*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FRACTOGRAPHIC EVALUATION OF CREEP EFFECTS ON STRAIN-CONTROLLED FATIGUE-CRACKING OF AISI 304LC AND 316 STAINLESS STEEL

Robert E. Oldrieve Jun 1978 22 p refs

(NASA-TM-78913, E-9648) Avail: NTIS HC A02/MF A01 CSCL 20K

Analysis of high temperature low cycle fatigue of AISI 304LC and 316 stainless steels by the method of strainrange partitioning results in four separate strainrange versus life relationships depending upon the way in which creep-strain and plastic strain are combined within a cycle. Fractography is used in this investigation of the creep-fatigue interaction associated with these cycles. The PP and PC-cycle fractures were transgranular. The PC-cycle resulted in fewer cycles of initiation and shorter total cyclic life for the same applied inelastic strainrange. The CC-cycle had mixed transgranular and intergranular fracture, fewer cycles of initiation and shorter cycle life than PP or PC. The CP-cycle had fully intergranular cracking, and failed in fewer cycles than were reqired for cracks to initate for PP,PC, and CC. Author

N78-32484*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

IMPETUS OF COMPOSITE MECHANICS ON TEST METHODS FOR FIBER COMPOSITES

C. C. Chamis 1978 31 p refs Presented at the US-USSR Seminar on Fracture of Composite Mater., Riga, USSR, 4-7 Sep. 1978

(NASA-TM-78979, E-9734) Avail: NTIS HC A03/MF A01 CSCL 11D

The impetus of composite mechanics on composite test methods and/or on interpreting test results is described by using examples from composite micromechanics, composite macromechanics and laminate theory. The specific examples included contributions such as criteria for selecting resin matrices for improved composite strength; the 10 deg off-axis tensile test; criteria for configuring hybrids and superhybrids for improved impact resistance and the reduced bending rigidities concept for buckling and vibration analyses. G.G.

A78-10831*# **Stress analysis and stress-intensity factors for finite geometry solids containing rectangular surface cracks.** J. P. Gyekenyesi and A. Mendelson (NASA, Lewis Research Center, Cleveland, Ohio). *(American Society of Mechanical Engineers, Winter Annual Meeting, Atlanta, Ga., Nov. 27-Dec. 2, 1977, Paper 77-WA/APM-5.) ASME, Transactions, Series E - Journal of Applied Mechanics*, vol. 44, Sept. 1977, p. 442-448. 18 refs.

The line method of analysis is applied to the Navier-Cauchy equations of elastic equilibrium to calculate the displacement field in a finite geometry bar containing a variable depth rectangular surface crack under extensionally applied uniform loading. The application of this method to these equations leads to coupled sets of simultaneous ordinary differential equations whose solutions are obtained along sets of lines in a discretized region. Using the obtained displacement field, normal stresses, and the stress-intensity factor variation along the crack periphery are calculated for different crack depth to bar thickness ratios. Crack opening displacements and stress-intensity factors are also obtained for a through-thickness, center-cracked bar with variable thickness. The reported results show a considerable potential for using this method in calculating stress-intensity factors for commonly encountered surface crack geometries in finite solids. (Author)

A78-13817* **Mode I stress intensity factors for round compact specimens.** B. Gross (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Testing and Evaluation*, vol. 5, Nov. 1977, p. 457-460. 8 refs.

Mode I stress intensity factors were computed for round compact specimens by the boundary collocation method. Results are presented for ratios At/R0 in the range 0.3 to 0.8, where At is the distance from the specimen center to the crack tip for a specimen of diameter 2R0. (Author)

A78-23355* **Effect of wall thickness and material on flexural fatigue of hollow rolling elements.** E. N. Bamberger (General Electric Co., Evendale, Ohio) and R. J. Parker (NASA, Lewis Research Center, Cleveland, Ohio). *(American Society of Lubrication Engineers and American Society of Mechanical Engineers, Joint Lubrication Conference, Kansas City, Mo., Oct. 3-5, 1977, ASME Paper 77-Lub-14.) ASME, Transactions, Journal of Lubrication Technology*, vol. 100, Jan. 1978, p. 39-46. 21 refs.

Hollow cylindrical bars were tested in a rolling-contact fatigue tester to determine the effects of material and outside diameter to inside diameter (OD/ID) ratios on fatigue failure mode and subsequent failure propagation. The range of applied loads with OD/ID ratios of 2.0, 1.6, 1.4, and 1.2 resulted in maximum tangential tensile stresses ranging from 165 to 655 MPa at the bore surface. Flexural failures of the hollow test bars occurred when this bore stress was 490 MPa or greater with AISI 52100 hollow bars and 338 MPa or greater with AISI M-50 hollow bars. Good correlation was obtained in relating the failures of these hollow bars with flexural failures of drilled balls from full-scale bearing test published previously. (Author)

A78-24903* **The use of parabolic variations and the direct determination of stress intensity factors using the BIE method.** A. Mendelson (NASA, Lewis Research Center, Cleveland, Ohio). *University of Southern California, Symposium on Applications of Computer Methods in Engineering, Los Angeles, Calif., Aug. 23-26, 1977, Paper*. 15 p.

Two advances in the numerical techniques of utilizing the BIE method are presented. The boundary unknowns are represented by parabolas over each interval which are integrated in closed form. These integrals are listed for easy use. For problems involving crack tip singularities, these singularities are included in the boundary integrals so that the stress intensity factor becomes just one more unknown in the set of boundary unknowns thus avoiding the uncertainties of plotting and extrapolating techniques. The method is applied to the problems of a notched beam in tension and bending with excellent results. (Author)

A78-28200 * **Simplified contact analysis.** D. E. Brewe and B. J. Hamrock (NASA, Lewis Research Center, Cleveland, Ohio). *Machine Design*, vol. 50, Mar. 9, 1978, p. 119.

A simple and straightforward method for calculating the elastic deformation at the center of contact between two solids with different radii of curvature is proposed instead of the conventional contact deformation analysis for ball bearings, gears, and cams, which usually involves tedious iterative procedures or the use of design charts. Ellipticity of the contact is approximated from a least-squares power fit. Simplified expressions are derived which allow rapid calculation of deformation from the material properties and geometry of the contacting elements. S.D.

A78-29798 * # **Nonlinear flap-lag-axial equations of a rotating beam with arbitrary precone angle.** R. G. Kvaternik (NASA, Langley Research Center, Aeroelasticity Branch, Hampton, Va.), W. F. White, Jr. (NASA, Langley Research Center; U.S. Army, Research and Technology Laboratories, Hampton, Va.), and K. R. V. Kaza (NASA, Lewis Research Center, Cleveland; Toledo, University, Toledo, Ohio). In: Structures, Structural Dynamics and Materials Conference, 19th, Bethesda, Md., April 3-5, 1978, Technical Papers. (A78-29776 11-39) New York, American Institute of Aeronautics and Astronautics, Inc., 1978, p. 214-227. 30 refs. (AIAA 78-491)

In an attempt both to unify and extend the analytical basis of several aspects of the dynamic behavior of flexible rotating beams, the second-degree nonlinear equations of motion for the coupled flapwise bending, lagwise bending, and axial extension of an untwisted, torsionally rigid, nonuniform, rotating beam having an arbitrary angle of precone with the plane perpendicular to the axis of rotation are derived using Hamilton's principle. The derivation of the equations is based on the geometric nonlinear theory of elasticity and the resulting equations are consistent with the assumption that the strains are negligible compared to unity. No restrictions are imposed on the relative displacements or angular rotations of the cross sections of the beam other than those implied by the assumption of small strains. Illustrative numerical results, obtained by using an integrating matrix as the basis for the method of solution, are presented both for the purpose of validating the present method of solution and indicating the range of applicability of the equations of motion and the method of solution. (Author)

A78-35396 * **Displacement coefficients along the inner boundaries of radially cracked ring segments subject to forces and couples.** B. Gross (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Testing and Evaluation*, vol. 6, May 1978, p. 196-201. 8 refs.

Displacement results of plane boundary collocation analysis are given for various locations on the inner boundaries of radially cracked ring segments (C-shaped specimens) subject to two complementary types of loading. Results are presented for ratios of outer to inner radius in the range of 1.1 to 2.5 and ratios a/W in the range 0.1 to 0.8, where a is the crack length for a specimen of wall thickness W. By combination of these results the resultant displacement coefficient or the corresponding influence coefficient can be obtained for any practical load line location of a pin-loaded specimen. (Author)

N78-18460* # Mechanical Technology, Inc., Latham, N. Y. Research and Development Div.
STIFFNESS AND DAMPING OF ELASTOMERIC O-RING BEARING MOUNTS Contractor Report, Sep. 1975 - Jan. 1977
A. J. Smalley Nov. 1977 75 p refs
(Contract NAS3-19751)
(NASA-CR-135328; MTI-78TR17) Avail: NTIS
HC A04/MF A01 CSCL 13I

A test rig to measure the dynamic stiffness and damping of elastomer O rings was described. Test results for stiffness and loss coefficient in the frequency range from 50 Hz to 1000 Hz are presented. Results are given for three different materials, for five temperatures, for three amplitudes, for five values of squeeze for three values of stretch for three values of cross-section diameter and for three values of groove width. All test data points were plotted. In addition, trend summary plots were presented which compare the effect of material, temperature, amplitude, squeeze, stretch, cross-section diameter, and groove width. O ring deflections under a static load for different material were presented; and effective static stiffness values were compared with dynamic values. Author

N78-21403* # Boeing Aerospace Co., Seattle, Wash.
ANALYSIS AND TEST OF DEEP FLAWS IN THIN SHEETS OF ALUMINUM AND TITANIUM. VOLUME 1: PROGRAM SUMMARY AND DATA ANALYSIS Contractor Report, Jul. 1976 - Dec. 1977
R. W. Finger Apr. 1978 189 p refs 2 Vol.
(Contract NAS3-19697)
(NASA-CR-135369; D180-24613-1) Avail: NTIS
HC A09/MF A01 CSCL 20K

Six thicknesses of 2219-T87 aluminum base metal surface flaw and center crack specimens ranging from 9.53 to 0.635 mm (0.375 to 0.025 inch) were tested at temperatures ranging from 295K to 20K. Additionally, 6A1-4V STA titanium base metal specimens were tested in three thicknesses 3.18, 2.03, and 1.02 mm (0.125, 0.080 and 0.040 inch) at room temperature. All tests were conducted on uniaxial specimens. Results were analyzed and compared with previously developed data to establish a criterion for proof testing thin walled pressure vessels. The data analysis and exact flaw size dimensions are presented. Author

N78-21404* # Boeing Aerospace Co., Seattle, Wash.
ANALYSIS AND TEST OF DEEP FLAWS IN THIN SHEETS OF ALUMINUM AND TITANIUM. VOLUME 2: CRACK OPENING DISPLACEMENT AND STRESS-STRAIN DATA Contractor Report, Jul. 1976 - Dec. 1977
R. W. Finger Apr. 1978 213 p 2 Vol.
(Contract NAS3-19697)
(NASA-CR-135370; D180-24613-2) Avail: NTIS
HC A10/MF A01 CSCL 20K

Static fracture tests were performed on surface flawed specimens of aluminum and titanium alloys. A simulated proof overload cycle was applied prior to all of the cyclic tests. Variables included in each test series were flaw shapes and thickness. Additionally, test temperature was a variable for the aluminum test series. The crack opening displacement and stress-strain data obtained are presented. Author

N78-22402* # Mechanical Technology, Inc., Latham, N. Y.
DEVELOPMENT OF PROCEDURES FOR CALCULATING STIFFNESS AND DAMPING PROPERTIES OF ELASTOMERS IN ENGINEERING APPLICATIONS. PART 4: TESTING OF ELASTOMERS UNDER A ROTATING LOAD Contractor Report, Oct. 1975 - Mar. 1977
M. S. Darlow and A. J. Smalley Nov. 1977 87 p refs
(Contract NAS3-18546)
(NASA-CR-135355; MTI-78TR18-Pt-4) Avail: NTIS
HC A05/MF A01 CSCL 20K

A test rig designed to measure stiffness and damping of elastomer cartridges under a rotating load excitation is described. The test rig employs rotating unbalance in a rotor which runs to 60,000 RPM as the excitation mechanism. A variable resonant mass is supported on elastomer elements and the dynamic characteristics are determined from measurements of input and output acceleration. Five different cartridges are considered: three of these are buttons cartridges having buttons located in pairs, with 120 between each pair. Two of the cartridges consist of 360 elastomer rings with rectangular cross-sections. Dynamic stiffness and damping are measured for each cartridge and compared with predictions at different frequencies and different strains. Author

N78-33478*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Group.
EVALUATION OF CYCLIC BEHAVIOR OF AIRCRAFT TURBINE DISK ALLOYS Final Report, Jun. 1976 - 1978
V. Shahani and H. G. Pop Jun. 1978 202 p refs
(Contract NAS3-20368)
(NASA-CR-159433) Avail: NTIS HC A10/MF A01 CSCL 20K

An evaluation of the cyclic behavior of three aircraft engine turbine disk materials was conducted to compare their relative crack initiation and crack propagation resistance. The disk alloys investigated were Inconel 718, hot isostatically pressed and forged powder metallurgy Rene '95, and as-hot-isostatically pressed Rene '95. The objective was to compare the hot isostatically pressed powder metallurgy alloy forms with conventionally processed superalloys as represented by Inconel 718. Cyclic behavior was evaluated at 650 C both under continuously cycling and a fifteen minute tensile hold time cycle to simulate engine conditions. Analysis of the test data were made to evaluate the strain range partitioning and energy exhaustion concepts for predicting hold time effects on low cycle fatigue. Author

A78-12071 * Lamination residual strains and stresses in hybrid laminates. I. M. Daniel and T. Liber (IIT Research Institute, Chicago, Ill.). In: Composite materials: Testing and design; Proceedings of the Fourth Conference, Valley Forge, Pa., May 3, 4, 1976. (A78-12051 02-24) Philadelphia, Pa., American Society for Testing and Materials, 1977, p. 330-343. 7 refs. Contract No. NAS3-16766.

An investigation is conducted of the effects of hybridization on the magnitude of lamination residual stresses. Eight-ply graphite/Kevlar 49/epoxy and graphite/S-glass/epoxy laminates were studied. The same matrix resin was selected for all basic materials to ensure compatibility and uniform curing of the various plies. The specimens, with inserted strain gages and thermocouples, were subjected to curing and postcuring cycles in an autoclave. Subsequently, the specimens were subjected to a thermal cycle from room temperature to 444 K and down to room temperature. It was found that hydridizing reduces apparently residual strains and stresses in the graphite plies. However, these strains were not affected much by the type and degree of hybridization. G.R.

43 EARTH RESOURCES

Includes remote sensing of earth resources by aircraft and spacecraft; photogrammetry; and aerial photography.

For instrumentation see *35 Instrumentation and Photography.*

N78-14462* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

IN-SITU LASER RETORTING OF OIL SHALE Patent

Harvey S. Bloomfield, inventor (to NASA) Issued 6 Dec. 1977 5 p Filed 26 Jan. 1977 Supersedes N77-18429 (15 - 09, p 1176)

(NASA-Case-LEW-12217-1; US-Patent-4,061,190; US-Patent-Appl-SN-763753; US-Patent-Class-166-259; US-Patent-Class-166-248) Avail: US Patent Office CSCL 08I

Oil shale formations are retorted in situ and gaseous hydrocarbon products are recovered by drilling two or more wells into an oil shale formation underneath the surface of the ground. A high energy laser beam is directed into the well and fractures the region of the shale formation. A compressed gas is forced into the well that supports combustion in the flame front ignited by the laser beam, thereby retorting the oil shale. Gaseous hydrocarbon products which permeate through the fractured region are recovered from one of the wells that were not exposed to the laser system. Official Gazette of the U.S. Patent Office

N78-33510*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AERIAL THERMOGRAPHY FOR ENERGY CONSERVATION

John R. Jack Sep. 1978 22 p refs Original contains color illustrations

(NASA-TM-78959; E-9711) Avail: NTIS HC A02/MF A01 CSCL 14E

Thermal infrared scanning from an aircraft is a convenient and commercially available means for determining relative rates of energy loss from building roofs. The need to conserve energy as fuel costs makes the mass survey capability of aerial thermography an attractive adjunct to community energy awareness programs. Background information on principles of aerial thermography is presented. Thermal infrared scanning systems, flight and environmental requirements for data acquisition, preparation of thermographs for display, major users and suppliers of thermography, and suggested specifications for obtaining aerial scanning services were reviewed. B.B.

44 ENERGY PRODUCTION AND CONVERSION

Includes specific energy conversion systems, e.g., fuel cells and batteries; global sources of energy; fossil fuels; geophysical conversion; hydroelectric power; and wind power.

For related information see also *07 Aircraft Propulsion and Power, 20 Spacecraft Propulsion and Power, 28 Propellants and Fuels,* and *85 Urban Technology and Transportation.*

N78-13527*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SOLAR CELL HIGH EFFICIENCY AND RADIATION DAMAGE
1977 221 p refs Conf. held at Cleveland, 18-19 May 1977
(NASA-CP-2020) Avail: NTIS HC A10/MF A01 CSCL 10A

Silicon solar cell analysis and fundamental measurements, silicon cell technology, gallium arsenide research and technology, and radiation effects on silicon and gallium arsenide cells, are reported. For individual titles, see N78-13528 through N78-13551.

N78-13528*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUMMARY OF THE NASA SPACE PHOTOVOLTAIC RESEARCH AND TECHNOLOGY PROGRAM
Henry W. Brandhorst, Jr. *In its* Solar Cell High Efficiency and Radiation Damage 1977 p 3-6 (For availability see N78-13527 04-44)
Avail: NTIS HC A10/MF A01 CSCL 10A

Low cost solar cells and arrays with high end-of-life efficiency are evaluated through two approaches: one, to obtain increased device efficiency at no increase in cost and two, to reduce the manufacturing costs of space solar cells and arrays. Technology efforts encompass high efficiency epitaxial cells, high efficiency wraparound contact solar cells, economical diffusion sources, automated cell fabrication and development of easily applied, durable cover glasses. The examination of ion-implanted profile tailored junctions and additional development of screen printed contact technology to cell development are also considered.
Author

N78-13534*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
IMPURITY CONCENTRATIONS AND SURFACE CHARGE DENSITIES ON THE HEAVILY DOPED FACE OF A SILICON SOLAR CELL
I. Weinberg and Lon Hsu (Wayne State Univ.) *In* NASA. Lewis Res. Center Solar Cell High Efficiency and Radiation Damage 1977 p 69-79 refs (For availability see N78-13527 04-44)
Avail: NTIS HC A10/MF A01 CSCL 10A

Increased solar cell efficiencies are attained by reduction of surface recombination and variation of impurity concentration profiles at the n(+) surface of silicon solar cells. Diagnostic techniques are employed to evaluate the effects of specific materials preparation methodologies on surface and near surface concentrations. It is demonstrated that the MOS C-V method, when combined with a bulk measurement technique, yields more complete concentration data than are obtainable by either method alone. Specifically, new solar cell MOS C-V measurements are combined with bulk concentrations obtained by a successive layer removal technique utilizing measurements of sheet resistivity and Hall coefficient.
Author

N78-13606*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
SOME BASIC CONSIDERATIONS OF MEASUREMENTS INVOLVING COLLIMATED DIRECT SUNLIGHT
An-Ti Chai 1976 18 p refs Presented at Terrest. PV Meas. Workshop, Baton Rouge, La., 10 Nov. 1976
(Contract EX-76-A-29-1022)
(NASA-TM-74947; TR-2-8; ERDA/NASA-1022/76/8; Conf-761129-8) Avail: NTIS HC A02/MF A01 CSCL 10A

The geometry of collimators for devices or instruments dealing with terrestrial direct sunlight is discussed. Effects of the opening angle and slope angle of a collimator on the measurements are investigated with regard to variations of turbidity and air mass. Based on this investigation, geometric dimensions for collimators and certain realistic terrestrial reference conditions are recommended for the purpose of solar cell calibration in terrestrial applications.
ERA

N78-14625* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MULTI-CELL BATTERY PROTECTION SYSTEM Patent
Ralph D. Thomas and William J. Nagle, inventors (to NASA) Issued 6 Dec. 1977 5 p Filed 19 May 1976 Supersedes N76-23713 (14 - 14, p 1820)
(NASA-Case-LEW-12039-1; US-Patent-4,061,955; US-Patent-Appl-SN-687822; US-Patent-Class-320-6; US-Patent-Class-320-15; US-Patent-Class-320-18; US-Patent-Class-320-40) Avail: US Patent Office CSCL 10A

A multi-cell battery protection system is described wherein each cell has its own individual protective circuit. The protective circuits consist of a solid state comparator unit and a high current switching device such as a relay. The comparator units each continuously monitor the associated cell and when the cell voltage either exceeds a predetermined high level or falls below a predetermined low level, the relay is actuated whereby a bypass circuit is completed across the cell thereby effectively removing the cell from the series of cells.
Official Gazette of the U.S. Patent Office

N78-14628*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
REAL-TIME AND ACCELERATED OUTDOOR ENDURANCE TESTING OF SOLAR CELLS
Americo F. Forestieri and Evelyn Anagnostou Aug. 1977 26 p refs Presented at 1977 Photovoltaics Solar Energy Conf., Luxembourg, 27-30 Sep. 1977, sponsored by Comm. of the European Communities. Sponsored in part by ERDA
(Contract E(49-26)-1022)
(NASA-TM-73743; E-9310; ERDA/NASA/1022/77/17) Avail: NTIS HC A03/MF A01 CSCL 10A

Real-time and accelerated outdoor endurance testing was performed on a variety of samples of interest to the National Photovoltaic Conversion Program. The real-time tests were performed at seven different sites and the accelerated tests were performed at one of those sites in the southwestern United States. The purpose of the tests were to help evaluate the lifetime of photovoltaic systems. Three types of samples were tested: transmission samples of possible cover materials; sub-modules constructed using these materials attached to solar cells; and solar cell modules produced by the manufacturers for the ERDA program. Results indicate that suitable cover materials are glass, FEP A and PFA. Dirt accumulation and cleanability are important factors in the selection of solar cell module covers and encapsulants.
Author

N78-14629*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
US TERRESTRIAL SOLAR CELL CALIBRATION AND MEASUREMENT PROCEDURES
Henry W. Brandhorst, Jr. Sep. 1977 16 p refs Presented at 1977 Photovoltaics Solar Energy Conf., Luxembourg, 27-30 Sep. 1977 sponsored by Comm. of the European Communities. Sponsored in part by ERDA
(Contract E(49-26)-1022)
(NASA-TM-73788; E-9353; ERDA/NASA/1022/77/20) Avail: NTIS HC A02/MF A01 CSCL 10A

A workshop was held in the fall of 1976, to evaluate and revise interim terrestrial solar cell calibration and measurement procedures. The revisions made to the interim testing procedures are described. The calibration of reference cells and the design of their holders are covered. Considerations include view angle and optical and thermal matching. Atmospheric factors which

affect the calibration and performance of solar cells are discussed. The most critical atmospheric parameter appears to be water vapor. Techniques for matching reference cells to cells or arrays under test are described. Data showing errors in performance under artificial sunlight simulators due to mismatch of reference and test cells are presented. Finally, measurement procedures and data transformations needed to obtain the performance of solar cells and arrays in outdoor natural sunlight are described. Author

N78-14630*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SOLAR ENERGY METER
R. M. Masters. Sep. 1977. 12 p. ref. Sponsored in part by ERDA
(Contract E(49-26)-1022)
(NASA-TM-73791; E-9358; ERDA/NASA/1022/77/21) Avail: NTIS HC A02/MF A01 CSCL 10A

An instrument was developed to continually integrate the energy available in incident light on a specifically oriented surface. The unit was designed for outdoor use in remote locations and is capable of operation over a temperature range of -20 to +60 C with good accuracy. The unit is weather resistant, requires low power, has a high input impedance, is inexpensive, and has a visual readout and an analog output for recording. Author

N78-14631*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANION EXCHANGE MEMBRANES FOR ELECTROCHEMICAL OXIDATION-REDUCTION ENERGY STORAGE SYSTEM
Patricia M. ODonnell, Dean W. Sheibley, and Randall F. Gahn. Aug. 1977. 22 p. refs
(Contract E(49-26)-1002)
(NASA-TM-73751; ERDA/NASA-1002/77/2; E-9222) Avail: NTIS HC A02/MF A01 CSCL 10C

Oxidation-reduction couples in concentrated solutions separated by appropriate ion selective membranes were considered as an attractive approach to bulk electrical energy storage. A key problem is the development of the membrane. Several promising types of anionic membranes are discussed which were developed and evaluated for redox energy storage systems. The copolymers of ethyleneglycoldimethacrylate with either 2-vinylpyridine or vinylbenzl chloride gave stable resistance values compared to the copolymer of vinylbenzichloride and divinylbenzene which served as the baseline membrane. A polyvinylchloride film aminated with tetraethylenepentamine had a low resistance but a high ion transfer rate. A slurry coated vinylpyridine had the lowest ion transfer rate. All these membranes functioned well in laboratory cells at ambient temperatures with the acidic chloride oxidant/reductant system, Fe 3, Fe 2/Ti 3, Ti 4. Author

N78-15562*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
BLACK CHROME ON COMMERCIALLY ELECTROPLATED TIN AS A SOLAR SELECTING COATING
G. E. McDonald. Sep. 1977. 10 p. refs. Presented at Concentrating Collector Conf., Atlanta, 26-28 Sep. 1977
(Contract EX-76-29-1060)
(NASA-TM-73799; ERDA/NASA-1060/77/1; E-9375) Avail: NTIS HC A02/MF A01 CSCL 10A

The reflectance properties of black chrome electroplated on commercially electroplated tin were measured for various black chrome plating times for both the solar and infrared spectrum. The values of absorptance and emittence were calculated from the measured reflectance values. The results indicate that the optimum combination of the highest absorptance in the solar region and the lowest emittance in the infrared of the black chrome plated on commercially electroplated tin is obtained for a black chrome plating time of between one and two minutes. Author

N78-15563*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
ERDA/NASA 100 KILOWATT MOD-0 WIND TURBINE OPERATIONS AND PERFORMANCE
R. L. Thomas and T. R. Richards. Sep. 1977. 18 p. refs. Presented at Conf. on Wind Energy Conversion Systems, Wash., D. C., 19-21 Sep. 1977
(Contract E(49-26)-1028)
(NASA-TM-73825; ERDA/NASA-1028/77/9) Avail: NTIS HC A02/MF A01 CSCL 10B

The ERDA/NASA 100 kW Mod-0 wind turbine is operating at the NASA Plum Brook Station near Sandusky, Ohio. The operation of the wind turbine has been fully demonstrated and includes start-up, synchronization to the utility network, blade pitch control for control of power and speed, and shut-down. Also, fully automatic operation has been demonstrated by use of a remote control panel, 50 miles from the site, similar to what a utility dispatcher might use. The operation systems and experience with the wind turbine loads, electrical power and aerodynamic performance obtained from testing are described. Author

N78-16434*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
APPROXIMATE METHOD FOR CALCULATING FREE VIBRATIONS OF A LARGE-WIND-TURBINE TOWER STRUCTURE
Sankar C. Das and Bradford S. Linscott. Dec. 1977. 46 p. refs
(Contract E(49-26)-1028)
(NASA-TM-73754; ERDA/NASA-1028/77/12) Avail: NTIS HC A03/MF A01 CSCL 10A

A set of ordinary differential equations were derived for a simplified structural dynamic lumped-mass model of a typical large-wind-turbine tower structure. Dunkerley's equation was used to arrive at a solution for the fundamental natural frequencies of the tower in bending and torsion. The ERDA-NASA 100-kW wind turbine tower structure was modeled, and the fundamental frequencies were determined by the simplified method described. The approximate fundamental natural frequencies for the tower agree within 18 percent with test data and predictions analyzed. Author

N78-16435*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
PHOTOVOLTAIC REFRIGERATION APPLICATION: ASSESSMENT OF THE NEAR-TERM MARKET
Louis Rosenblum, William J. Bifano, William A. Poley, and Larry R. Scudder. Dec. 1977. 19 p.
(Contract E(49-26)-1022)
(NASA-TM-73876; E-9476; DOE/NASA-1022/77/23) Avail: NTIS HC A02/MF A01 CSCL 10A

This foreign and domestic market assessment was performed as part of the Tests and Applications Project being conducted by NASA-LeRC as part of the Department of Energy's (DOE) National Photovoltaic Program. One of the objectives of that program was to stimulate the demand for photovoltaic power systems so that appropriate markets would be developed in concert with the increasing photovoltaic production capacity. The refrigeration application represented a possible market for photovoltaics; hence, a brief survey of potential applications was conducted. Both refrigerators and refrigeration systems were considered in the assessment although the primary emphasis is on refrigerators of 9 cu ft of less. Three user sectors were examined: (1) government, (2) commercial/institutional, and (3) general public. Author

N78-17466*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
WIND TURBINE GENERATOR ROTOR BLADE CONCEPTS WITH LOW COST POTENTIAL
T. L. Sullivan, T. P. Cahill, D. G. Griffee, Jr. (United Technologies Corp., Windsor Locks, Conn.), and H. W. Gewehr (Karman Aerospace Corp.). Dec. 1977. 38 p. refs. To be Presented at the 23rd Natl. SAMPE Symp., Anaheim, Calif., 2-4 May 1978

(Contract E(49-26)-1028)
(NASA-TM-73835, DOE/NASA-1028-77/13; E-9422) Avail: NTIS HC A03/MF A01 CSCL 10A

Four processes for producing blades are examined. Two use filament winding techniques and two involve filling a mold or form to produce all or part of a blade. The processes are described and a comparison is made of cost, material properties, design and free vibration characteristics. Conclusions are made regarding the feasibility of each process to produce low cost, structurally adequate blades. Author

N78-17467*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SYNCHRONIZATION OF THE DOE/NASA 100-KILOWATT WIND TURBINE GENERATOR WITH A LARGE UTILITY NETWORK
Leonard J. Gilbert Dec 1977 19 p refs
(Contract E(49-26)-1028)
(NASA-TM-73861, E-9450; DOE/NASA/1028/77/10) Avail: NTIS HC A02/MF A01 CSCL 10A

The DOE/NASA 100 kilowatt wind turbine generator system was synchronized with a large utility network. The system equipments and procedures associated with the synchronization process were described. Time history traces of typical synchronizations were presented indicating that power and current transients resulting from the synchronizing procedure are limited to acceptable magnitudes. Author

N78-17468*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
STATUS OF THE DOE (STOR)-SPONSORED NATIONAL PROGRAM ON HYDROGEN PRODUCTION FROM WATER VIA THERMOCHEMICAL CYCLES
C. E. Baker 1977 16 p refs Presented at the Miami Intern. Conf. on Alternative Energy Sources, Miami Beach, Fla., 5-7 Dec. 1977; sponsored by Dept. of Energy and Miami Univ.
(NASA-TM-78825; E-9529) Avail: NTIS HC A02/MF A01 CSCL 07D

The program structure is presented. The activities of the thermochemical cycles program are grouped according to the following categories: (1) specific cycle development, (2) support research and technology, (3) cycle evaluation. Specific objectives and status of on-going activities are discussed. Chemical reaction series for the production of hydrogen are presented. Efficiency and economic evaluations are also discussed. G.Y.

N78-17469*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
TECHNICAL AND ECONOMIC FEASIBILITY STUDY OF SOLAR/FOSSIL HYBRID POWER SYSTEMS
Harvey S. Bloomfield and James E. Calogeras Dec. 1977 70 p refs
(NASA-TM-73820, E-9409) Avail: NTIS HC A04/MF A01 CSCL 10B

Results show that new hybrid systems utilizing fossil fuel augmentation of solar energy can provide significant capital and energy cost benefits when compared with solar thermal systems requiring thermal storage. These benefits accrue from a reduction of solar collection area that results from both the use of highly efficient gas and combined cycle energy conversion subsystems and elimination of the requirement for long-term energy storage subsystems. Technical feasibility and fuel savings benefits of solar hybrid retrofit to existing fossil-fired gas and vapor cycle powerplants were confirmed, however economic viability of steam cycle retrofit was found to be dependent on the thermodynamic and operational characteristics of the existing powerplant. Author

N78-18888* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SELECTIVE COATING FOR SOLAR PANELS Patent
Glen E. McDonald, inventor (to NASA) Issued 25 Oct. 1977 6 p Filed 22 Dec. 1975 Supersedes N76-15803 (14 - 06, p. 0741)
(NASA-Case-LEW-12159-1; US-Patent-4,055,707; US-Patent-Appl-SN-643041; US-Patent-Class-428-652; US-Patent-Class-126-270; US-Patent-Class-427-160; US-Patent-Class-428-667; US-Patent-Class-428-679) Avail: US Patent Office CSCL 10A

The energy absorbing properties of solar heating panels are improved by depositing a black chrome coating of controlled thickness on a specially prepared surface of a metal substrate. The surface is prepared by depositing a dull nickel on the substrate, and the black chrome is plated on this low emittance surface to a thickness between 0.5 micron and 2.5 microns.
Official Gazette of the U.S. Patent Office

N78-19616*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
WIND TURBINE STRUCTURAL DYNAMICS
Dean R. Miller, ed. 1978 280 p refs Workshop held at Cleveland, 15-17 Nov. 1977; sponsored by DOE
(NASA-CP-2034; DOE-Conf-771148; E-9518) Avail: NTIS HC A13/MF A01 CSCL 10A

A workshop on wind turbine structural dynamics was held to review and document current United States work on the dynamic behavior of large wind turbines, primarily of the horizontal-axis type, and to identify and discuss other wind turbine configurations that may have lower cost and weight. Information was exchanged on the following topics: (1) Methods for calculating dynamic loads; (2) Aeroelasticity stability; (3) Wind loads, both steady and transient; (4) Critical design conditions; (5) Drive train dynamics; and (6) Behavior of operating wind turbines. For individual titles, see N78-19617 through N78-19641.

N78-19617*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPARISON OF COMPUTER CODES FOR CALCULATING DYNAMIC LOADS IN WIND TURBINES
David A. Spera *In its* Wind Turbine Structural Dyn. 1978 p 1-13 refs (For availability see N78-19616 10-04)
Avail: NTIS HC A13/MF A01 CSCL 10A

The development of computer codes for calculating dynamic loads in horizontal axis wind turbines was examined, and a brief overview of each code was given. The performance of individual codes was compared against two sets of test data measured on a 100 KW Mod-0 wind turbine. All codes are aeroelastic and include loads which are gravitational, inertial and aerodynamic in origin. Author

N78-19618*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SIMPLIFIED MODELING FOR WIND TURBINE MODAL ANALYSIS USING NASTRAN
Timothy L. Sullivan *In its* Wind Turbine Structural Dyn. 1978 p 31-38 refs (For availability see N78-19616 10-44)
Avail: NTIS HC A13/MF A01 CSCL 10A

A detailed finite element model of the MOD-0 wind turbine tower was reduced to six beam elements (stick model). The method used to calculate the properties of the beam elements in the stick model was explained and the accuracy of the stick model in predicting natural frequencies and mode shapes was examined. Computer times were compared and several applications where the stick model was used are described. From results obtained from the MOD-0 tower it is concluded that a tower of this type can be modeled as a simple cantilever beam for modal analysis. However, this model should be limited to tower torsional modes and tower bending modes where the mode shape resembles a cantilever beam first bending mode shape. Author

N78-19826* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INFLUENCE OF WIND TURBINE FOUNDATION
Suey T. Yee *In its* Wind Turbine Structural Dyn. 1978 p 103-108 (For availability see N78-19816 10-44)
Avail: NTIS HC A13/MF A01 CSCL 10A

The 200 kW Mod-0A wind turbine was modeled using a 3 lumped mass-spring system for the superstructure and a rotational spring for the foundation and supporting soil. Natural frequencies were calculated using soil elastic moduli varying from 3000 to 22,400 p.s.i. The reduction in natural frequencies from the rigid foundation case ranged up to 20 percent. Author

N78-19827*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUMMARY OF STATIC LOAD TEST OF THE MOD-0 BLADE
Dean R. Miller *In its* Wind Turbine Structural Dyn. 1978 p 109-116 refs (For availability see N78-19816 10-44)
Avail: NTIS HC A13/MF A01 CSCL 10A

A static load test was performed on the spare Mod-0 wind turbine blade to define load transfer at the root end of the blade, and to validate stress analysis of this particular type of blade construction (frame and stringer). Analysis of the load transfer from the airfoil skin to the shank tube predicted a step change in spanwise stress in the airfoil skin at station 81.5 inches (STA 81.5). For flatwise bending a 40% reduction in spanwise stress was predicted, and for edgewise bending a 6% reduction. Experimental results verified the 40% reduction for flatwise bending, but indicated about a 30% reduction for edgewise bending. Author

N78-19828*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
DOE/NASA MOD-0 100KW WIND TURBINE TEST RESULTS
John C. Glasgow *In its* Wind Turbine Structural Dyn. 1978 p 117-150 refs (For availability see N78-19816 10-44)
Avail: NTIS HC A13/MF A01 CSCL 10A

The Wind Turbine demonstrates the capability of automatic unattended operation, including startup, achieving synchronism, and shutdown as dictated by wind conditions. During the course of these operations, a wealth of engineering data was generated. Some of the data which is associated with rotor and machine dynamics problems encountered, and the machine modifications incorporated as a solution are presented. These include high blade loads due to tower shadow, excessive nacelle yawing motion, and power oscillations. The results of efforts to correlate measured wind velocity with power output and wind turbine loads are also discussed. Author

N78-19829*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
POWER OSCILLATION OF THE MOD-0 WIND TURBINE
Robert C. Seidel *In its* Wind Turbine Structural Dyn. 1978 p 151-156 (For availability see N78-19816 10-44)
Avail: NTIS CSCL 10A

The Mod-0 power has noise components with varying frequency patterns. Magnitudes reach more than forty percent power at the frequency of twice per rotor revolution. Analysis of a simple torsional model of the power train predicts less than half the observed magnitude and does not explain the shifting frequencies of the noise patterns. Author

N78-19832*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
METHODS OF ATTENUATING WIND TURBINE ac GENERATOR OUTPUT VARIATIONS
Harold Gold *In its* Wind Turbine Structural Dyn. 1978 p 179-186 refs (For availability see N78-19816 10-44)
Avail: NTIS HC A13/MF A01 CSCL 10A

Wind speed variation, tower blockage and structural and inertial factors produce unsteady torque in wind turbines. Methods for modifying the turbine torque so that steady torque is delivered to the coupled ac generator are discussed. The method that may evolve will be influenced by the power use that develops and the trade-offs of cost, weight and complexity. Author

N78-19833*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECTS OF ROTOR LOCATION, CONING, AND TILT ON CRITICAL LOADS IN LARGE WIND TURBINES
D. A. Spera and D. C. Janetzke *In its* Wind Turbine Structural Dyn. 1978 p 227-236 refs (For availability see N78-19816 10-44)
Avail: NTIS HC A13/MF A01 CSCL 10A

Several large (1500 kW) horizontal rotor configurations were analyzed to determine the effects on dynamic loads of upwind downwind rotor locations, coned and radial blade positions, and tilted and horizontal rotor axis positions. Loads were calculated for a range of wind velocities at three locations in the structure: (1) the blade shank; (2) the hub shaft; and (3) the yaw drive. Blade axis coning and rotor axis tilt were found to have minor effects on loads. However, locating the rotor upwind of the tower significantly reduced loads at all locations analyzed. Author

N78-19835*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FIXED PITCH WIND TURBINES
David S. Fenn and Larry A. Viterna *In its* Wind Turbine Structural Dyn. 1978 p 243-254 (For availability see N78-19816 10-44)
Avail: NTIS HC A13/MF A01 CSCL 10A

Wind turbines designed for fixed pitch operation offer potential reductions in the cost of the machine by eliminating many costly components. It was shown that a rotor can be designed which produces the same energy annually as Mod-0 but which regulates its power automatically by progressively stalling the blades as wind speed increases. Effects of blade twist, taper, root cutout, and airfoil shape on performance are discussed as well as various starting techniques. Author

N78-19842*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL DATA AND THEORETICAL ANALYSIS OF AN OPERATING 100 kW WIND TURBINE
Bradford S. Linscott, John C. Glasgow, William D. Anderson (Lockheed California Co., Burbank), and Robert E. Donham (Lockheed California Co., Burbank) Jan. 1978 21 p refs Presented at 12th Intersoc. Energy Conversion Engr. Conf., Washington, D. C., 28 Aug. - 2 Sep. 1977; sponsored by Am. Nucl. Soc.
(Contract E(49-26)-1028)
(NASA-TM-73883, DOE/NASA/1028-78/15, E-9496) Avail: NTIS HC A02/MF A01 CSCL 10A

Experimental test data are correlated with analyses of turbine loads and complete system behavior of the ERDA-NASA 100 kW Mod-0 wind turbine generator over a broad range of steady state conditions, as well as during transient conditions. The deficit in the ambient wind field due to the upwind tower turbine support structure is found to be very significant in exciting higher harmonic loads associated with the flapping response of the blade in bending. Author

N78-19843*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PHOTOVOLTAIC VILLAGE POWER APPLICATION: ASSESSMENT OF THE NEAR-TERM MARKET
Louis Rosenblum, William J. Briano, William A. Poley, and Larry R. Scudder Jan. 1978 29 p refs
(Contract E(49-26)-1022)
(NASA-TM-73893, DOE/NASA/1022-78/25, E-9510) Avail: NTIS HC A03/MF A01 CSCL 10B

The village power application represents a potential market for photovoltaics. The price of energy for photovoltaic systems

was compared to that of utility line extensions and diesel generators. The potential domestic demand was defined in both the government and commercial sectors. The foreign demand and sources of funding for village power systems in the developing countries were also discussed briefly. It was concluded that a near term domestic market of at least 12 MW min and a foreign market of about 10 GW exists. Author

N78-19846*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PHOTOVOLTAIC WATER PUMPING APPLICATIONS: ASSESSMENT OF THE NEAR-TERM MARKET
Louis Rosenblum, William J. Bifano, Larry R. Scudder, William A. Patay, and James P. Cusik. Mar. 1978. 24 p. refs.
(Contract E(49-26)-1022)
(NASA-TM-78847; E-9566; DOE/NASA/1022-78/29) Avail: NTIS HC A02/MF A01 CSCL 10B

Water pumping applications represent a potential market for photovoltaics. The price of energy for photovoltaic systems was compared to that of utility line extensions and diesel generators. The potential domestic demand was defined in the government, commercial/institutional and public sectors. The foreign demand and sources of funding for water pumping systems in the developing countries were also discussed briefly. It was concluded that a near term domestic market of at least 240 megawatts and a foreign market of about 6 gigawatts exist. Author

N78-19848*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DETERMINATION OF THE ZINCATE DIFFUSION COEFFICIENT AND ITS APPLICATION TO ALKALINE BATTERY PROBLEMS
Charles E. May. 1978. 20 p. refs. Proposed for presentation at the Electrochemical Soc. Meeting, Pittsburgh, 15-20 Oct. 1978.
(NASA-TM-73879; E-9486) Avail: NTIS HC A02/MF A01 CSCL 10C

The diffusion coefficient for the zincate ion at 24 C was found to be 9.9 X 10 to the minus 7th power squared cm per sec + or - 30 percent in 45 percent potassium hydroxide and 1.4 x 10 to the minus 7 squared cm per sec + or - 25 percent in 40 percent sodium hydroxide. Comparison of these values with literature values at different potassium hydroxide concentrations show that the Stokes-Einstein equation is obeyed. The diffusion coefficient is characteristic of the zincate ion (not the cation) and independent of its concentration. Calculations with the measured value of the diffusion coefficient show that the zinc concentration in an alkaline zincate half cell becomes uniform throughout in tens of hours by diffusion alone. Diffusion equations are derived which are applicable to finite size chambers. Details and discussion of the experimental method are also given. Author

N78-19868*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REDOX FLOW CELL DEVELOPMENT AND DEMONSTRATION PROJECT: CALENDAR YEAR 1976
Dec. 1977. 48 p. refs.
(Contract E(49-28)-1002)
(NASA-TM-73873; E-9354; CONS/1002-3) Avail: NTIS HC A03/MF A01 CSCL 10A

The major focus of the effort was the key technology issues that directly influence the fundamental feasibility of the overall redox concept. These issues were the development of a suitable semipermeable separator membrane for the system, the screening and study of candidate redox couples to achieve optimum cell performance and the carrying out of systems analysis and modeling to develop system performance goals and cost estimates. Author

N78-19887*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PHOTOVOLTAIC POWER SYSTEM TESTS ON AN 8-KILOWATT SINGLE-PHASE LINE-COMMUTATED INVERTER
John B. Stover. Feb. 1978. 18 p. refs.
(Contract E(49-26)-1022)
(NASA-TM-78824; E-9527; DOE/NASA/1022-78/26) Avail: NTIS HC A02/MF A01 CSCL 10B

Efficiency and power factor were measured as functions of solar array voltage and current. The effects of input shunt capacitance and series inductance were determined. Tests were conducted from 15 to 75 percent of the 8 kW rated inverter input power. Measured efficiencies ranged from 78 percent to 88 percent at about 50 percent of rated inverter input power. Power factor ranged from 36 percent to 72 percent. Author

N78-19888*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RESULTS OF MODULE ELECTRICAL MEASUREMENT OF THE DOE 40-KILOWATT PROCUREMENT
Henry B. Curtis. Feb. 1978. 20 p. refs.
(Contract E(49-26)-1022)
(NASA-TM-78829; E-9534; DOE/NASA/1022-78/27) Avail: NTIS HC A02/MF A01 CSCL 10B

Current-voltage measurements have been made on terrestrial solar cell modules of the DOE/JPL Low Cost Silicon Solar Array procurement. Data on short circuit current, open circuit voltage, and maximum power for the four types of modules are presented in normalized form, showing distribution of the measured values. Standard deviations from the mean values are also given. Tests of the statistical significance of the data are discussed. Author

N78-21886*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFLUENT CHARACTERIZATION FROM A CONICAL PRESSURIZED FLUID BED
R. J. Priem, R. J. Rollbuhler, and R. W. Patch. Dec. 1977. 15 p. refs. Presented at the 5th Intern. Conf. on Fluidized-Bed Combust., Washington, D. C., 12-14 Dec. 1977.
(NASA-TM-73897; E-9524) Avail: NTIS HC A02/MF A01 CSCL 10A

To obtain useable corrosion and erosion results it was necessary to have data with several levels of particulate matter in the hot gases. One level of particulate loading was as low as possible so that ideally no erosion and only corrosion occurred. A conical fluidized bed was used to obtain some degree of filtration through the top of the bed which would not be highly fluidized. This would minimize the filtration required for the hot gases or conversely the amount of particulate matter in the hot gases after a given level of filtration by cyclones and/or filters. The data obtained during testing characterized the effluent from the bed at different test conditions. A range of bed heights, coal flows, air flows, limestone flows, and pressure are represented. These tests were made to determine the best operating conditions prior to using the bed to determine erosion and corrosion rates of typical turbine blade materials. Author

N78-22471*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SOME PROPERTIES OF LOW-VAPOR-PRESSURE BRAZE ALLOYS FOR THERMIONIC CONVERTERS
Virginia Sau. 1978. 14 p. refs. Presented at the Intern. Plasma Sci. Conf., Monterey, Calif., sponsored by IEEE.
(NASA-TM-78567; E-9598) Avail: NTIS HC A02/MF A01 CSCL 10A

Property measurements were made for arc melted rod shaped specimens. Density and dc electrical resistivity at 296 K were measured for various binary eutectic alloys. Thermal conductivity was inferred from the electrical conductivity using the Wiedemann-Franz-Lorenz relation. Linear thermal expansion from 293 K to two thirds melting point under a helium atmosphere was measured for Zr-21.7 wt. percent Ru, Zr-13 wt. percent W, Zr-22.3 wt. percent Nb, Nb-66.9-wt. percent Ru, and Zr-25.7 wt. percent Ta. Author

N78-23558*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMPARISON OF COMPUTER CODES FOR CALCULATING DYNAMIC LOADS IN WIND TURBINES

David A. Spera 1977 39 p refs Presented at the 3d Biennial Conf. and Workshop on Wind Energy Conversion Systems, Washington, D. C., 19-21 Sep. 1977

(Contract E(49-26)-1028)

(NASA-TM-73773; DOE/NASA/1028-78/16; E-9577) Avail: NTIS HC A03/MF A01 CSCL 10B

Seven computer codes for analyzing performance and loads in large, horizontal axis wind turbines were used to calculate blade bending moment loads for two operational conditions of the 100 kW Mod-0 wind turbine. Results were compared with test data on the basis of cyclic loads, peak loads, and harmonic contents. Four of the seven codes include rotor-tower interaction and three were limited to rotor analysis. With a few exceptions, all calculated loads were within 25 percent of nominal test data. Author

N78-23557*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE POTENTIAL OF COMBINED CYCLES INTEGRATED WITH LOW-Btu GASIFIERS FOR FUTURE ELECTRIC UTILITY APPLICATIONS

Joseph J. Nainiger and Raymond K. Burns [1977] 42 p refs Presented at the 69th Ann. Meeting of the Am. Inst. of Chem. Engr., Chicago, 28 Nov. - 2 Dec. 1976

(NASA-TM-73775; E-9567) Avail: NTIS HC A03/MF A01 CSCL 10A

A comparison and an assessment of 10 advanced utility power systems on a consistent basis and to a common level of detail were analyzed. Substantial emphasis was given to a combined cycle systems integrated with low-Btu gasifiers. Performance and cost results from that study were presented for these combined cycle systems, together with a comparative evaluation. The effect of the gasifier type and performance and the interface between the gasifier and the power system were discussed. Author

N78-23559*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

WAKE CHARACTERISTICS OF A TOWER FOR THE DOE-NASA MOD-1 WIND TURBINE

Joseph M. Savino, Lee H. Wagner, and Mary Nash Apr. 1978 76 p refs

(Contract E(49-26)-1028)

(NASA-TM-78853; E-9575; DOE/NASA/1028-78/17) Avail: NTIS HC A05/MF A01 CSCL 10A

A 1/40th scale model of a tower concept designed for a MOD-1 wind power turbine was tested in a low speed wind tunnel. Wake wind speed profiles were measured, and from these were determined local values of wake minimum velocity ratio, average velocity ratio, and width over a range of tower elevations and wind approach angles. Comparison with results from two other all tubular models (MOD-0 and eight leg designs) tested earlier in the same tunnel indicated that wake width and flow blockage at the rotor plane of rotation were slightly larger for the MOD-1 tower than for the other two models. The differences in wake characteristics were attributed to differences in tower geometry and member dimensions. Author

N78-24615*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

WAKE CHARACTERISTICS OF AN EIGHT-LEG TOWER FOR A MOD-0 TYPE WIND TURBINE

Joseph M. Savino, Lee H. Wagner, and Donald Sinclair Dec. 1977 70 p refs

(Contract E(49-26)-1028)

(NASA-TM-73868; E-9463; DOE/NASA/1028-77/14) Avail: NTIS HC A04/MF A01 CSCL 10B

Low speed wind tunnel tests were conducted to determine the flow characteristics of the wake downwind of a 1/25th scale all tubular eight leg tower concept suitable for application to the DOE-NASA MOD-0 wind power turbine. Measurements were made of wind speed profiles, and from these were determined the wake local minimum velocity, average velocity, and width for several wind approach angles. These data are presented herein along with tower shadow photographs and comparisons with data from an earlier lattice type, four leg tower model constructed of tubular members. Values of average wake velocity defect ratio and average ratio of wake width to blade radius for the eight leg model were estimated to be around 0.17 and 0.30, respectively, at the plane of the rotor blade. These characteristics suggest that the tower wake of the eight leg concept is slightly less than that of the four leg design. Author

N78-24616*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RAPID, EFFICIENT CHARGING OF LEAD-ACID AND NICKEL-ZINC TRACTION CELLS

John J. Smithrick 1978 9 p refs To be presented at the 13th Intersoc. Energy Conversion Eng. Conf., San Diego, Calif., 20-25 Aug. 1978

(Contract EC-77-A-31-1011)

(NASA-TM-78901; E-9637; DOE/NASA/1011-78/26) Avail: NTIS HC A02/MF A01 CSCL 10C

Lead-acid and nickel-zinc traction cells were rapidly and efficiently charged using a high rate tapered direct current (HRTDC) charge method which could possibly be used for on-the-road service recharge of electric vehicles. The HRTDC method takes advantage of initial high cell charge acceptance and uses cell gassing rate and temperature as an indicator of charging efficiency. On the average, in these preliminary tests, 300 amp-hour nickel-zinc traction cells were given a HRTDC (initial current 500 amps, final current 100 amps) to 78 percent of rated amp-hour capacity within 53 minutes at an amp-hour efficiency of 92 percent and an energy efficiency of 52 percent. Three hundred amp-hour lead-acid traction cells were charged to 69 percent of rated amp-hour capacity within 48 minutes at an amp-hour efficiency of 91 percent with an energy efficiency of 64 percent. In order to find ways to further decrease the recharge times, the effect of periodically (0 to 400 Hz) pulse discharging cells during a constant current charging process (94% duty cycle) was investigated. Preliminary data indicate no significant effect of this type of pulse discharging during charge on charge acceptance of lead-acid or nickel-zinc cells. Author

N78-24617*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DIMINIODE THERMIONIC ENERGY CONVERSION WITH LANTHANUM-HEXABORIDE ELECTRODES

Erich W. Kroeger, Virginia L. Bair, and James F. Morris 1978 18 p refs Presented at the International Conference on Plasma Science, Monterey, Calif., 15-18 May 1978; sponsored by IEEE

(NASA-TM-78887; E-9622) Avail: NTIS HC A02/MF A01 CSCL 10A

Thermionic conversion data obtained from a variable gap cesium diminiode with a hot pressed, sintered lanthanum hexaboride emitter and an arc melted lanthanum hexaboride collector are presented. Performance curves cover a range of temperatures: emitter 1500 to 1700 K, collector 750 to 1000 K, and cesium reservoir 370 to 510 K. Calculated values of emitter and collector work functions and barrier index are also given. Author

N78-24659*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ENERGY CONVERSION ALTERNATIVES STUDY (ECAS) Summary Report

Sep. 1977 101 p refs Sponsored in part by NSF

(Contract E(49-18)-1751)

(NASA-TM-73871; E-8596) Avail: NTIS HC A06/MF A01 CSCL 10A

ECAS compared various advanced energy conversion systems that can use coal or coal-derived fuels for baseload electric power generation. It was conducted in two phases. Phase 1 consisted of parametric studies. From these results, 11 concepts were selected for further study in Phase 2. For each of the Phase 2 systems and a common set of ground rules, performance, cost,

environmental intrusion, and natural resource requirements were estimated. In addition, the contractors defined the state of the associated technology, identified the advances required, prepared preliminary research and development plans, and assessed other factors that would affect the implementation of each type of powerplant. The systems studied in Phase 2 include steam systems with atmospheric- and pressurized-fluidized-bed boilers; combined cycle gas turbine/steam systems with integrated gasifiers or fired by a semiclean, coal derived fuel; a potassium/steam system with a pressurized-fluidized-bed boiler; a closed-cycle gas turbine/organic system with a high-temperature, atmospheric-fluidized-bed furnace; a direct-coal-fired, open- cycle magnetohydrodynamic/steam system, and a molten-carbonate fuel cell/steam system with an integrated gasifier. The sensitivity of the results to changes in the ground rules and the impact of uncertainties in capital cost estimates were also examined.

Author

N78-28627* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SOLAR CELL COLLECTOR Patent

John C. Evans, Jr., inventor (to NASA). Issued 4 Apr. 1978. 5 p. Filed 22 Feb. 1977. Supersedes N77-17564 (15 - 08, p. 1052).

(NASA-Case-LEW-12552-1; US-Patent-4,082,569; US-Patent-Appl-SN-770869; US-Patent-Class-136-89CC; US-Patent-Class-357-30; US-Patent-Class-357-65; US-Patent-Class-357-67; US-Patent-Class-29-572; US-Patent-Class-427-75; US-Patent-Class-427-261) Avail: US Patent Office CSCL 10A

A method is provided for the fabrication of a photovoltaic device which possesses an efficient collector system for the conduction of the current generated by incident photons to the external circuitry of the device.

Official Gazette of the U.S. Patent Office

N78-28628* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

METHOD OF MAKING ENCAPSULATED SOLAR CELL MODULES Patent

Evelyn Anagnostou and Americo F. Forestieri, inventors (to NASA). Issued 11 Apr. 1978. 4 p. Filed 30 Nov. 1976. Supersedes N77-15490 (15 - 06, p. 0769).

(NASA-Case-LEW-12185-1; US-Patent-4,083,097; US-Patent-Appl-SN-746269; US-Patent-Class-29-572; US-Patent-Class-29-628; US-Patent-Class-136-89P; US-Patent-Class-136-89H) Avail: US Patent Office CSCL 10A

Electrical connections to solar cells in a module are made at the same time the cells are encapsulated for protection. The encapsulating material is embossed to facilitate the positioning of the cells during assembly.

Official Gazette of the U.S. Patent Office

N78-28629* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

METHOD FOR PRODUCING SOLAR ENERGY PANELS BY AUTOMATION Patent

John C. Evans, Jr., inventor (to NASA). Issued 18 Apr. 1978. 11 p. Filed 25 Apr. 1977. Supersedes N77-22615 (15 - 13, p. 1744).

(NASA-Case-LEW-12541-1; US-Patent-4,084,985; US-Patent-Appl-SN-790637; US-Patent-Class-136-89P; US-Patent-Class-29-572; US-Patent-Class-136-89H; US-Patent-Class-136-89CC; US-Patent-Class-156-633) Avail: US Patent Office CSCL 10A

A solar cell panel was fabricated by photoetching a pattern of collector grid systems with appropriate interconnections and bus bar tabs into a glass or plastic sheet. These regions were then filled with a first, thin conductive metal film followed by a layer of a mixed metal oxide, such as InAsO or InSnO. The multiplicity of solar cells were bonded between the protective sheet at the sites of the collector grid systems and a back electrode substrate by conductive metal filled epoxy to complete the fabrication of an integrated solar panel.

Official Gazette of the U.S. Patent Office

N78-28630* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

INORGANIC-ORGANIC SEPARATORS FOR ALKALINE BATTERIES Patent

Dean W. Shaibley, inventor (to NASA). Issued 18 Apr. 1978. 4 p. Filed 7 Sep. 1976. Supersedes N76-31674 (14 - 22, p. 2890).

(NASA-Case-LEW-12649-1; US-Patent-4,085,241; US-Patent-Appl-SN-720521; US-Patent-Class-427-385B; US-Patent-Class-427-385C; US-Patent-Class-429-254) Avail: US Patent Office CSCL 10C

A flexible separator is reported for use between the electrodes of Ni-Cd and Ni-Zn batteries using alkaline electrolytes. The separator was made by coating a porous substrate with a battery separator composition. The coating material included a rubber-based resin copolymer, a plasticizer and inorganic and organic fillers which comprised 55% by volume or less of the coating as finally dried. One or more of the filler materials, whether organic or inorganic, is preferably active with the alkaline electrolyte to produce pores in the separator coating. The plasticizer was an organic material which is hydrolyzed by the alkaline electrolyte to improve conductivity of the separator coating.

Official Gazette of the U.S. Patent Office

N78-28631*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PHOTON DEGRADATION EFFECTS IN TERRESTRIAL SOLAR CELLS

V. G. Weizer, H. W. Brandhorst, Jr., J. D. Broder, R. E. Hart and S. H. Lamneck. 1978. 14 p. refs. Presented at the 13th Photovoltaic Specialists Conf., Washington, D. C., 5-8 Jun. 1978; sponsored by IEEE.

(Contract E(49-26)-1022)

(NASA-TM-78924; DOE/NASA/1022-78/35; E-9664) Avail: NTIS HC A02/MF A01 CSCL 10A

Reduction in cell output was observed in N(+)/P cells upon exposure to illumination or upon the application of a sufficiently high forward bias. Conversely, an enhancement in output was observed when P(+)/N cells were illuminated. Investigations performed on N(+)/P cells indicated that a recombination center located at E sub c - 0.37 eV in the forbidden band was responsible for the loss in output. The center was electrically inactive in its ground state but was activated either by raising the minority carrier quasi-Fermi level sufficiently close to the latent center energy level in the band gap, or by direct excitation of electrons from the valence band to the latent center level. The center was identified as a complex of a lattice defect and a silver atom or cluster of atoms.

Author

N78-28653*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SOLAR CELL SYSTEM HAVING ALTERNATING CURRENT OUTPUT Patent Application

J. C. Evans, Jr., inventor (to NASA). Filed 9 Jun. 1978. 11 p.

(NASA-Case-LEW-12806-1; US-Patent-Appl-SN-915050) Avail: NTIS HC A02/MF A01 CSCL 10A

A P-N junction solar cell modified by fabricating an integrated circuit inverter on the back of the cell to produce a device capable of generating an alternating current output was developed. In another embodiment, integrated circuit power conditioning electronics is incorporated in a module containing a solar cell power supply.

NASA

N78-28654*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ELECTROCHEMICAL CELL FOR REBALANCING REDOX FLOW SYSTEM Patent Application

Lawrence H. Thaller, inventor (to NASA). Filed 9 Jun. 1978. 12 p.

(NASA-Case-LEW-13150-1; US-Patent-Appl-SN-914260) Avail: NTIS HC A02/MF A01 CSCL 10A

Electricity producing cells which utilize reduction and oxidation of anode and cathode fluids are called REDOX cells. The fluids were aqueous solutions of HCl each including a different metal

chloride salt and were separated by a membrane which was permeable to certain ions. A provision of a rebalancing cell is provided, which utilized gas from undesirable side reactions and/or from an independent source to rebalance the anode and cathode fluids in a REDOX system. NASA

N78-26555*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CESIUM THERMIONIC CONVERTERS HAVING IMPROVED ELECTRODES Patent Application
James F. Morris, inventor (to NASA) Filed 1 May 1978 9 p (NASA-Case-LEW-12038-3; US-Patent-Appl-SN-901892) Avail: NTIS HC A02/MF A01 CSCL 10A

A high electric-power output thermionic converter is reported that uses a combination of lanthanum hexaboride emitter and collector electrodes in a cesium medium. The interaction between the lanthanum hexaboride electrodes and cesium vapor, which is adsorbed on the lanthanum hexaboride electrodes, results in lower emitter and collector work functions to produce a thermionic converter with high current density and voltage output. The lanthanum hexaboride emitter and collector electrodes employed in the cesium thermionic converter can be either in the monocrystalline or polycrystalline state. NASA

N78-26556*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IMPROVED BACK WALL CELL Patent Application
Henry W. Brandhorst, Jr., inventor (to NASA) Filed 24 Apr. 1978 13 p
(NASA-Case-LEW-12236-2; US-Patent-Appl-SN-899123) Avail: NTIS HC A02/MF A01 CSCL 10A

Back-wall solar cells are described that consist of a first material of one conductivity type with one face more heavily doped to form a field region to receive radiant energy. A layer of opposite conductivity, or a metallic layer forming a Schottky barrier, was applied to the opposite face. A gridded contact previous to the radiant energy was applied to the region of the heavily doped material for electrical contact. Separate control of either the p-n junction or the Schottky diode junction provided for efficient collection of light. NASA

N78-26558*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
METHOD FOR FABRICATING SOLAR CELLS HAVING INTEGRAL COLLECTOR GRIDS Patent Application
John C. Evans, Jr., inventor (to NASA) Filed 23 Dec. 1977 17 p
(NASA-Case-LEW-12819-2; US-Patent-Appl-SN-863770) Avail: NTIS HC A02/MF A01 CSCL 10A

A photovoltaic device was designed which possesses an integral mixed metal oxide coating in which is embedded a metallic network which functions as an efficient collector for electrons set in motion by the photovoltaic process. The metal grid system is formed from the metal elements of the transparent, conductive mixed metal oxide coating which is in contact with the oxide coating which constitutes the barrier of the devices with the semiconductor substrate. NASA

N78-26642*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TRANSIENT RESPONSE TO THREE-PHASE FAULTS ON A WIND TURBINE GENERATOR Ph.D. Thesis - Toledo Univ.
Leonard J. Gilbert Jun. 1978 146 p refs
(NASA-TM-78902; E-9638) Avail: NTIS HC A07/MF A01 CSCL 10A

In order to obtain a measure of its responses to short circuits a large horizontal axis wind turbine generator was modeled and its performance was simulated on a digital computer. Simulation of short circuit faults on the synchronous alternator of a wind turbine generator, without resort to the classical assumptions generally made for that analysis, indicates that maximum clearing times for the system tied to an infinite bus are longer than the typical clearing times for equivalent capacity conventional machines. Also, maximum clearing times are independent of tower shadow and wind shear. Variation of circuit conditions produce the modifications in the transient response predicted by analysis. P.R.A.

N78-26643*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STATUS OF WRAPAROUND CONTACT SOLAR CELLS AND ARRAYS
Cosmo R. Baraona and L. E. Young 1978 10 p refs Proposed for presentation at the 13th Intersociety Energy Conversion Engr. Conf., San Diego, Calif., 20-25 Aug. 1978; sponsored by SAE, ACS, AIAA, ASME, IEEE, AICHE, and ANS
(NASA-TM-78911; E-9646) Avail: NTIS HC A02/MF A01 CSCL 10A

Solar cells with wraparound contacts provide the following advantages in array assembly: (1) eliminate the need for discretely formed, damage susceptible series tabs; (2) eliminate the n gap problem by allowing the use of uniform covers over the entire cell surface, (3) allow a higher packing factor by reducing the additional series spacing formly required for forming, and routing the series tab; and (4) allow the cell bonding to the interconnect system to be a single-side function wherein series contacts can be made at the same time parallel contracts are made. Author

N78-26644*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY EVALUATION OF GLASS RESIN MATERIALS FOR SOLAR CELL COVER USE
Stanley J. Marsik, Clifford K. Swartz, and Cosmo R. Baraona Jun. 1978 7 p refs Presented at 13th Photovoltaic Specialists Conf., Washington, D. C., 5-8 Jun. 1978; sponsored by IEEE
(NASA-TM-78925; E-9665) Avail: NTIS HC A02/MF A01 CSCL 10A

The glass resins were deposited by several techniques on 200 micron thick cells and on 50 microns thick wafers. The covered cells were exposed to ultraviolet light in vacuum to an intensity of 10 UV energy-equivalent solar constants at air mass zero for 728 hr. The exposure was followed by a single long thermal cycle from ambient temperature to -150 C. Visual inspection of the samples indicated that all samples had darkened to varying degrees. The loss in short-circuit current was found to range from 8 to 24%, depending on the resin formulation. In another test over 40 glass resin-coated silicon wafers withstood 15 thermal cycles from 100 to -196 C in one or more of the thicknesses tested. Several of the resin-coated wafers were tested at 65 C and 90% relative humidity for 170 hr. No change in physical appearance was detected. Author

N78-26645*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ULTRAVIOLET IRRADIATION AT ELEVATED TEMPERATURES AND THERMAL CYCLING IN VACUUM OF FEP-A COVERED SILICON SOLAR CELLS
J. D. Broder and S. J. Marsik 1978 8 p refs Presented at the 13th Photovoltaic Specialists Conf., Washington, D. C., 5-8 Jun. 1978; sponsored by IEEE
(NASA-TM-78926; E-9666) Avail: NTIS HC A02/MF A01 CSCL 10A

Experiments were designed and performed on silicon solar cells covered with heat-bonded FEP-A in an effort to explain the rapid degeneration of open-circuit voltage and maximum power observered on cells of this type included in an experiment on the ATS-6 spacecraft. Solar cells were exposed to ultraviolet light in vacuum at temperatures ranging from 30 to 105 C. The samples were then subjected to thermal cycling from 130 to -130 C. Inspection following irradiation indicated that all the covers remained physically intact. However, during the temperature cycling heat-bonded covers showed cracking. The test showed that heat-bonded FEP-A covers embrittle during UV exposure and the embrittlement is dependent upon sample temperature during irradiation. The results of the experiment suggest a probable mechanism for the degradation of the FEP-A cells on ATS-6. Author

N78-26546*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN IMPROVED TECHNIQUE FOR THE CALIBRATION OF SOLAR CELLS USING A HIGH ALTITUDE AIRCRAFT
Earle O. Boyer Apr. 1978 13 p refs
(NASA-TM-78871; E-9603) Avail: NTIS HC A02/MF A01 CSCL 10A

A description of a technique for the airborne calibration of solar cells is given. Aircraft modifications and data supporting the inherent advantages of the techniques are discussed. Author

N78-26547*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
VARIATION OF SOLAR CELL SENSITIVITY AND SOLAR RADIATION ON TILTED SURFACES
Thomas M. Klucher 1978 10 p refs Presented at the 13th Photovoltaic Specialists Conf., Washington, D. C., 5-8 Jun. 1978; sponsored by IEEE
(Contract E(49-26)-1022)
(NASA-TM-78921; DOE/NASA/1022-78/32; E-9661) Avail: NTIS HC A02/MF A01 CSCL 10A

The validity is studied that one of various insolation models used to compute solar radiation incident on tilted surfaces from global data measured on horizontal surfaces. The variation of solar cell sensitivity to solar radiation is determined over a wide range of atmospheric condition. A new model was formulated that reduced the deviations between measured and predicted insolation to less than 3 percent. Evaluation of solar cell sensitivity data indicates small change (2 3 percent) in sensitivity from winter to summer for tilted cells. The feasibility of using such global data as a means for calibrating terrestrial solar cells is discussed. G.G.

N78-26548*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
ENDURANCE TESTING OF FIRST GENERATION (BLOCK 1) COMMERCIAL SOLAR CELL MODULES
E. Anagnostou and Americo F. Forestieri 1978 9 p ref. Presented at the 13th Photovoltaic Specialists Conf., Washington, D. C., 5-8 Jun. 1978, sponsored by IEEE
(Contract E(49-26)-1022)
(NASA-TM-78922; DOE/NASA/1022-78/33; E-9662) Avail: NTIS HC A02/MF A01 CSCL 10A

To determine lifetimes of the first generation (Block 1) commercial solar cell modules used in solar cell arrays, a program was initiated to expose these modules to a range of environments. The conditions endured by these modules encompassed hot and dry, hot and humid, tropical rain forests, sea-air, urban industrial and urban clean. Exposures were for periods up to 1 year. The effect of outdoor exposure on the performance of the modules was determined using current-voltage curves. Short-circuit current (I sub sc) and maximum power (P sub max) were the parameters monitored. In all cases, there was a loss of performance of the modules with outdoor exposure. Author

N78-26549*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
DOE LeRC PHOTOVOLTAIC SYSTEMS TEST FACILITY
Ronald C. Cull and Americo F. Forestieri 1978 10 p refs Presented at the 13th Photovoltaic Specialists Conf., 5-8 Jun. 1978, sponsored by IEEE
(Contract E(49-26)-1022)
(NASA-TM-78923; DOE/NASA/1022-78/34; E-9663) Avail: NTIS HC A02/MF A01 CSCL 10A

The facility was designed and built and is being operated as a national facility to serve the needs of the entire DOE National Photovoltaic Program. The object of the facility is to provide a place where photovoltaic systems may be assembled and electrically configured, without specific physical configuration, for operation and testing to evaluate their performance and characteristics. The facility as a breadboard system allows investigation of operational characteristics and checkout of components, subsystems and systems before they are mounted in field experiments or demonstrations. The facility as currently configured consist of 10 kW of solar arrays built from modules, two inverter test stations, a battery storage system, interface with local load and the utility grid, and instrumentation and control necessary to make a flexible operating facility. Expansion to 30 kW is planned for 1978. Test results and operating experience are summarized to show the variety of work that can be done with this facility. G.Y.

N78-26550*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IMPACT OF BALANCE OF SYSTEM (BOS) COSTS ON PHOTOVOLTAIC POWER SYSTEMS
Gerald F. Hein, James P. Cusick, and William A. Poley 1978 8 p Presented at the 13th Photovoltaic Specialists Conf., Washington, D. C., 5-8 Jun. 1978, sponsored by IEEE
(Contract E(49-26)-1022)
(NASA-TM-78939; DOE/NASA/1022-78/40; E-9685) Avail: NTIS HC A02/MF A01 CSCL 10A

The Department of Energy has developed a program to effect a large reduction in the price of photovoltaic modules, with significant progress already achieved toward the 1986 goal of 50 cents/watt (1975 dollars). Remaining elements of a P/V power system (structure, battery storage, regulation, control, and wiring) are also significant cost items. The costs of these remaining elements are commonly referred to as Balance-of-System (BOS) costs. The BOS costs are less well defined and documented than module costs. The Lewis Research Center (LeRC) in 1976/77 and with two village power experiments that will be installed in 1978. The costs were divided into five categories and analyzed. A regression analysis was performed to determine correlations of BOS Costs per peak watt with power size for these photovoltaic systems. The statistical relationship may be used for flat-plate, DC systems ranging from 100 to 4,000 peak watts. A survey of suppliers was conducted for comparison with the predicted BOS cost relationship. Author

N78-26551*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
BASELINE TESTS OF THE KORDESH HYBRID PASSENGER VEHICLE
Richard F. Soltis, John M. Bozek, Robert J. Denington, and Miles O. Dustin Jun. 1978 69 p
(Contract EC-77-A-31-1011)
(NASA-TM-73769; CONS/1011-14; E-9604) Avail: NTIS HC A04/MF A01 CSCL 10A

Performance test results are presented for a four-passenger Austin A40 sedan that was converted to a heat engine-alternator- and battery-powered hybrid. It is propelled by a conventional, gasoline fueled, heat engine-driven alternator and a traction pack powering a series wound, 10 hp direct current electric drive motor. The 16 hp gasoline engine drives the 7 kilowatt alternator, which provides electrical power to the drive motor or to the 96 volt traction battery through a rectifier. The propulsion battery consists of eight 12 volt batteries connected in series. The electric motor is coupled to a four-speed standard transmission, which drives the rear wheels. Power to the motor is controlled by a three-step foot throttle, which actuates relays that control armature current and field excitation. Conventional hydraulic brakes are used. G.G.

N78-26552*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
DESIGN AND OPERATING EXPERIENCE ON THE US DEPARTMENT OF ENERGY EXPERIMENTAL MOD-0 100-kW WIND TURBINE
John C. Glasgow and Arthur G. Birchenough 1978 17 p refs Proposed for presentation at the 13th Intersoc. Energy Conversion Eng. Conf., San Diego, Calif., 20-25 Aug. 1978
(Contract E(49-26)-1028)
(NASA-TM-78915; E-9652; DOE/NASA/1028-78/18) Avail: NTIS HC A02/MF A01 CSCL 10A

The experimental wind turbine was designed and fabricated to assess technology requirements and engineering problems of large wind turbines. The machine has demonstrated successful operation in all of its design modes and served as a prototype

developmental test bed for the Mod-0A operational wind turbines which are currently used on utility networks. The mechanical and control system are described as they evolved in operational tests and some of the experience with various systems in the downwind rotor configurations are elaborated. G.G.

N78-26653*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DOE/NASA MOD-0A WIND TURBINE PERFORMANCE
T. R. Richards and H. E. Neustadter. 1978. 8 p. refs. Proposed for presentation at the 13th Intersoc. Energy Conversion Eng. Conf., San Diego, Calif., 20-25 Aug. 1978
(Contract E(49-26)-1004)
(NASA-TM-78916; E-9654; DOE/NASA/1004-78/13) Avail: NTIS HC A02/MF A01 CSCL 10A

Design and operation of a large wind turbine at Clayton, New Mexico is reported. This is the first of three identical 200 kW wind turbines to be operated on electric utility networks. A comparison between its predicted and measured power versus wind speed performance is presented. G.G.

N78-26654*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESCRIPTION AND STATUS OF NASA-LERC/DOE PHOTOVOLTAIC APPLICATIONS SYSTEMS
Anthony F. Ratajczak. 1978. 10 p. refs. Presented at the 13th Photovoltaic Specialists Conf., Washington, D. C., 5-8 Jun. 1978; sponsored by IEEE
(Contract E(49-26)-1022)
(NASA-TM-78936; E-9679; DOE/NASA/1022-78/38) Avail: NTIS HC A02/MF A01 CSCL 10A

Designed, fabricated and installed were 16 geographically dispersed photovoltaic systems. These systems are powering a refrigerator, highway warning sign, forest lookout towers, remote weather stations, a water chiller at a visitor center, and insect survey traps. Each of these systems is described in terms of load requirements, solar array and battery size, and instrumentation and controls. Operational experience is described and present status is given for each system. The P/V power systems have proven to be highly reliable with almost no problems with modules and very few problems overall. Author

N78-26655*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
DESIGN AND FABRICATION OF A PHOTOVOLTAIC POWER SYSTEM FOR THE PAPAGO INDIAN VILLAGE OF SCHUCHULI (GUNSIGHT), ARIZONA
William J. Bifano, Anthony F. Ratajczak, and William J. Ice. 1978. 10 p. Presented at the 13th Photovoltaic Specialists Conf., Washington, D. C., 5-8 Jun. 1978; sponsored by the IEEE
(Contract E(49-26)-1022)
(NASA-TM-78948; E-9672; DOE/NASA/1022-78/39) Avail: NTIS HC A02/MF A01 CSCL 10A

A stand alone photovoltaic power system for installation in the Papago Indian village of Schuchuli is being designed and fabricated to provide electricity for village water pumping and basic domestic needs. The system will consist of a 3.5 kW (peak) photovoltaic array; controls, instrumentations, and storage batteries located in an electrical equipment building and a 120 volt dc village distribution network. The system will power a 2 HP dc electric motor. Author

N78-27520*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
SELF-RECONFIGURING SOLAR CELL SYSTEM Patent Application
Robert P. Gruber, inventor (to NASA). Filed 19 Jun. 1978. 18 p
(NASA-Case-LEW-12586-1; US Patent-Appl-SN-916655) Avail: NTIS HC A02/MF A01 CSCL 10A

An improved solar cell system is reported that utilizes control circuits to switch some of its cells so that they can be either in series or in shunt within the array to match the load for maximum power transfer. Automatic control is provided by a sensor solar cell mounted into the configurable array; its open circuit voltage multiplied by a constant is equal to cell voltage at maximum power point. NASA

N78-27539*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
COST OF PHOTOVOLTAIC ENERGY SYSTEMS AS DETERMINED BY BALANCE-OF-SYSTEM COSTS
Louis Rosenblum. Jun. 1978. 14 p. refs
(NASA-TM-78957; E-9708) Avail: NTIS HC A02/MF A01 CSCL 10B

The effect of the balance-of-system (BOS) i.e., the total system less the modules, on photo-voltaic energy system costs is discussed for multikilowatt, flat-plate systems. Present BOS costs are in the range of 10 to 16 dollars per peak watt (1978 dollars). BOS costs represent approximately 50% of total system cost. The possibility of future BOS cost reduction is examined. It is concluded that, given the nature of BOS costs and the lack of comprehensive national effort focussed on cost reduction, it is unlikely that BOS costs will decline greatly in the next several years. This prognosis is contrasted with the expectations of the Department of Energy National Photovoltaic Program goals and pending legislation in the Congress which require a BOS cost reduction of an order of magnitude or more by the mid-1980s. Author

N78-28607*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
AN IMPROVED METHOD FOR ANALYSIS OF HYDROXIDE AND CARBONATE IN ALKALINE ELECTROLYTES CONTAINING ZINC
Margaret A. Reid. 1978. 14 p. refs. To be presented at the 154th meeting of the Electrochem. Soc., Inc., Pittsburgh, 15-20 Oct. 1978
(NASA-TM-78961) Avail: NTIS HC A02/MF A01 CSCL 10C

A simplified method for titration of carbonate and hydroxide in alkaline battery electrolyte is presented involving a saturated KSCN solution as a complexing agent for zinc. Both hydroxide and carbonate can be determined in one titration, and the complexing reagent is readily prepared. Since the pH at the end point is shifted from 8.3 to 7.9 - 8.0, m-cresol purple or phenol red are used as indicators rather than phenolphthalein. Bromcresol green is recommended for determination of the second end point of a pH of 4.3 to 4.4. Author

N78-28614*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
COMPARISON OF THREE EXPERIMENTAL METHODS USED IN DETERMINING THE THERMAL PERFORMANCE OF FLAT-PLATE SOLAR COLLECTORS Ph.D. Thesis - Kansas Univ.
Gregory B. Hotchkiss. Oct. 1978. 289 p. refs
(NASA-TM-78929; E-9669) Avail: NTIS HC A13/MF A01 CSCL 10A

Three experimental methods for evaluating the thermal performance of flat plate solar collectors are presented. The methods are classified according to the nature of the ambient conditions encountered during experimental testing. The classifications are: (1) steady state, (2) quasi steady state, and (3) unsteady state. Experimental tests on two solar collectors were conducted in an indoor solar simulator and also out-of-doors. From the experimental collector data, collector efficiency factors, which describe the steady state behavior of a collector, were determined for each experimental method. A parameter identification method based upon a discrete gradient optimization technique was used to determine the collector parameters from unsteady state data. Such a method would allow on-line data reduction and would enable speedy determination of the collector efficiency factors from transient data. The design, construction, and operation of the test rig which was used to obtain the experimental data are also described. Author

N78-28824*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SOLUBILITY, STABILITY, AND ELECTROCHEMICAL STUDIES OF SULFUR-SULFIDE SOLUTIONS IN ORGANIC SOLVENTS

William L. Fielder and Joseph Singer Aug. 1978 43 p refs (NASA-TP-1245; E-9552) Avail: NTIS HC A03/MF A01 CSCL 10A

A preliminary study of the sulfur electrode in organic solvents suggests that the system warrants further investigation for use in a low temperature (100 deg to 120 C) Na-S secondary battery. A qualitative screening was undertaken at 120 C to determine the solubilities and stabilities of Na2S and Na2S2 in representatives of many classes of organic solvents. From the screening and quantitative studies, two classes of solvents were selected for work: amides and cyclic polyalcohols. Voltammetric and Na-S cell charge discharge studies of sulfide solutions in organic solvents (e.g., N, N-dimethylformamide) at 120 C suggested that the reversibilities of the reactions on Pt or high density graphite were moderately poor. However, the sulfur electrode was indeed reducible (and oxidizable) through the range of elemental sulfur to Na2S. Reactions and mechanisms are proposed for the oxidation reduction processes occurring at the sulfur electrode. Author

N78-29666*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PERFORMANCE AND STABILITY ANALYSIS OF A PHOTOVOLTAIC POWER SYSTEM Final Report

Walter C. Merrill, Ronald J. Blaha, and Roy L. Pickrell Aug. 1978 43 p refs

(Contract E(49-26)-1022)

(NASA-TM-78880; E-9609; DOE/NASA/1022-78/30) Avail: NTIS HC A03/MF A01 CSCL 10A

The performance and stability characteristics of a 10 kVA photovoltaic power system are studied using linear Bode analysis and a nonlinear analog simulation. Power conversion efficiencies, system stability, and system transient performance results are given for system operation at various levels of solar insolation. Additionally, system operation and the modeling of system components for the purpose of computer simulation are described. F.O.S.

N78-29675*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LARGE WIND TURBINE GENERATORS

Ronald L. Thomas and Richard M. Donovon Mar. 1978 37 p refs Presented at 5th Energy Technol. Conf. and Exposition, Washington, D. C., 27 Feb. - 1 Mar. 1978

(Contract E(49-26)-1059)

(NASA-TM-73767; DOE/NASA/1059-78/1; E-9553) Avail: NTIS HC A03/MF A01 CSCL 10B

The development associated with large wind turbine systems is briefly described. The scope of this activity includes the development of several large wind turbines ranging in size from 100 kW to several megawatt levels. A description of the wind turbine systems, their programmatic status and a summary of their potential costs is included. L.S.

N78-29676*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

THERMAL ENERGY STORAGE FOR INDUSTRIAL WASTE HEAT RECOVERY

H. W. Hoffman (ORNL), R. J. Kedl (ORNL), and R. A. Duscha Aug. 1978 10 p Presented at 13th Intersociety Energy Conversion Engineering Conf., San Diego, Calif., 20-25 Aug. 1978

(Contracts EC-77-A-31-1034; W-7405-eng-26)

(NASA-TM-78953; DOE/NASA/1034-78/2; E-9702) Avail: NTIS HC A02/MF A01 CSCL 10C

The potential is examined for waste heat recovery and reuse through thermal energy storage in five specific industrial categories: (1) primary aluminum, (2) cement, (3) food processing, (4) paper and pulp, and (5) iron and steel. Preliminary results from Phase 1 feasibility studies suggest energy savings through fossil fuel displacement approaching 0.1 quad/yr in the 1985 period. Early implementation of recovery technologies with minimal development appears likely in the food processing and paper and pulp industries; development of the other three categories, though equally desirable, will probably require a greater investment in time and dollars. L.S.

N78-29677*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STORAGE SYSTEMS FOR SOLAR THERMAL POWER

James E. Calogeras and Larry H. Gordon Aug. 1978 9 p refs Presented at the 13th Intersoc. Energy Conversion Eng. Conf., San Diego, Calif., 20-25 Aug. 1978

(Contract EC-77-A-31-1034)

(NASA-TM-78952; DOE/NASA/1034-78/1; E-9698) Avail: NTIS HC A02/MF A01 CSCL 10C

The development status is reviewed of some thermal energy storage technologies specifically oriented towards providing diurnal heat storage for solar central power systems and solar total energy systems. These technologies include sensible heat storage in caverns and latent heat storage using both active and passive heat exchange processes. In addition, selected thermal storage concepts which appear promising to a variety of advanced solar thermal system applications are discussed. L.S.

N78-29678*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

UTILIZATION OF SOLAR ENERGY IN DEVELOPING COUNTRIES: IDENTIFYING SOME POTENTIAL MARKETS

Gerald F. Hein and Toufiq A. Siddiqi (Environment and Policy Inst., Honolulu, Hawaii) Feb. 1978 13 p refs Presented at the Ann. Meeting of the Am. Assoc. for the Advan. of Sci., Washington, D.C., 12-17 Feb. 1978

(Contract E(49-26)-1022)

(NASA-TM-78964; DOE/NASA/1022-78/41) Avail: NTIS HC A02/MF A01 CSCL 10B

The potential use of solar electricity generated from photovoltaic cells is examined for nineteen developing nations. Energy and economic profiles are summarized for each country. A comparison is made between the use of autogeneration and photovoltaics in a rural area of Haiti. Author

N78-29683*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE 200-KILOWATT WIND TURBINE PROJECT

Jan. 1978 17 p refs Prepared for DOE

(NASA-TM-79757) Avail: NTIS HC A02/MF A01 CSCL 10B

The three 200 kilowatt wind turbines described, compose the first of three separate systems. Proposed wind turbines of the two other systems, although similar in design, are larger in both physical size and rated power generation. The overall objective of the project is to obtain early operation and performance data while gaining initial experience in the operation of large, horizontal-axis wind turbines in typical utility environments. Several of the key issues addressed include the following: (1) impact of the variable power output (due to varying wind speeds) on the utility grid (2) compatibility with utility requirements (voltage and frequency control of generated power) (3) demonstration of unattended, fail-safe operation (4) reliability of the wind turbine system (5) required maintenance and (6) initial public reaction and acceptance. L.S.

N78-31633*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

INITIAL TEST RESULTS WITH A SINGLE-CYLINDER RHOMBIC-DRIVE STIRLING ENGINE Final Report

J. E. Cairelli, L. G. Thieme, and R. J. Walter Jul. 1978 42 p refs

(Contract EC-77-A-31-1040)

(NASA-TM-78919; E-9656; DOE/NASA/1040-78/1) Avail: NTIS HC A03/MF A01 CSCL 10B

A 6 kW (8 hp), single-cylinder, rhombic-drive Stirling engine was restored to operating condition, and preliminary characteriza-

tion tests run with hydrogen and helium as the working gases. Initial tests show the engine brake specific fuel consumption (BSFC) with hydrogen working gas to be within the range of BSFC observed by the Army at Fort Belvoir, Virginia, in 1966. The minimum system specific fuel consumption (SFC) observed during the initial tests with hydrogen was 669 g/kW hr (1.1 lb/hpx hr), compared with 620 g/kWx hr (1.02 lb/hpx hr) for the Army tests. However, the engine output power for a given mean compression-space pressure was lower than for the Army tests. The observed output power at a working-space pressure of 5 MPa (725 psig) was 3.27 kW (4.39 hp) for the initial tests and 3.80 kW (5.09 hp) for the Army tests. As expected, the engine power with helium was substantially lower than with hydrogen. J.M.S.

N78-31534*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

EFFECT OF INLET TEMPERATURE ON THE PERFORMANCE OF A CATALYTIC REACTOR

David N. Anderson 1978 21 p refs Presented at the 3d Workshop on Catalytic Combust., Asheville, N. C., 3-4 Oct. 1978; sponsored by EPA

(Contract EC-77-A-31-1040)

(NASA-TM-78977; DOE/NASA/1040-78/3; E-9752) Avail: NTIS HC A02/MF A01 CSCL 10A

A 12 cm diameter by 15 cm long catalytic reactor was tested with No. 2 diesel fuel in a combustion test rig at inlet temperatures of 700, 800, 900, and 1000 K. Other test conditions included pressures of 3 and 6 x 10 to the 5th power Pa, reference velocities of 10, 15, and 20 m/s, and adiabatic combustion temperatures in the range 1100 to 1400 K. The combustion efficiency was calculated from measurements of carbon monoxide and unburned hydrocarbon emissions. Nitrogen oxide emissions and reactor pressure drop were also measured. At a reference velocity of 10 m/s, the CO and unburned hydrocarbons emissions, and, therefore, the combustion efficiency, were independent of inlet temperature. At an inlet temperature of 1000 K, they were independent of reference velocity. Nitrogen oxides emissions resulted from conversion of the small amount (135 ppm) of fuel-bound nitrogen in the fuel. Up to 90 percent conversion was observed with no apparent effect of any of the test variables. For typical gas turbine operating conditions, all three pollutants were below levels which would permit the most stringent proposed automotive emissions standards to be met. Author

A78-10903 * **A methodology for experimentally-based determination of gap shrinkage and effective lifetimes in the emitter and base of p-n-junction solar cells.** F. A. Lindholm, A. Neugroschel (Florida, University, Gainesville, Fla.), C. T. Sah (Illinois, University, Urbana, Ill.), M. P. Godlewski, and H. W. Brandhorst, Jr. (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Specialists Conference, 12th, Baton Rouge, La., November 15-18, 1976, Conference Record. (A78-10902 01-44) New York, Institute of Electrical and Electronics Engineers, Inc., 1976, p. 1-8. 21 refs. Grant No. NsG-3018; Contract No. E(40-1)-5134.

A78-10904 * **Analysis of epitaxial drift field N on P silicon solar cells.** C. R. Baraona and H. W. Brandhorst, Jr. (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Specialists Conference, 12th, Baton Rouge, La., November 15-18, 1976, Conference Record. (A78-10902 01-44) New York, Institute of Electrical and Electronics Engineers, Inc., 1976, p. 9-14. 14 refs.

A78-11014 * **Status of the ERDA/NASA Photovoltaic Tests and Applications Project.** J. N. Deyo, H. W. Brandhorst, Jr., and A. F. Forestieri (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Specialists Conference, 12th, Baton Rouge, La., November 15-18, 1976, Conference Record. (A78-10902 01-44) New York, Institute of Electrical and Electronics Engineers, Inc., 1976, p. 698-704.

A78-11019 * **The Redox Flow System for solar photovoltaic energy storage.** P. O'Donnell, R. F. Gahn, and W. Pfeiffer (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Specialists Conference, 12th, Baton Rouge, La., November 15-18, 1976, Conference Record. (A78-10902 01-44) New York, Institute of Electrical and Electronics Engineers, Inc., 1976, p. 733-736.

The interfacing of a Solar Photovoltaic System and a Redox Flow System for storage was workable. The Redox Flow System, which utilizes the oxidation-reduction capability of two redox couples, in this case iron and titanium, for its storage capacity, gave a relatively constant output regardless of solar activity so that a load could be run continually day and night utilizing the sun's energy. One portion of the system was connected to a bank of solar cells to electrochemically charge the solutions, while a separate part of the system was used to electrochemically discharge the stored energy. (Author)

A78-11391 * # **Evaluation of initial collector field performance at the Langley Solar Building Test Facility.** R. J. Boyle, R. H. Knoll (NASA, Lewis Research Center, Cleveland, Ohio), and R. N. Jensen (NASA, Langley Research Center, Hampton, Va.). *International Solar Energy Society, Annual Meeting, Orlando, Fla., June 6-10, 1977, Paper.* 20 p. 6 refs.

The thermal performance of the solar collector field for the NASA Langley Solar Building Test Facility is given for October 1976 through January 1977. An 1180 square meter solar collector field with seven collector designs helped to provide hot water for the building heating system and absorption air conditioner. The collectors were arranged in 12 rows with nominally 51 collectors per row. Heat transfer rates for each row are calculated and recorded along with sensor, insolation, and weather data every 5 minutes using a mini-computer. The agreement between the experimental and predicted collector efficiencies was generally within five percentage points. (Author)

A78-16923 * # **New batteries and their impact on electric vehicles.** H. J. Schwartz (NASA, Lewis Research Center, Cleveland, Ohio). *Electric Vehicle Council, International Electric Vehicle Exposition and Conference, 1st, Chicago, Ill., Apr. 26-29, 1977, Paper.* 15 p. 18 refs.

The paper is concerned with the development of electric vehicles and electric vehicle batteries. The present and predicted performance levels of some battery systems such as lead-acid, nickel-iron, nickel-zinc, and zinc-chlorine are considered, as are the characteristics that an electric vehicle must possess in order to appeal to customers. The implications of battery improvements for manufacturers of electric vehicles are discussed. Lack of knowledge of passenger range requirements for electric vehicles is noted. M.L.

A78-20476 * **Effects of rotor location, coning, and tilt on critical loads in large wind turbines.** D. A. Spera and D. C. Janetzke (NASA, Lewis Research Center, Wind Turbine Analysis Section, Cleveland, Ohio). *Wind Technology Journal*, vol.1, Summer 1977, p. 5-10. 7 refs.

Three large (1500 kW) horizontal rotor configurations were analyzed to determine the effects on dynamic loads of upwind and downwind rotor locations, coned and radial blade positions, and tilted and horizontal rotor axis positions. Loads were calculated for a range of wind velocities at three locations in the structure: the blade shank, the hub shaft, and the yaw drive. Blade axis coning and rotor axis tilt were found to have little effect on loads. However, locating the rotor upwind of the tower significantly reduced loads at all locations analyzed. (Author)

A78-24400 * Energy resources of the developing countries and some priority markets for the use of solar energy. T. A. Siddiqi (East-West Center, Honolulu, Hawaii) and G. F. Hein (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Energy and Development*, vol. 3, Autumn 1977, p. 164-189.

Energy consumption for the developed and non-developed world is expressed as a function of GNP. An almost straight-line graph results when energy consumption statistics are treated in this manner. The richest countries consume the most energy, and the poorest countries the least. It therefore follows that greater energy production in the developing countries (leading to greater energy consumption) will contribute to their economic growth. Energy resources in the developing countries are compared, including: solid fossil fuels, crude oil, natural gas, oil shale, and uranium. Mention is also made of the potential of renewable energy resources, such as solar, wind, and hydroelectric power, in the underdeveloped world; and it is these resources which offer the greatest possibilities for economic improvement if the money is forthcoming, i.e., from the world bank, to fund the necessary technology. D.M.W.

A78-26110 * # ECAS Phase I fuel cell results. M. Warshay (NASA, Lewis Research Center, Fuel Cell Projects Office, Cleveland, Ohio). *Journal of Energy*, vol. 2, Jan.-Feb. 1978, p. 46-52. 10 refs.

This paper summarizes and discusses the fuel cell system results of Phase I of the Energy Conversion Alternatives Study (ECAS). Ten advanced electric powerplant systems for central-station baseload generation using coal were studied by NASA in ECAS. Three types of low-temperature fuel cells (solid polymer electrolyte, SPE, aqueous alkaline, and phosphoric acid) and two types of high-temperature fuel cells (molten carbonate, MC, and zirconia solid electrolyte, SE) were studied. The results indicate that (1) overall efficiency increases with fuel cell temperature, and (2) scale-up in powerplant size can produce a significant reduction in cost of electricity (COE) only when it is accompanied by utilization of waste fuel cell heat through a steam bottoming cycle and/or integration with a gasifier. For low-temperature fuel cell systems, the use of hydrogen results in the highest efficiency and lowest COE. In spite of higher efficiencies, because of higher fuel cell replacement costs integrated SE systems have higher projected COEs than do integrated MC systems. Present data indicate that life can be projected to over 30,000 hr for MC fuel cells, but data are not yet sufficient for similarly projecting SE fuel cell life expectancy. (Author)

A78-29331 * # Status of the DOE /STOR/-sponsored national program on hydrogen production from water via thermochemical cycles. C. E. Baker (NASA, Lewis Research Center, Cleveland, Ohio). *U.S. Department of Energy and University of Miami, Miami International Conference on Alternative Energy Sources, Miami Beach, Fla., Dec. 5-7, 1977, Paper.* 15 p. 5 refs.

A pure thermochemical cycle is a system of linked regenerative chemical reactions which accepts only water and heat and produces hydrogen. Thermochemical cycles are potentially a more efficient and cheaper means of producing hydrogen from water than is the generation of electricity followed by electrolysis. The Energy Storage Systems Division of the Department of Energy is currently funding a national program on thermochemical hydrogen production. The National Aeronautics and Space Administration is responsible for the technical management of this program. The goal is to develop a cycle which can potentially operate with an efficiency greater than 40% using a heat source providing a maximum available temperature of 1150 K. A closed bench-scale demonstration of such a cycle would follow. This cycle would be labeled a 'reference cycle' and would serve as a baseline against which future cycles would be compared. (Author)

A78-30196 * Synchronization of wind turbine generators against an infinite bus under gusting wind conditions H. H. Hwang (Hawaii, University, Honolulu, Hawaii) and L. J. Gilbert (NASA, Lewis Research Center, Cleveland, Ohio). *(Institute of Electrical and Electronics Engineers, Summer Meeting, Mexico City, Mexico, July 17-22, 1977, Paper F 77 675-2.) IEEE Transactions on Power Apparatus and Systems*, vol. PAS-97, Mar.-Apr. 1978, p. 536-544. 6 refs. Research supported by the Hawaii Natural Energy Institute and NASA.

Studies of synchronizing a wind turbine generator against an infinite bus are performed on a digital computer. In the digital simulation, wind gusts of different magnitudes and durations are hypothesized. Prior to the synchronization, differences of the frequency and phase position between voltages of the alternator and the bus are also included in the simulation. Solutions for rotor speed, generator power angle, electromagnetic torque, wind turbine torque, wind turbine blade pitch angle, and armature current are simulated and presented graphically. The ERDA-NASA 100-kW wind turbine is used as a case study. The results so obtained will thus have immediate applications. (Author)

A78-33217 * # A review of the Thermoelectronic Laser Energy Converter /TELEC/ Program at Lewis Research Center. D. L. Alger, E. J. Manista, and R. W. Thompson (NASA, Lewis Research Center, Cleveland, Ohio). *NASA, Conference on Radiation Energy Conversion, 3rd, Moffett Field, Calif., Jan. 26, 27, 1978, Paper.* 18 p. 12 refs.

The investigation of the Thermoelectronic Laser Energy Converter (TELEC) concept at the Lewis Research Center (LeRC) began with a feasibility study of a 1 megawatt sized TELEC system. The TELEC was to use either cesium vapor or hydrogen as the plasma medium. The cesium vapor TELEC appears to be the more practical device studied with an overall calculated conversion efficiency of greater than 48%. Following this study, a small TELEC cell was fabricated which demonstrated the conversion of a small amount of laser power to electrical power. The cell developed a short circuit current of 0.7 amperes and an open circuit voltage, as extrapolated from volt-ampere curves, of about 1.5 volts. Work is now in progress to construct and test a cesium vapor TELEC capable of absorbing 20% of an incident 10 kW, 10.6 micrometer beam, and converting 35% of this power to electrical power. (Author)

A78-37678 * # Comparison of computer codes for calculating dynamic loads in wind turbines. D. A. Spera (NASA, Lewis Research Center, Cleveland, Ohio). *Biennial Conference and Workshop on Wind Energy Conversion Systems, 3rd, Washington, D.C., Sept. 19-21, 1977, Paper.* 38 p. 14 refs.

Seven computer codes for analyzing performance and loads in large, horizontal-axis wind turbines were used to calculate blade bending moment loads for two operational conditions of the 100 kW Mod-0 wind turbine. Results are compared with test data on the basis of cyclic loads, peak loads, and harmonic contents. Four of the seven codes include rotor-tower interaction and three are limited to rotor analysis. With a few exceptions, all calculated loads were within 25% of nominal test data. (Author)

A78-45437 * # Utilization of solar energy in developing countries - Identifying some potential markets. G. F. Hein (NASA, Lewis Research Center, Cleveland, Ohio) and T. A. Siddiqi (Environment and Policy Institute, Honolulu, Hawaii). *American Association for the Advancement of Science, Annual Meeting, Washington, D.C., Feb. 12-17, 1978, Paper.* 11 p. 11 refs. Contract No. E(49-28)-1022.

A78-52837 * Real-time and accelerated outdoor endurance testing of solar cells. A. F. Forestieri and E. Anagnostou (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Solar Energy Conference, Luxembourg, September 27-30, 1977, Proceedings. (A78-52776 24-44) Dordrecht, D. Reidel Publishing Co., 1978, p. 656-676. 6 refs. ERDA-supported research.

Materials for solar-cell module construction have been studied on the basis of limited real-time outdoor exposure evaluations. The materials tested included transmission samples, sub-modules, and

actual solar cells. The results suggest that glass, fluorinated ethylene propylene, and perfluoroalkoxy are good materials for the covering or encapsulation of solar-cell modules. In all cases, dirt accumulation and cleanability are important factors. S.C.S.

A78-52844 * U.S. terrestrial solar cell calibration and measurement procedures. H. W. Brandhorst, Jr. (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Solar Energy Conference, Luxembourg, September 27-30, 1977, Proceedings. (A78-52776 24-44) Dordrecht, D. Reidel Publishing Co., 1978, p. 745-753. 10 refs. ERDA-supported research.

An outline is presented of changes in measurement procedures concerning solar cells. Outdoor measurements of cell performance based on pyranometer or pyrheliometer determination of intensity are discouraged. The absolute scale of irradiance is to be adopted as soon as possible. The standard atmosphere conditions are 1000 W/sq m irradiance, temperature 28 C, air mass 1.5, and precipitable water vapor content of 2 cm. The allowable light sources for solar simulation are short arc xenon lamps, pulsed xenon lamps, and dichroic filtered tungsten lamps. Key considerations in the design of a reference cell are considered and approaches for the matching of a reference cell to a test cell or modules are discussed. G.R.

A78-52851 * The ERDA/LeRC Photovoltaic Systems Test Facility. A. F. Forestieri (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Solar Energy Conference, Luxembourg, September 27-30, 1977, Proceedings. (A78-52776 24-44) Dordrecht, D. Reidel Publishing Co., 1978, p. 817-824. 5 refs. ERDA-supported research.

The ERDA/LeRC Photovoltaic Systems Test Facility (STF) provides a vital support function to the overall ERDA National Solar Photovoltaic Program. It allows preliminary investigation and check-out of components, subsystems, and complete photovoltaic systems before installation in actual service. The STF can also be used to determine optimum system configurations and operating modes. A facility description is presented, taking into account the solar cell array, the energy storage equipment, the power conditioning equipment, electric utility distribution network and loads, and instrumentation and data acquisition systems. Safety procedures which have been set up for maintenance and inspection of the solar array are discussed. Attention is also given to a number of investigations regarding the effect of environmental factors on solar cell array operation. G.R.

N78-12629*# General Electric Co., Philadelphia, Pa. Valley Forge Space Center.
DESIGN STUDY OF WIND TURBINES 50 kW TO 3000 kW FOR ELECTRIC UTILITY APPLICATIONS. VOLUME 1: SUMMARY REPORT Final Report
Sep. 1976 65 p
(Contracts NAS3-19403; E(49-26)-1010)
(NASA-CR-134934; ERDA/NASA-9403-76/1-Vol-1; Doc-SDS4287-Vol-1) Avail: NTIS HC A04/MF A01 CSCL 10B

Wind turbine configurations that would lead to generation of electrical power in a cost effective manner were considered. All possible overall system configurations, operating modes, and subsystem concepts were evaluated for both technical feasibility and compatibility with utility networks, as well as for economic attractiveness. A design optimization computer code was developed to determine the cost sensitivity of the various design features, and thus establish the configuration and design conditions that would minimize the generated energy costs. The preliminary designs of both a 500 kW unit and a 1500 kW unit operating in a 12 mph and 18 mph median wind speed respectively, were developed. The rationale employed and the key findings are summarized. Author

N78-13589*# Thermo Electron Engineering Corp., Waltham, Mass.
ADVANCED THERMIONIC TECHNOLOGY PROGRAM Progress Report
Apr. 1977 21 p
(Contracts NAS3-20302; EY-76-C-02-3056)
(NASA-CR-155299; COO-3056-23; TE-4217/4220-123-77; PR-22) Avail: NTIS HC A02/MF A01 CSCL 01B

Topics include surface studies (surface theory, basic surface experiments, and activation chamber experiments); plasma studies (converter theory and enhanced mode conversion experiments); and component development (low temperature conversion experiments, high efficiency conversion experiments, and hot shell development). ERA

N78-14632*# Grumman Aerospace Corp., Bethpage, N.Y.
THERMAL ENERGY STORAGE HEAT EXCHANGER: MOLTEN SALT HEAT EXCHANGER DESIGN FOR UTILITY POWER PLANTS Final Report, Jul. 1976 - Jul. 1977
Angelo Ferarra, George Yenetchi, Robert Haslett, and Robert Kosson Oct. 1977 207 p refs
(Contract NAS3-20117)
(NASA-CR-135244) Avail: NTIS HC A10/MF A01 CSCL 10C

The use of thermal energy storage (TES) in the latent heat of molten salts as a means of conserving fossil fuels and lowering the cost of electric power was evaluated. Public utility systems provided electric power on demand. This demand is generally maximum during late weekday afternoons, with considerably lower overnight and weekend loads. Typically, the average demand is only 60% to 80% of peak load. As peak load increases, the present practice is to purchase power from other grid facilities or to bring older less efficient fossil-fuel plants on line which increase the cost of electric power. The widespread use of oil-fired boilers, gas turbine and diesel equipment to meet peaking loads depletes our oil-based energy resources. Heat exchangers utilizing molten salts can be used to level the energy consumption curve. The study begins with a demand analysis and the consideration of several existing modern fossil-fuel and nuclear power plants for use as models. Salts are evaluated for thermodynamic, economic, corrosive, and safety characteristics. Heat exchanger concepts are explored and heat exchanger designs are conceived. Finally, the economics of TES conversions in existing plants and new construction is analyzed. The study concluded that TES is feasible in electric power generation. Substantial data are presented for TES design, and reference material for further investigation of techniques is included. Author

N78-14633*# Grumman Aerospace Corp., Bethpage, N.Y.
THERMAL ENERGY STORAGE HEAT EXCHANGER: MOLTEN SALT HEAT EXCHANGER DESIGN FOR UTILITY POWER PLANTS Topical Report, Jul. 1976 - Jul. 1977
Angelo Ferarra, George Yenetchi, Robert Haslett, and Robert Kosson Oct. 1977 36 p refs
(Contract NAS3-20117)
(NASA-CR-135245) Avail: NTIS HC A03/MF A01 CSCL 10C

Sizing procedures are presented for latent heat thermal energy storage systems that can be used for electric utility off-peak energy storage, solar power plants and other preliminary design applications. Author

N78-17462*# General Electric Co., Philadelphia, Pa.
DESIGN STUDY OF WIND TURBINES 50 kW TO 3000 kW FOR ELECTRIC UTILITY APPLICATIONS. VOLUME 2: ANALYSIS AND DESIGN Final Report
Dec. 1976 328 p refs
(Contract NAS3-19403)
(NASA-CR-134935; ERDA/NASA-9403-76/2-Vol-2; GE-SD-76SDS4288-Vol-2) Avail: NTIS HC A15/MF A01 CSCL 10A

All possible overall system configurations, operating modes, and subsystem concepts for a wind turbine configuration for cost effective generation of electrical power were evaluated for both technical feasibility and compatibility with utility networks,

as well as for economic attractiveness. A design optimization computer code was developed to determine the cost sensitivity of the various design features, and thus establish the configuration and design conditions that would minimize the generated energy costs. The preliminary designs of both a 500 kW unit and a 1500 kW unit operating in a 12 mph and 18 mph median wind speed respectively, were developed. The various design features and components evaluated are described, and the rationale employed to select the final design configuration is given. All pertinent technical performance data and component cost data are included. The costs of all major subassemblies are estimated and the resultant energy costs for both the 500 kW and 1500 kW units are calculated. Author

N78-17483*# General Electric Co., Philadelphia, Pa.
DESIGN STUDY OF WIND TURBINES 50 kW TO 3000 kW FOR ELECTRIC UTILITY APPLICATIONS. VOLUME 3: SUPPLEMENTARY DESIGN AND ANALYSIS TASKS Final Report
Dec 1976 62 p refs
(Contract NAS3-19403)
(NASA-CR-135121; ERDA/NASA-9403-76/3-Vol-3) Avail: NTIS HC A04/MF A01 CSCL 10A

Additional design and analysis data are provided to supplement the results of the two parallel design study efforts. The key results of the three supplemental tasks investigated are: (1) The velocity duration profile has a significant effect in determining the optimum wind turbine design parameters and the energy generation cost. (2) Modest increases in capacity factor can be achieved with small increases in energy generation costs and capital costs. (3) Reinforced concrete towers that are esthetically attractive can be designed and built at a cost comparable to those for steel truss towers. The approach used, method of analysis, assumptions made, design requirements, and the results for each task are discussed in detail. Author

N78-18516*# Ionics, Inc., Watertown, Mass. Research Div.
ANION PERMSELECTIVE MEMBRANE Summary Report
Samuel Alexander and Russell B. Hodgdon Jul. 1977 77 p
(Contract NAS3-20108)
(NASA-CR-135316) Avail: NTIS HC A05/MF A01 CSCL 10A

The objective of NAS 3-20108 was the development and evaluation of improved anion selective membranes useful as efficient separators in a redox power storage cell system being constructed. The program was divided into three parts, (a) optimization of the selected candidate membrane systems, (b) investigation of alternative membrane/polymer systems, and (c) characterization of candidate membranes. The major synthesis effort was aimed at improving and optimizing as far as possible each candidate system with respect to three critical membrane properties essential for good redox cell performance. Substantial improvements were made in 5 candidate membrane systems. The critical synthesis variables of cross-link density, monomer ratio, and solvent composition were examined over a wide range. In addition, eight alternative polymer systems were investigated, two of which attained candidate status. Three other alternatives showed potential but required further research and development. Each candidate system was optimized for selectivity. Author

N78-20003*# Hawaii Univ., Honolulu
EMPLOYING STATIC EXCITATION CONTROL AND TIE LINE REACTANCE TO STABILIZE WIND TURBINE GENERATORS Final Report
H. H. Hwang, H. V. Mozeico, and Tenhuei Guo Apr. 1978 77 p refs
(Grant NsG-3132, Contract E(49-26)-1004)
(NASA-CR-135344; DOE/NASA/3132-78/1) Avail: NTIS HC A05/MF A01 CSCL 10A

An analytical representation of a wind turbine generator is presented which employs blade pitch angle feedback control. A mathematical model was formulated. With the functioning MOD-0 wind turbine serving as a practical case study, results of computer simulations of the model as applied to the problem of dynamic stability at rated load are also presented. The effect of the tower shadow was included in the input to the system. Different configurations of the drive train, and optimal values of the tie line reactance were used in the simulations. Computer results revealed that a static excitation control system coupled with optimal values of the tie line reactance would effectively reduce oscillations of the power output, without the use of a slip clutch. Author

N78-20621*# Rocketdyne, Canoga Park, Calif.
HYDROGEN TURBINE POWER CONVERSION SYSTEM ASSESSMENT Final Report, Aug. 1973 - Apr. 1976
D. E. Wright, A. D. Lucci, J. Campbell, and J. C. Lee 19 Apr. 1978 155 p refs
(Contract NAS3-20388)
(NASA-CR-135298; RI/RD77-252) Avail: NTIS HC A08/MF A01 CSCL 10A

A three part technical study was conducted whereby parametric technical and economic feasibility data were developed on several power conversion systems suitable for the generation of central station electric power through the combustion of hydrogen and the use of the resulting heat energy in turbogenerator equipment. The study assessed potential applications of hydrogen-fueled power conversion systems and identified the three most promising candidates: (1) Ericsson Cycle, (2) gas turbine, and (3) direct steam injection system for fossil fuel as well as nuclear powerplants. A technical and economic evaluation was performed on the three systems from which the direct injection system (fossil fuel only) was selected for a preliminary conceptual design of an integrated hydrogen-fired power conversion system. Author

N78-23558*# Kaman Aerospace Corp., Bloomfield, Conn.
DESIGN STUDY OF WIND TURBINES, 50 kW TO 3000 kW FOR ELECTRIC UTILITY APPLICATIONS: EXECUTIVE SUMMARY Final Report
Jul. 1977 95 p
(Contracts NAS3-19404, E(49-26)-1010)
(NASA-CR-134936, R-1382, DOE/NASA/9404-7611) Avail: NTIS HC A05/MF A01 CSCL 10A

Preliminary designs of low power (50 to 500 kW) and high power (500 to 3000 kW) wind generator systems (WGS) for electric utility applications were developed. These designs provide the bases for detail design, fabrication, and experimental demonstration testing of these units at selected utility sites. Several feasible WGS configurations were evaluated, and the concept offering the lowest energy cost potential and minimum technical risk for utility applications was selected. The selected concept was optimized utilizing a parametric computer program prepared for this purpose. The utility requirements evaluation task examined the economic, operational and institutional factors affecting the WGS in a utility environment, and provided additional guidance for the preliminary design effort. Results of the conceptual design task indicated that a rotor operating at constant speed, driving an AC generator through a gear transmission is the most cost effective WGS configuration. Author

N78-23560*# Kaman Aerospace Corp., Bloomfield, Conn.
DESIGN STUDY OF WIND TURBINES 50 kW TO 3000 kW FOR ELECTRIC UTILITY APPLICATIONS: ANALYSIS AND DESIGN Final Report
Feb 1978 567 p refs
(Contracts NAS3-10094, E(49-26)-1010)
(NASA-CR-134937, R-1382 DOE/NASA/9404-76/2) Avail: NTIS HC A24/MF A01 CSCL 10A

In the conceptual design task, several feasible wind generator systems (WGS) configurations were evaluated, and the concept offering the lowest energy cost potential and minimum technical risk for utility applications was selected. In the optimization task, the selected concept was optimized utilizing a parametric computer program prepared for this purpose. In the preliminary design task, the optimized selected concept was designed and analyzed in detail. The utility requirements evaluation task examined the economic, operational, and institutional factors affecting the WGS in a utility environment and provided additional guidance for the preliminary design effort. Results of the conceptual design

task indicated that a rotor operating at constant speed, driving an AC generator through a gear transmission is the most cost effective WGS configuration. The optimization task results led to the selection of a 500 kW rating for the low power WGS and a 1500 kW rating for the high power WGS. Author

N78-24674*# Thermo Electron Corp., Waltham, Mass.
ERDA/NASA ADVANCED THERMIONIC TECHNOLOGY PROGRAM Progress Report
May 1977 24 p refs
(Contracts NAS3-20302; EY-76-C-02-3056)
(NASA-CR-157117; PR-23, TE-4217/4220-140-77; COO-3056-25) Avail: NTIS HC A02/MF A01 CSCL 10A

Research progress is outlined in the areas of surface studies (basic experiments and direct beam chamber), plasma studies (converter theory and advanced mode conversion experiments), component development (low-temperature and high-temperature converter experiments), and component hardware (hot shell development). ERA

N78-26579*# Thermo Electron Engineering Corp., Waltham, Mass.
ERDA-NASA ADVANCED THERMIONIC TECHNOLOGY PROGRAM Program Report
Aug 1977 16 p refs
(Contracts NAS3-20959; EY-76-C-02-3056)
(NASA-CR-157222; PR-26, TE-4220/4233-29-78; COO-3056-28) Avail: NTIS HC A02/MF A01 CSCL 10B

Research is summarized on surface studies (work functions of different LaB6 surfaces), plasma studies, converter development (tungsten emitter, nickel collector and tungsten emitter La B6 collector), and hot shell development for using thermionic converters in the topping cycle of fossil-fuel plants.Author (ERA)

N78-27540*# ...ternational Corp., Lewistown, Pa.
EVALUATION OF GLASS RESIN COATINGS FOR SOLAR CELL APPLICATIONS Final Report
M. B. Field Apr 1978 38 p
(Contract NAS3-20958)
(NASA CR-159392) Avail: NTIS HC A03/MF A01 CSCL 10A

Using a variety of non-vacuum deposition techniques coatings were implemented on silicon solar cells and arrays of cells interconnected on Kapton substrates. The coatings provide both antireflection optical matching and environmental protection. Reflectance minima near 2% was achieved at a single wavelength in the visible. Reflectance averaging below 5% across the useful collection range was demonstrated. The coatings and methods of deposition were: (1) Ta2O5 spun, dipped or sprayed, (2) Ta2O5 SiO2 spun, dipped or sprayed, (3) GR908 (SiO2) spun, dipped, or sprayed. Total coating thickness were in the range of 18 microns to 25 microns. The coatings and processes are compatible with single cells or cells mounted on Kapton substrates. G.Y.

N78-27552*# Thermo Electron Engineering Corp., Waltham, Mass.
ERDA-NASA ADVANCED THERMIONIC TECHNOLOGY PROGRAM Progress Report
Sep 1977 11 p
(Contracts NAS3-20959; EY-76-C-02-3056)
(NASA-CR-157248; TE-4220/4233-44-78; COO-3056-29; PR-27) Avail: NTIS HC A02/MF A01

Research progress is briefly outlined in the areas of activation experiments, enchanced mode conversion experiments, converter development (tungsten emitter, lanthanum hexaboride collector) and hot shell development. Author (ERA)

N78-28668*# AiResearch Mfg. Co., Torrance, Calif.
PRELIMINARY DESIGN STUDY OF AN ALTERNATE HEAT SOURCE ASSEMBLY FOR A BRAYTON ISOTOPE POWER SYSTEM Final Report, Oct. 1977 - Apr. 1978
Hal J. Strumpf May 1978 112 p refs Prepared for JPL
(Contract NAS3-20816)
(NASA-CR-135428; AiResearch-78-15171) Avail: NTIS HC A06/MF A01 CSCL 10A

Results are presented for a study of the preliminary design of an alternate heat source assembly (HSA) intended for use in the Brayton isotope power system (BIPS). The BIPS converts thermal energy emitted by a radioactive heat source into electrical energy by means of a closed Brayton cycle. A heat source heat exchanger configuration was selected and optimized. The design consists of a 10 turn helically wound Hastelloy X tube. Thermal analyses were performed for various operating conditions to ensure that post impact containment shell (PICS) temperatures remain within specified limits. These limits are essentially satisfied for all modes of operation except for the emergency cooling system for which the PICS temperatures are too high. Neon was found to be the best choice for a fill gas for auxiliary cooling system operation. Low cycle fatigue life, natural frequency, and dynamic loading requirements can be met with minor modifications to the existing HSA. B.B.

N78-29574*# Ionics, Inc., Watertown, Mass. Research Div.
ANION PERMSELECTIVE MEMBRANE
S. S. Alexander and R. B. Hodgdon Jan. 1978 77 p
(Contracts NAS3-20108; E(49-28)-1002)
(NASA-CR-135316; CONS/0108-1) Avail: NTIS HC A05/MF A01 CSCL 10A

Experimental anion permselective membranes were improved and characterized for use as separators in a chemical redox power storage cell being developed at the NASA Lewis Research Center. The goal of minimal Fe(+3) ion transfer was achieved for each candidate membrane system. Minimal membrane resistivity was demonstrated by reduction of film thickness using synthetic backing materials but usefulness of thin membranes was limited by the scarcity of compatible fabrics. The most durable and useful backing fabrics were modacrylics. One membrane, a copolymer of 4 vinylpyridine and vinyl benzylchloride was outstanding in overall electrochemical and physical properties. Long term (1000 hrs) membrane chemical and thermal durability in redox environment was shown by three candidate polymers and two membranes. The remainder had good durability at ambient temperature. Manufacturing capability was demonstrated for large scale production of membrane sheets 5.5 sq ft in area for two candidate systems. Author

N78-29684*# Rohr Industries, Inc., Chula Vista, Calif.
PRELIMINARY POWER TRAIN DESIGN FOR A STATE-OF-THE-ART ELECTRIC VEHICLE Final Report
James A. Ross and Gerald A. Wooldridge Apr. 1978 222 p refs
(Contracts NAS3-20592; EC-77-A-31-1044)
(NASA-CR-135340; RHR-78-035; DOE/NASA/0592-78/1)
Avail: NTIS HC A10/MF A01 CSCL 10A

The state-of-the-art (SOTA) of electric vehicles built since 1965 was reviewed to establish a base for the preliminary design of a power train for a SOTA electric vehicle. The performance of existing electric vehicles were evaluated to establish preliminary specifications for a power train design using state-of-the-art technology and commercially available components. Power train components were evaluated and selected using a computer simulation of the SAE J227a Schedule D driving cycle. Predicted range was determined for a number of motor and controller combinations in conjunction with the mechanical elements of power trains and a battery pack of sixteen lead-acid batteries - 471.7 kg at 0.093 MJ/Kg (1040 lbs at 11.7 Whr/lb). On the basis of maximum range and overall system efficiency using the Schedule D cycle, an induction motor and 3 phase inverter/controller was selected as the optimum combination when used with a two-speed transaxle and steel belted radial tires. The predicted Schedule D range is 90.4 km (56.2 mi). Four near term improvements to the SOTA were identified, evaluated, and predicted to increase range approximately 7%. F.O.S.

N78-33827*# Honeywell, Inc., Minneapolis, Minn.
DEVELOPMENT OF FLAT-PLATE SOLAR COLLECTORS FOR THE HEATING AND COOLING OF BUILDINGS: EXECUTIVE SUMMARY
[1978] 21 p
(Contract NAS3-17862)
(NASA-CR-134804) Avail: NTIS HC A02/MF A01 CSCL 10A

An efficient, low cost, flat-plate solar collector was developed. Computer aided mathematical models of the heat process in the collector were used in defining absorber panel configuration; determining insulation thickness; and in selecting the number, spacing, and material of the covers. Prototypes were built and performance tested. Data from simulated operation of the collector are compared with predicted loads from a number of locations to determine the degree of solar utilization. S.B.S.

A78-10947 * Application of thick-film technology to solar cell fabrication. M. B. Field (Owens-Illinois, Inc., Toledo, Ohio) and L. R. Scudder (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Specialists Conference, 12th, Baton Rouge, La., November 15-18, 1976, Conference Record. (A78-10902 01-44) New York, Institute of Electrical and Electronics Engineers, Inc., 1976, p. 303-308. Contract No. NAS3-19441.

Several uses of thick-film technology in solar cell fabrication are discussed. Wrap-around contacts are obtained by first printing and firing a dielectric over the edge and subsequently applying a low-firing temperature conductor. Interconnection of cells into arrays can be achieved by printing and co-firing thick-film pastes, soldering, or with heat-curing conductive epoxies on low-cost substrates. Despite ongoing research, printed (thick) film vitreous protective coatings do not yet offer sufficient optical uniformity and transparency for use on silicon. Ohmic contacts on n- and p-type silicon are considered. M.L.

A78-29636 * Experiments with enhanced mode thermionic converters. P. E. Oettinger and F. N. Hussman (Thermo Electron Research and Development Center, Waltham, Mass.). *IEEE Transactions on Plasma Science*, vol. PS-6, Mar. 1978, p. 83-88. 8 refs. Contract No. NAS3-20302.

Reduction of the ionization and scattering losses associated with ignited mode cesium diodes is essential for high thermal-to-electrical conversion efficiency. Use of an auxiliary electrode in conjunction with a noble gas in the interelectrode space should permit more efficient ion generation for space charge neutralization. The characteristics of a thermionic triode utilizing a ring electrode and a dispenser cathode emitter have been studied as a function of xenon pressure, cesium reservoir temperature, spacing, electrode temperature and pulse parameters (i.e., potential, duration and repetition rate) applied to the auxiliary electrode. Pulsed operation significantly enhanced output power with uniform discharges appearing to be sustained at emitter-collector spacings as low as 0.5 mm. (Author)

A78-31974 * # Pulse battery charger employing 1000 ampere transistor switches. R. L. Steigerwald (General Electric Co., Schenectady, N.Y.). *Institute of Electrical and Electronics Engineers, Annual Conference, 12th, Los Angeles, Calif., Oct. 26, 1977, Paper.* 6 p. Contract No. NAS3-19750

A pulse charger which uses water-cooled 1000 amp transistor switches has been developed to determine empirically the best methods of rapidly charging large cells in the one- to two-volt range. The pulse charger is capable of delivering a positive current from 0 to 1000 amps and extracting a negative current from 0 to 1000 amps. The charger can supply a 1000-amp DC charge or can switch 1000 amps at a rate of 1000 Hz. Special attention is given to problems associated with rapid switching of high currents through use of transistors. J.M.B.

A78-33147 * # Open-Cycle Gas Turbine/Steam Turbine Combined Cycles with synthetic fuels from coal. R. P. Shah and J. C. Corman (General Electric Co., Schenectady, N.Y.). *American Society of Mechanical Engineers, Winter Annual Meeting, Atlanta, Ga., Nov. 27-Dec. 2, 1977, Paper 77-WA/Ener-9.* 12 p. Members, $1.50; nonmembers, $3.00. ERDA-NSF-sponsored research; Contract No. NAS3-19406.

The Open-Cycle Gas Turbine/Steam Turbine Combined Cycle can be an effective energy conversion system for converting coal to electricity. The intermediate step in this energy conversion process is to convert the coal into a fuel acceptable to a gas turbine. This can be accomplished by producing a synthetic gas or liquid, and by removing, in the fuel conversion step, the elements in the fuel that would be harmful to the environment if combusted. In this paper, two open-cycle gas turbine combined systems are evaluated: one employing an integrated low-Btu gasifier, and one utilizing a semi-clean liquid fuel. A consistent technical/economic information base is developed for these two systems, and is compared with a reference steam plant burning coal directly in a conventional furnace. (Author)

A78-34078 * # Performance and economics of advanced energy conversion systems for coal and coal-derived fuels. J. C. Corman and G. R. Fox (General Electric Co., Schenectady, N.Y.). *ASME, Transactions, Journal of Engineering for Power*, vol. 100, Apr. 1978, p. 252-259. Contract No. NAS3-19406.

The desire to establish an efficient Energy Conversion System to utilize the fossil fuel of the future - coal - has produced many candidate systems. A comparative technical/economic evaluation was performed on the seven most attractive advanced energy conversion systems. The evaluation maintains a cycle to cycle consistency in both performance and economic projections. The technical information base can be employed to make program decisions regarding the most attractive concept. A reference steam power plant was analyzed to the same detail and, under the same ground rules, was used as a comparison base. The power plants were all designed to utilize coal or coal-derived fuels and were targeted to meet an environmental standard. The systems evaluated were two advanced steam systems, a potassium topping cycle, a closed cycle helium system, two open cycle gas turbine combined cycles, and an open cycle MHD system. (Author)

A78-53489 * Dendritic web silicon for solar cell application. R. G. Seidensticker (Westinghouse Research Laboratories, Pittsburgh, Pa.). In: Materials and energy; Selected topics. (A78-53487 24-44) Amsterdam, North-Holland Publishing Co., 1977, p. 17-22. 18 refs. USAF-supported research; Contracts No. NAS3-18034; No. NAS3-19439.

The dendritic web process for growing long thin ribbon crystals of silicon and other semiconductors is described. Growth is initiated from a thin wirelike dendrite seed which is brought into contact with the melt surface. Initially, the seed grows laterally to form a button at the melt surface; when the seed is withdrawn, needlelike dendrites propagate from each end of the button into the melt, and the web portion of the crystal is formed by the solidification of the liquid film supported by the button and the bounding dendrites. Apparatus used for dendritic web growth, material characteristics, and the two distinctly different mechanisms involved in the growth of a single crystal are examined. The performance of solar cells fabricated from dendritic web material is indistinguishable from the performance of cells fabricated from Czochralski-grown material. M.L.

45 ENVIRONMENT POLLUTION

Includes air, noise, thermal and water pollution; environment monitoring; and contamination control.

A78-15828 * # Global measurements of gaseous and aerosol trace species in the upper troposphere and lower stratosphere from daily flights of 747 airliners. P. J. Perkins (NASA, Lewis Research Center, Cleveland, Ohio). *AGU, AIAA, and AMS, Joint Symposium on Nonurban Troposphere, Miami Beach, Fla., Nov. 10-12, 1976, Paper.* 17 p. 8 refs.

A description is given of the NASA Global Atmospheric Sampling Program (GASP), taking into account the onboard system which collects atmospheric data automatically, the extensive atmospheric measurement capability, and the data handling and distribution procedure. GASP was implemented to assess the environmental impact of aircraft exhaust emissions in the upper troposphere and lower stratosphere. Global air quality data are to be obtained for a period of five to ten years. Measurements of pollutants not related to aircraft exhaust emissions, such as chlorofluoromethanes, are now included. GASP systems are operating on a United Airlines 747, two Pan Am 747s, and a Qantas Airways of Australia 747. Real-time, in-situ measurements are conducted of ozone, water vapor, carbon monoxide, and oxides of nitrogen. Chlorofluoromethanes are measured by laboratory analysis. Typical GASP data show significant changes in ozone, carbon monoxide, and water vapor related to crossings of the tropopause. G.R.

46 GEOPHYSICS

Includes aeronomy; upper and lower atmosphere studies; ionospheric and magnetospheric physics; and geomagnetism. For space radiation see 93 *Space Radiation.*

N78-13669*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN ANALYSIS OF THE FIRST TWO YEARS OF GASP DATA
J. D. Holdeman, G. D. Nastrom (Control Data Corp., Minneapolis, Minn.), and P. D. Falconer (Albany Univ., N. Y.) 1977 10 p refs Presented at 4th Joint Conf. on Sensing of Environmental Pollutants New Orleans, La., 6-11 Nov. 1977; sponsored by Am. Chem. Soc.
(NASA-TM-73817, E-9406) Avail: NTIS HC A02/MF A01 CSCL 04A

Distributions of mean ozone levels from the first two years of data from the NASA Global Atmospheric Sampling Program (GASP) show spatial and temporal variations in agreement with previous measurements. The standard deviations of these distributions reflect the large natural variability of ozone levels in the altitude range of the GASP measurements. Monthly mean levels of ozone below the tropopause show an annual cycle with a spring maximum which is believed to result from transport from the stratosphere. Correlations of ozone with independent meteorological parameters, and meteorological parameters obtained by the GASP systems show that this transport occurs primarily through cyclogenesis at mid-latitudes. Author

N78-13670*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
GLOBAL SENSING OF GASEOUS AND AEROSOL TRACE SPECIES USING AUTOMATED INSTRUMENTATION ON 747 AIRLINERS
Porter J. Perkins and Leonidas C. Papetheliou 1977 11 p refs Presented at 4th Joint Conf. on Sensing of Environmental Pollutants, New Orleans, La., 6-11 Nov. 1977
(NASA-TM-73810, E-9396) Avail: NTIS HC A02/MF A01 CSCL 04A

The Global Atmospheric Sampling Program (GASP) by NASA is collecting and analyzing data on gaseous and aerosol trace species in the upper troposphere and lower stratosphere. Measurements are obtained from automated systems installed on four 747 airliners flying global air routes. Advances were made in airborne sampling instrumentation. Improved instruments and analysis techniques are providing an expanding data base for trace species including ozone, carbon monoxide, water vapor, condensation nuclei and mass concentrations of sulfates and nitrates. Simultaneous measurements of several trace species obtained frequently can be used to uniquely identify the source of the air mass as being typically tropospheric or stratospheric. A quantitative understanding of the tropospheric-stratospheric exchange processes leads to better knowledge of the atmospheric impact of pollution through the development of improved simulation models of the atmosphere. Author

A78-24883*# Description and review of global measurements of atmospheric species from GASP. D. J. Gauntner, J. D. Holdeman, D. Briehl, and F. M. Humenik (NASA, Lewis Research Center, Cleveland, Ohio). *ASTM, AMS, APCA, EPA, International Ozone Institute, NBS, and NOAA, Conference on Air Quality Meteorology and Atmospheric Ozone, Boulder, Colo., July 31-Aug. 6, 1977, Paper.* 24 p. 9 refs.

A large volume of atmospheric constituent data is being collected in the global airlanes by specially equipped B 747 aircraft. This NASA program also obtains data from the similarly equipped NASA CV 990 aircraft during dedicated flights such as a recent near pole-to-pole latitude survey mission. Aerosol composition data are also collected with a NASA F 106 aircraft. Present measurements include ozone, carbon monoxide, water vapor, aerosol and condensation nuclei number densities, sulphates, nitrates, and the chlorofluoromethanes. Meteorological and flight parameters are also recorded for use in data analysis. The present aircraft operations obtain data between 8 and 13.5 km from 85 deg N between Europe and the North Pacific, and from 23 deg S over South America and 42 deg S over New Zealand. Typical constituent data from the aircraft operations during the first one and a half years are presented. Instrumentation is discussed. (Author)

A78-24884*# Atmospheric ozone measurements made from B-747 airliners - Spring 1976. P. D. Falconer, A. D. Taylor (NOAA, Air Resources Laboratories, Silver Spring, Md.), and J. D. Holdeman (NASA, Lewis Research Center, Cleveland, Ohio). *IAMAP, WMO, and IAGA, Joint Symposium on Atmospheric Ozone, Dresden, East Germany, Aug. 9-17, 1976, Paper.* 29 p.

Atmospheric ozone in the upper troposphere and lower stratosphere north of the equator has been registered aboard two commercial B-747 airliners during the Spring of 1975. This monitoring is part of a much broader and continuing project developed by NASA and known as the Global Atmospheric Sampling Program (GASP). Additional flight and meteorological conditions have also been automatically recorded on board concurrent with the ozone measurements. Independently-derived tropopause pressure information was available from NMC data archives and was used to identify stratospheric and tropospheric flight. The composite ozone, flight and meteorological data are reported for selected dates in March, April, and May. Attention is drawn particularly to the vertical profiles of atmospheric ozone mixing ratio as a function of both distance from the tropopause and curvature of the streamlines. The GASP observations suggest that ozone levels typical of the lower stratosphere are often embedded in the upper troposphere, principally during occasions when cyclonic wind curvature was noted. (Author)

N78-23648*# Control Data Corp., Minneapolis, Minn. Research Div.
VARIABILITY OF OZONE NEAR THE TROPOPAUSE FROM GASP DATA Research Report
G. D. Nastrom 14 Apr. 1978 50 p refs
(Contract NAS3-20618)
(NASA-CR-135405-RR-1) Avail: NTIS HC A03/MF A01 CSCL 04A

The first 22 months of ozone data from the Global Atmospheric Sampling Program are summarized. Variations in space and time were examined at nearly all scales permitted by the data. Case studies in the tropics suggest that local ozone maxima may be found in or near clouds. Preliminary seasonal mean maps of ozone during spring are presented for the Northern Hemisphere. In the troposphere over the United States during summer there is a distinct midcontinental ozone maximum. There is a diurnal variation in ozone in the upper troposphere and the daily range is about 5 ppbv. Correlations between ozone and other variables are given for the synoptic-scale and on a hemispheric scale. The possible bearing of these results on ozone transport computations is discussed. Author

A78-38836* Measurement of tropospheric 300 nm solar ultraviolet flux for determination of O/1D/ photoproduction rate. B. Sellers and F. A. Hanser (Parametrics, Inc., Waltham, Mass.). *Journal of the Atmospheric Sciences*, vol. 35, May 1978, p. 912-918. 23 refs. Research supported by the Georgia Institute of Technology; NSF Grant No. ENV-76-23802; Contracts No. N00014-73-C-0316; No. NAS3-20472.

The tropospheric importance of the OH radical, and the reaction scheme that leads to its formation, are now being widely investigated. Ozone photolysis at wavelengths no greater than 318 nm produces O(1D), a small fraction of which then reacts with water vapor to yield OH. Although experimental data are available for the O(1D) quantum yield, as well as the O3 absorption cross section, all previous tropospheric photochemical models have had to use theoretical calculations to determine the UV flux. Discussed in this paper are aircraft spectral measurements of the solar UV flux at two altitudes - 2 and 6 km. These results have been compared with three

theoretical approaches. The measured experimental fluxes have been combined here with recent quantum yield data to calculate the O(1D) photoproduction rate for various albedo values. This rate is larger than that used in models by about a factor of 2 for reasonable values of assumed albedo. (Author)

A78-41788 * **Experiments on whistler wave filamentation and VLF hiss in a laboratory plasma.** R. L. Stenzel (TRW Defense and Space Systems Group, Redondo Beach; California, University, Los Angeles, Calif.). *(European Physical Society, IUPAP, URSI, and Société Française de Physique, International Congress on Waves and Instabilities in Plasmas, 3rd, Palaiseau, Essonne, France, June 27-July 1, 1977.)* *Journal de Physique*, vol. 38, Dec. 1977, Supplement, p. C6-89 to C6-102. 33 refs. Research supported by TRW Independent Research and Development Funds; Contracts No. NAS3-1175; No. NASW-2953.

With the development of a large magnetized plasma source it has become possible to investigate space plasma physics problems in the laboratory. First, the nonlinear effects associated with the excitation of a large amplitude whistler wave have been explored. It is found that the radiation pressure of the wave and thermal effects give rise to a field-aligned density depression in which the wave becomes completely trapped. Hyperfine filaments with diameters small compared with the parallel wavelength are observed. Second, the stability of oblique whistler waves in the presence of an electron beam has been studied. A broadband whistler instability is observed and identified as a Cherenkov interaction between beam electrons and whistlers propagating near the resonance cone. These observations confirm the present model for the generation of VLF hiss in the aurora. (Author)

47 METEOROLOGY AND CLIMATOLOGY

Includes weather forecasting and modification.

N78-17558*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AUTOMATED METEOROLOGICAL DATA FROM COMMERCIAL AIRCRAFT VIA SATELLITE: PRESENT EXPERIENCE AND FUTURE IMPLICATIONS
Robert Steinberg 1978 7 p refs Presented at Intern. Conf. on Maritime and Aeron. Satellite Commun. and Navigation, London, 7-10 Mar. 1978; sponsored by Institution of Elec. Eng.
(NASA-TM-73750; E-9323) Avail: NTIS HC A02/MF A01 CSCL 04B

A low-cost communications system to provide meteorological data from commercial aircraft, in near real-time, on a fully automated basis has been developed. The complete system including the low profile antenna and all installation hardware weighs 34 kg. The prototype system was installed on a B-747 aircraft and provided meteorological data (wind angle and velocity, temperature, altitude and position as a function of time) on a fully automated basis. The results were exceptional. This concept is expected to have important implications for operational meteorology and airline route forecasting. Author

N78-19710*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PHOTOVOLTAIC REMOTE INSTRUMENT APPLICATIONS: ASSESSMENT OF THE NEAR-TERM MARKET
Louis Rosenblum, Larry R. Scudder, William A. Poley, and William J. Bifano Dec. 1977 19 p refs
(Contract E(49-26)-1022)
(NASA-TM-73881; DOE/NASA/1022-77/24; E-9492) Avail: NTIS HC A02/MF A01 CSCL 14B

A preliminary assessment of the near term market for photovoltaic remote instrument applications is presented. Among the potential users, two market sectors are considered: government and private. However, the majority of the remote systems studied are operated by or for the federal, state, or local governments. Environmental monitoring and surveillance remote instrument systems are discussed. Based on information obtained in this preliminary market survey, a domestic, civilian market of at least 1.3 MW sub pk is forecast for remote instrument systems. This estimate is exclusive of several potentially large scale markets for remote instruments which are identified but for which no hard data is available. Author

A78-14581* Models for some aspects of atmospheric vortices. R. G. Deissler (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of the Atmospheric Sciences*, vol. 34, Oct. 1977, p. 1502-1517. 31 refs.

A frictionless adiabatic model is used to study the growth of random vortices in an atmosphere with buoyant instability and vertical wind shear, taking account of the effects of axial drag, heat transfer, and precipitation-induced downdrafts. It is found that downdrafts of tornadic magnitude may occur in negatively buoyant columns. The radial-inflow velocity required to maintain a given maximum tangential velocity in a tornado is determined by using a turbulent vortex model. A tornado model which involves a rotating parent cloud as well as buoyancy and precipitation effects is also discussed. B.J.

A78-42962*# Cloud effects on middle ultraviolet global radiation. J. Borkowski (Warszawa, Uniwersytet, Warsaw, Poland), A.-T. Chai (NASA, Lewis Research Center, Cleveland, Ohio), T. Mo (NASA, Goddard Institute for Space Studies, New York, N.Y.), and A. E. O. Green (Florida, University, Gainesville, Fla.). *Acta Geophysica Polonica*, vol. 25, no. 4, 1977, p. 287-301. 16 refs. Research supported by the U.S. Department of Transportation.

An Eppley radiometer and a Robertson-Berger sunburn meter are employed along with an all-sky camera setup to study cloud effects on middle ultraviolet global radiation at the ground level. Semiempirical equations to allow for cloud effects presented in previous work are compared with the experimental data. The study suggests a means of defining eigenvectors of cloud patterns and correlating them with the radiation at the ground level. (Author)

48 OCEANOGRAPHY

Includes biological, dynamic and physical oceanography; and marine resources.

A78-47223 * Numerical computation of three-dimensional circulation in Lake Erie - A comparison of a free-surface model and a rigid-lid model. Y. P. Sheng, W. Lick (Case Western Reserve University, Cleveland, Ohio), R. T. Gedney, and F. B. Molls (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Physical Oceanography*, vol. 8, July 1978, p. 713-727. 23 refs. Research supported by the U.S. Environmental Protection Agency.

51 LIFE SCIENCES (GENERAL)

Includes genetics.

N78-22618*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE USE OF AN ION-BEAM SOURCE TO ALTER THE SURFACE MORPHOLOGY OF BIOLOGICAL IMPLANT MATERIALS

A. J. Weigand 1978 28 p refs Presented at Soc. for Biomater. Conf., San Antonio, 29 Apr. - 2 May 1978

(NASA-TM-78851; E-9573) Avail: NTIS HC A03/MF A01 CSCL 06C

An electron bombardment, ion thruster was used as a neutralized-ion beam sputtering source to texture the surfaces of biological implant materials. Scanning electron microscopy was used to determine surface morphology changes of all materials after ion-texturing. Electron spectroscopy for chemical analysis was used to determine the effects of ion texturing on the surface chemical composition of some polymers. Liquid contact angle data were obtained for ion textured and untextured polymer samples. Results of tensile and fatigue tests of ion-textured metal alloys are presented. Preliminary data of tissue response to ion textured surfaces of some metals, polytetrafluoroethylene, alumina, and segmented polyurethane were obtained. Author

N78-31680*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DIGITAL ENHANCEMENT OF COMPUTERIZED AXIAL TOMOGRAMS

Ernest Roberts, Jr. 1978 6 p refs Presented at the 5th Ann. Computers in Cardiology Conf., Stanford, Calif., 12-14 Sep. 1978; cosponsored by IEEE, NIH, and Stanford Univ. School of Med.

(NASA-TM-78974; E-9748) Avail: NTIS HC A02/MF A01 CSCL 06E

A systematic evaluation was conducted of certain digital image enhancement techniques performed in image space. Three types of images were used, computer generated phantoms, tomograms of a synthetic phantom, and axial tomograms of human anatomy containing images of lesions, artificially introduced into the tomograms. Several types of smoothing, sharpening, and histogram modification were explored. It was concluded that the most useful enhancement techniques are a selective smoothing of singular picture elements, combined with contrast manipulation. The most useful tool in applying these techniques is the gray-scale histogram. L.S.

N78-18672*# Case Western Reserve Univ., Cleveland, Ohio. Dept. of Biomedical Engineering.

EFFECT OF SURFACE TEXTURE BY ION BEAM SPUTTERING ON IMPLANT BIOCOMPATIBILITY AND SOFT TISSUE ATTACHMENT Annual Report

Donald F. Gibbons Dec. 1977 15 p refs

(Grant NsG-3126)

(NASA-CR-135311; AR-1) Avail: NTIS HC A02/MF A01 CSCL 06C

The objectives in this report were to use the ion beam sputtering technique to produce surface textures on polymers, metals, and ceramics. The morphology of the texture was altered by varying both the width and depth of the square pits which were formed by ion beam erosion. The width of the ribs separating the pits were defined by the mask used to produce the texture. The area of the surface containing pits varies as the width was changed. The biological parameters used to evaluate the biological response to the texture were: (1) fibrous capsule and inflammatory response in subcutaneous soft tissue; (2) strength of the mechanical attachment of the textured surface by the soft tissue; and (3) morphology of the epidermal layer interfacing the textured surface of percutaneous connectors. Because the sputter yield on teflon ribs was approximately an order of magnitude larger than any other material the majority of the measurements presented in the report were obtained with teflon. Author

52 AEROSPACE MEDICINE

Includes physiological factors; biological effects of radiation; and weightlessness.

N78-14773* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
TISSUE MACERATING INSTRUMENT Patent
Edward F. Baehr and James E. Burnett, inventors (to NASA) Issued 6 Dec. 1977 4 p Filed 15 Apr. 1976 Supersedes N76-23837 (14 - 14, p 1836)
(NASA-Case-LEW-12668-1; US-Patent-4,061,146; US-Patent-Appl-SN-677353; US-Patent-Class-128-305) Avail: US Patent Office CSCL 06B

A surgical tissue macerating and removal tool is described which has a rotating rod with a cutting member at one end and which is disposed in a tube which is then contained in an extension of the tool handle. A frusto-conical member extends into the extension at the cutter member end of the rotating rod with its small end engaging the tube. The portion of the frusto-conical member outside of the extension forms a tissue engaging member and may be cut off at an angle to the axis of the rod to form a tissue engaging edge. Apertures are provided in the extension adjacent the frusto-concial member so that treatment fluid supplied in the annular space between the tube and the extension may flow to the operative site. An aperture is provided in the frustoconical member between the extension and the tube so that fluid may also flow into the tube where it mixes with macerated tissue being directed through an aperture in the tube to a passageway which may have suction applied to help remove macerated material

Official Gazette of the U.S. Patent Office

N78-20758*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TOXIC SUBSTANCES ALERT PROGRAM
Thomas L. Junod Jan. 1978 287 p refs Revised
(NASA-TM-73866; E-9456) Avail: NTIS HC A13/MF A01 CSCL 06T

A toxicity profile is provided, of 187 toxic substances procured by NASA Lewis Research Center during a 3 1/2 year period, including 27 known or suspected carcinogens. The goal of the program is to assure that the center's health and safety personnel are aware of the procurement and use of toxic substances and to alert and inform the users of these materials as to the toxic characteristics and the control measures needed to ensure their safe use. The program also provides a continuing record of the toxic substances procured, who procured them, what other toxic substances the user has obtained in the past, and where similar materials have been used elsewhere at the center.

Author

54 MAN/SYSTEM TECHNOLOGY AND LIFE SUPPORT

Includes human engineering; biotechnology; and space suits and protective clothing.

N78-24807*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ESCORT: A DATA ACQUISITION AND DISPLAY SYSTEM TO SUPPORT RESEARCH TESTING

Robert L. Miller 1978 10 p Presented at Electro 1978, Boston, 23-25 May 1978; sponsored by IEEE

(NASA-TM-78909; E-9644) Avail: NTIS HC A02/MF A01 CSCL 09B

Primarily designed to acquire data at steady state test conditions, the system can also monitor slow transients such as those generated in moving to a new test condition. The system configuration makes use of a microcomputer at the test site which acts as a communications multiplexer between the measurement and display devices and a centrally located minicomputer. A variety of measurement and display devices are supported using a modular approach. This allows each system to be configured with the proper combination of devices to meet the specific test requirements, while still leaving the option to add special interfaces when needed. Centralization of the minicomputer improves utilization through sharing. The creation of a pool of minis to provide data acquisition and display services to a variable number of running tests also offers other important advantages. Author

60 COMPUTER OPERATIONS AND HARDWARE

Includes computer graphics and data processing.

For components see *33 Electronics and Electrical Engineering*.

N78-23761*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A DATA ACQUISITION AND HANDLING SYSTEM FOR THE MEASUREMENT OF RADIAL PLASMA TRANSPORT RATES

W. M. Krawczonek, C. E. Boyd (Tex. Univ., Austin), J. Y. Hong (Tex. Univ., Austin), and E. J. Powers (Tex. Univ., Austin) 1977 107 p refs Presented at Symp. on Eng. Aspects of Fusion Res., Knoxville, Tenn., 25-28 Oct. 1977

(NASA-TM-78849) Avail: NTIS HC A06/MF A01 CSCL 09B

A system which allows the transfer of experimental data from one or more transient recorders to a digital computer, the entry of calibration data and the entry of archival data is described. The overall approach is discussed and illustrated in detail.

Author

A78-37685 * # **Escort - A data acquisition and display system to support research testing.** R. L. Miller (NASA, Lewis Research Center, Cleveland, Ohio). *Institute of Electrical and Electronics Engineers, ELECTRO '78 Conference, Boston, Mass., May 23-25, 1978, Paper.* 10 p.

A combination of a central minicomputer and test-site microcomputers has been adopted to provide on-line data acquisition and display service for a large number of different research programs. By integrating the data acquisition and recording functions in the minicomputer/microcomputer system, rapidly updated displays of selected data in terms of engineering units may be obtained. The system described here is primarily designed for steady-state test conditions, but may also provide data on slow transients associated with changing experimental conditions. Application of the system to full-scale jet engine tests, ion thruster assessments and anechoic chamber analyses are mentioned. J.M.B.

61 COMPUTER PROGRAMMING AND SOFTWARE

Includes computer programs, routines, and algorithms.

N78-10746*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
USER'S GUIDE FOR SFTRAN/360
Theodore E. Fessler and William F. Ford Oct. 1977 51 p ref
(NASA-TP-1006; E-9264) Avail: NTIS HC A04/MF A01 CSCL 09B

Extension and improvements made to SFTRAN, a structured-programming language are discussed. This improved language is implemented as a precompiler that translates from SFTRAN to FORTRAN. The SFTRAN language and its use are described. Time-Sharing System (TSS) command procedures were implemented that eliminate the complications of dealing with extra files and processing steps which the use of a precompiler would otherwise require. These command procedures are described and their use is illustrated by examples. Author

N78-15729*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN AUTOMATED PROCEDURE FOR CALCULATING SYSTEM MATRICES FROM PERTURBATION DATA GENERATED BY AN EAI PACER AND 100 HYBRID COMPUTER SYSTEM
Edward J. Milner and Susan M. Krosel Dec. 1977 44 p
(NASA-TM-73869; E-9465) Avail: NTIS HC A03/MF A01 CSCL 09B

Techniques are presented for determining the elements of the A, B, C, and D state variable matrices for systems simulated on an EAI Pacer 100 hybrid computer. An automated procedure systematically generates disturbance data necessary to linearize the simulation model and stores these data on a floppy disk. A separate digital program verifies this data, calculates the elements of the system matrices, and prints these matrices appropriately labeled. The partial derivatives forming the elements of the state variable matrices are approximated by finite difference calculations. Author

N78-17724*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPUTER PROGRAM FOR CALCULATION OF COMPLEX CHEMICAL EQUILIBRIUM COMPOSITIONS, ROCKET PERFORMANCE, INCIDENT AND REFLECTED SHOCKS, AND CHAPMAN-JOUGUET DETONATIONS
Sanford Gordon and Bonnie J. McBride Mar. 1976 145 p refs Revised
(NASA-SP-273) Avail: NTIS HC A07/MF A01 CSCL 09B

A detailed description of the equations and computer program for computations involving chemical equilibria in complex systems is given. A free-energy minimization technique is used. The program permits calculations such as (1) chemical equilibrium for assigned thermodynamic states (T,P), (H,P), (S,P), (T,V), (U,V), or (S,V), (2) theoretical rocket performance for both equilibrium and frozen compositions during expansion, (3) incident and reflected shock properties, and (4) Chapman-Jouguet detonation properties. The program considers condensed species as well as gaseous species. Author

N78-20808*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
USER'S GUIDE TO SFTRAN/1100
William F. Ford and Theodore E. Fessler Apr. 1978 44 p refs
(NASA-TP-1200; E-9445) Avail: NTIS HC A03/MF A01 CSCL 09B

Extensions and improvements were made to SFTRAN, a structured programming language. This language was implemented as a precompiler that translates from SFTRAN to FORTRAN. It was available to batch and conversational users of the UNIVAC 1100 computer system. The SFTRAN language and its use are described. In addition, conversational time-sharing system command subroutines were implemented that eliminated the complications of dealing with extra files and processing steps that the use of a precompiler would otherwise require. These command subroutines are reported, and their use is illustrated by examples. Author

N78-21791*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FLOWNET: A COMPUTER PROGRAM FOR CALCULATING SECONDARY FLOW CONDITIONS IN A NETWORK OF TURBOMACHINERY
James R. Rose Mar. 1978 68 p refs
(NASA-TM-73774; E-9579) Avail: NTIS HC A04/MF A01 CSCL 09B

The program requires the network parameters, the flow component parameters, the reservoir conditions, and the gas properties as input. It will then calculate all unknown pressures and the mass flow rate in each flow component in the network. The program can treat networks containing up to fifty flow components and twenty-five unknown network pressures. The types of flow components that can be treated are face seals, narrow slots, and pipes. The program is written in both structured FORTRAN (SFTRAN) and FORTRAN 4. The program must be run in an interactive (conversational) mode. Author

N78-20802*# Boeing Computer Services, Inc., Seattle, Wash. Energy Technology Applications Div.
A SIMULATION MODEL FOR WIND ENERGY STORAGE SYSTEMS. VOLUME 1: TECHNICAL REPORT Final Report
A. W. Warren, R. W. Edsinger, and Y. K. Chan Aug. 1977 101 p refs
(Contracts NAS3-20385; E(49-28)-1026)
(NASA-CR-135283; BCS-40180-1-Vol-1; CONS-038-5-1) Avail: NTIS HC A06/MF A01 CSCL 09B

A comprehensive computer program for the modeling of wind energy and storage systems utilizing any combination of five types of storage (pumped hydro, battery, thermal, flywheel and pneumatic) was developed. The level of detail of Simulation Model for Wind Energy Storage (SIMWEST) is consistent with a role of evaluating the economic feasibility as well as the general performance of wind energy systems. The software package consists of two basic programs and a library of system, environmental, and load components. The first program is a precompiler which generates computer models (in FORTRAN) of complex wind source storage application systems, from user specifications using the respective library components. The second program provides the techno-economic system analysis with the respective I/O, the integration of systems dynamics, and the iteration for conveyance of variables. SIMWEST program, as described, runs on the UNIVAC 1100 series computers. Author

N78-20803*# Boeing Computer Services, Inc., Seattle, Wash. Energy Technology Applications Div.

A SIMULATION MODEL FOR WIND ENERGY STORAGE SYSTEMS. VOLUME 2: OPERATION MANUAL Final Report

A. W. Warren, R. W. Edsinger, and J. D. Burroughs Aug. 1977 421 p refs 3 Vol.

(Contracts NAS3-20385; E(49-28)-1026)

(NASA-CR-135284; BCS-40180-2-Vol-2; CONS-0385-2) Avail: NTIS HC A18/MF A01 CSCL 09B

A comprehensive computer program (SIMWEST) developed for the modeling of wind energy/storage systems utilizing any combination of five types of storage (pumped hydro, battery, thermal, flywheel, and pneumatic) is described. Features of the program include: a precompiler which generates computer models (in FORTRAN) of complex wind source/storage/application systems, from user specifications using the respective library components; a program which provides the techno-economic system analysis with the respective I/O the integration of system dynamics, and the iteration for conveyance of variables; and capability to evaluate economic feasibility as well as general performance of wind energy systems. The SIMWEST operation manual is presented and the usage of the SIMWEST program and the design of the library components are described. A number of example simulations intended to familiarize the user with the program's operation is given along with a listing of each SIMWEST library subroutine. Author

N78-20804*# Boeing Computer Services, Inc., Seattle, Wash. Energy Technology Applications Div.

A SIMULATION MODEL FOR WIND ENERGY STORAGE SYSTEMS. VOLUME 3: PROGRAM DESCRIPTIONS Final Report

A. W. Warren, R. W. Edsinger, and J. D. Burroughs Aug. 1977 234 p 3 Vol.

(Contracts NAS3-20385; E(49-28)-1026)

(NASA-CR-135285; BCS-40180-3-Vol-3; CONS-0385-3) Avail: NTIS HC A11/MF A01 CSCL 09B

Program descriptions, flow charts, and program listings for the SIMWEST model generation program, the simulation program, the file maintenance program, and the printer plotter program are given. Author

63 CYBERNETICS

Includes feedback and control theory.
For related information see also *54 Man/System Technology and Life Support.*

A78-23909 * Solution of transient optimization problems by using an algorithm based on nonlinear programming. F. Teren (NASA, Lewis Research Center, Cleveland, Ohio). In: Joint Automatic Control Conference, San Francisco, Calif., June 22-24, 1977, Proceedings. Volume 2. (A78-23851 08-63) New York, Institute of Electrical and Electronics Engineers, Inc., 1977, p. 1549-1560. 11 refs.

A new algorithm is presented for solution of dynamic optimization problems which are nonlinear in the state variables and linear in the control variables. It is shown that the optimal control is bang-bang. A nominal bang-bang solution is found which satisfies the system equations and constraints, and influence functions are generated which check the optimality of the solution. Nonlinear optimization (gradient search) techniques are used to find the optimal solution. The algorithm is used to find a minimum time acceleration for a turbofan engine. (Author)

64 NUMERICAL ANALYSIS

Includes iteration, difference equations, and numerical approximation.

A78-16304 * Diagonal dominance using function minimization algorithms. G. G. Leininger (Toledo, University, Toledo, Ohio). In: Multivariable technological systems; International Symposium, 4th, Fredericton, New Brunswick, Canada, July 4-8, 1977, Preprints. (A78-16301 04-63) Oxford and New York, Pergamon Press, 1977, p. 106-112. 15 refs. Contract No. NAS3-17826; Grant No. NsG-3063.

A new approach to the design of multivariable control systems using the inverse Nyquist array method is proposed. The technique utilizes a conjugate direction function minimization algorithm to achieve dominance over a specified frequency range by minimizing the ratio of the moduli of the off-diagonal terms to the moduli of the diagonal term of the inverse open loop transfer function matrix. The technique is easily implemented in either a batch or interactive computer mode and will yield diagonalization when previously suggested methods fail. The proposed method has been successfully applied to design a control system for a sixteenth order state model of the F-100 turbofan engine with three inputs. (Author)

65 STATISTICS AND PROBABILITY

Includes data sampling and smoothing; Monte Carlo method; and stochastic processes.

N78-16726*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

CHAIN POOLING MODELING SELECTION AS DEVELOPED FOR THE STATISTICAL ANALYSIS OF A ROTOR BURST PROTECTION EXPERIMENT

Arthur G. Holms Dec 1977 60 p refs Presented at 137th Ann Meeting, of the Am Statist Assoc., Chicago, 15-18 Aug 1977

(NASA-TM-73874, E-9479) Avail NTIS HC A04/MF A01 CSCL 12A

As many as three iterated statistical model deletion procedures were considered for an experiment. Population model coefficients were chosen to simulate a saturated 2 to the 4th power experiment, having an unfavorable distribution of parameter values. Using random number studies, three model selection strategies were developed, namely, (1) a strategy to be used in anticipation of large coefficients of variation, approximately 65 percent, (2) a strategy to be sued in anticipation of small coefficients of variation, 4 percent or less, and (3) a security regret strategy to be used in the absence of such prior knowledge. Author

A78-28327 * # **'Chain pooling' model selection as developed for the statistical analysis of a rotor burst protection experiment.** A. G. Holms (NASA, Lewis Research Center, Cleveland, Ohio). *American Statistical Association, Annual Meeting, 137th, Chicago, Ill., Aug. 15-18, 1977, Paper.* 60 p. 18 refs.

A statistical decision procedure called chain pooling had been developed for model selection in fitting the results of a two-level fixed-effects full or fractional factorial experiment not having replication. The basic strategy included the use of one nominal level of significance for a preliminary test and a second nominal level of significance for the final test. The subject has been reexamined from the point of view of using as many as three successive statistical model deletion procedures in fitting the results of a single experiment. The investigation consisted of random number studies intended to simulate the results of a proposed aircraft turbine-engine rotor-burst-protection experiment. As a conservative approach, population model coefficients were chosen to represent a saturated 2 to the 4th power experiment with a distribution of parameter values unfavorable to the decision procedures. Three model selection strategies were developed. (Author)

66 SYSTEMS ANALYSIS

Includes mathematical modeling; network analysis; and operations research.

N78-30888*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PROCEDURES FOR GENERATION AND REDUCTION OF LINEAR MODELS OF A TURBOFAN ENGINE

Kurt Seldner and David S. Cwynar Aug. 1978 46 p refs (NASA-TP-1261; E-9460) Avail: NTIS HC A03/MF A01 CSCL 12B

A real time hybrid simulation of the Pratt & Whitney F100-PW-F100 turbofan engine was used for linear-model generation. The linear models were used to analyze the effect of disturbances about an operating point on the dynamic performance of the engine. A procedure that disturbs, samples, and records the state and control variables was developed. For large systems, such as the F100 engine, the state vector is large and may contain high-frequency information not required for control. This, reducing the full-state to a reduced-order model may be a practicable approach to simplifying the control design. A reduction technique was developed to generate reduced-order models. Selected linear and nonlinear output responses to exhaust-nozzle area and main-burner fuel flow disturbances are presented for comparison. Author

70 PHYSICS (GENERAL)

For geophysics see *46 Geophysics*. For astrophysics see *90 Astrophysics*. For solar physics see *92 Solar Physics*.

N78-13048*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
OPTICAL AND ELECTRICAL PROPERTIES OF ION BEAM TEXTURED KAPTON AND TEFLON
Michael J Mirtich and James S Sovey 1977 16 p refs Presented at 24th Natl Vacuum Symp., Boston, 8-11 Nov. 1977; sponsored by Am Vacuum Soc
(NASA-TM-73778, E-9329) Avail NTIS HC A02/MF A01 CSCL 11G

An electron bombardment argon ion source was used to ion etch polyimide (Kapton) and fluorinated ethylene, FEP (Teflon). Samples of polyimide and FEP were exposed to (0.5-1.0) keV Ar ions at ion current densities of (1.0-1/8) mA/sq cm for various exposure times. Changes in the optical and electrical properties of the samples were used to characterize the exposure. Spectral reflectance and transmittance measurements were made between 0.33 and 2.16 micron m using an integrating sphere after each exposure. From these measurements, values of solar absorptance were obtained. Total emittance measurements were also recorded for some samples. Surface resistivity was used to determine changes in the electrical conductivity of the etched samples. A scanning electron microscope recorded surface structure after exposure. Spectral optical data, resistivity measurements, calculated absorptance and emittance measurements are presented along with photomicrographs of the surface structure for the various exposures to Ar ions. Author

N78-32869*# Sunitech, Inc., Marcus Hook, Pa
STUDY OF DYNAMIC EMISSION SPECTRA FROM LUBRICANT FILMS IN AN ELASTOHYDRODYNAMIC CONTACT USING FOURIER TRANSFORM SPECTROSCOPY Final Report, 1 Jan. 1976 - 31 Dec. 1977
J. L. Lauer (Rensselaer Polytechnic Inst., Troy, N. Y.) 28 Aug. 1978 128 p refs
(Contract NAS3-19758)
(NASA-CR-159418) Avail NTIS HC A07/MF A01 CSCL 20K

Infrared emission spectra were obtained through a diamond window from lubricating fluids in an operating sliding elastohydrodynamic contact and analyzed by comparison with static absorption spectra under similar pressures. Different loads, shear rates and temperatures were used. Most of the spectra exhibited polarization characteristics, indicating directional alignment of the lubricant in the EHD contact. Among the fluids studied were a traction fluid, an advanced ester, and their mixtures, a synthetic paraffin, a naphthenic reference fluid (N-1) both neat and containing 1 percent of p-tricresyl phosphate as an anti-wear additive and a C-ether. Traction properties were found to be nearly proportional to mixture composition for traction fluid and ester mixtures. The anti-wear additive reduced traction and fluid temperature under low loads but increased them under higher loads, giving rise to formation of a friction polymer. GRA

71 ACOUSTICS

Includes sound generation, transmission, and attenuation. For noise pollution see *45 Environment Pollution*.

N78-13853*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NOISE OF DEFLECTORS USED FOR FLOW ATTACHMENT WITH STOL-OTW CONFIGURATIONS
U. vonGlahn and D. Groesbeck 1977 17 p refs Presented at 94th Meeting of Acoust. Soc. Am., Miami Beach, Fla., 13-16 Dec. 1977
(NASA-TM-73809; E-9392) Avail: NTIS HC A02/MF A01 CSCL 20A

Future STOL aircraft may utilize engine-over-the-wing installations in which the exhaust nozzles are located above and separated from the upper surface of the wing. An external jet flow deflector can be used with such installations to provide flow attachment to the wing/flap surfaces for lift augmentation. Deflector noise in the flyover plane measured with several model-scale nozzle/deflector/wing configurations is examined. The deflector-associated noise is correlated in terms of velocity and geometry parameters. The data also indicate that the effective overall sound pressure level of the deflector-associated noise peaks in the forward quadrant near 40 deg from the inlet axis. Author

N78-13854*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A PARAMETRIC INVESTIGATION OF AN EXISTING SUPERSONIC RELATIVE TIP SPEED PROPELLER NOISE MODEL
James H. Dittmar Nov. 1977 25 p refs
(NASA-TM-73816; E-9405) Avail: NTIS HC A02/MF A01 CSCL 20A

A high tip speed turboprop is being considered as a future energy conservative airplane. The high tip speed of the propeller combined with the cruise speed of the airplane may result in supersonic relative flow on the propeller tips. These supersonic blade sections could generate noise that is a cabin environment problem. An existing supersonic propeller noise model was parametrically investigated to identify and evaluate the noise reduction variables. Both independent and interdependent parameter variations (constant propeller thrust) were performed. The noise reductions indicated by the independent investigation varied from sizable in the case of reducing Mach number to minimal for adjusting the thickness and loading distributions. The noise reduction possibilities of decreasing relative Mach number were further investigated during the interdependent variations. The interdependent investigation indicated that significant noise reductions could be achieved by increasing the propeller diameter and/or increasing the number of propeller blades while maintaining a constant propeller thrust. Author

N78-13855*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FAR-FIELD MULTIMODAL ACOUSTIC RADIATION DIRECTIVITY
Arthur V. Saule and Edward J. Rice 1977 22 p refs Presented at 94th Meeting of the Acoustical Soc. of Am., Miami Beach, Fla., 12-16 Dec. 1977
(NASA-TM-73839; E-9426) Avail: NTIS HC A02/MF A01 CSCL 20A

Approximate equations for the far field acoustic radiation patterns in the forward quadrant from a flanged circular duct were compared with exact equations for both single and multimodal excitations. The single mode comparison showed good agreement between the exact and approximate equations for the principal lobes of higher radial order modes. For lower and especially for zero radial order modes, there was some error in the angular location and decibel level of principal lobe peak pressure obtained from the approximate equation. Some agreement of sidelobes was also observed although the approximate equation was not intended to simulate the sidelobes. The multimodal approximate summation equations consisting only of a simple function of directivity angle and an acoustic power biasing function were checked against the exact equations for several distributions of modal power and showed excellent agreement with exact equations for all cases. Although many modes contribute to the final level and shape of the directivity curve, the major contributions appear to come from the higher radial order modes. Author

N78-13856*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECTIVENESS OF AN INLET FLOW TURBULENCE CONTROL DEVICE TO SIMULATE FLIGHT NOISE FAN IN AN ANECHOIC CHAMBER
R. P. Woodward, J. A. Wazyniak, L. M. Shaw, and M. J. MacKinnon 1977 16 p refs Presented at the 94th Meeting of the Acoust. Soc. of Am., Miami, Fla., 13-16 Dec. 1977
(NASA-TM-73855; E-9444) Avail: NTIS HC A02/MF A01 CSCL 20A

A hemispherical inlet flow control device was tested on a 50.8 cm. (20-inch) diameter fan stage in the NASA-Lewis anechoic chamber. The control device used honeycomb and wire mesh to reduce turbulence intensities entering the fan. Far field acoustic power level results show about a 5 db reduction in blade passing tone and about 10 dB reduction in multiple pure tone sound power at 90% design fan speed with the inlet device in place. Hot film cross probes were inserted in the inlet to obtain data for two components of the turbulence at 65 and 90% design fan speed. Without the flow control device, the axial intensities were below 1.0%, while the circumferential intensities were almost twice this value. The inflow control device significantly reduced the circumferential turbulence intensities and also reduced the axial length scale. Author

N78-15852*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EBF NOISE SUPPRESSION AND AERODYNAMIC PENALTIES
D. J. Mckinzie, Jr. 1978 18 p refs Presented at the 16th Aerospace Sci. Meeting, Hunstville, Ala., 16-18 Jan. 1978; Sponsored by AIAA
(NASA-TM-73823; E-9412) Avail: NTIS CSCL 20A

Acoustic tests were conducted at model scale to determine the noise produced in the flyover and sideline planes at reduced separation distances between the nozzle exhaust plane and the flaps of an under-the-wing externally blown flap configuration in its approach attitude. Tests were also made to determine the noise suppression effectiveness of two types of passive devices which were located on the jet impingement surfaces of the configuration. In addition, static aerodynamic performance data were obtained to evaluate the penalties produced by these suppression devices. Author

N78-15853*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OPTIMUM WALL IMPEDANCE FOR SPINNING MODES: A CORRELATION WITH MODE CUT-OFF RATIO
Edward J. Rice 1978 17 p refs Presented at the 16th Aerospace Sci. Meeting, Hunstsville, Ala., 16-18 Jan. 1978; Sponsored by AIAA
(NASA-TM-73862; E-9451) Avail: NTIS HC A02/MF A01 CSCL 20A

A correlating equation relating the optimum acoustic impedance for the wall lining of a circular duct to the acoustic mode cut-off ratio, is presented. The optimum impedance was correlated with cut-off ratio because the cut-off ratio appears to be the fundamental parameter governing the propagation of sound in the duct. Modes with similar cut-off ratios respond in a similar way to the acoustic liner. The correlation is a semi-empirical expression developed from an empirical modification of an equation originally derived from sound propagation theory in a thin boundary layer. This correlating equation represents a part of a simplified liner design method, based upon modal cut-off ratio, for multimodal noise propagation. Author

N78-16766*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PROPAGATION OF SOUND WAVES THROUGH A LINEAR SHEAR LAYER: A CLOSED FORM SOLUTION

James N Scott 1978 16 p refs Presented at 16th Aerospace Sci. Meeting Huntsville, Ala., 16-18 Jan. 1978; sponsored by AIAA

(NASA-TM-73828, E-9203) Avail: NTIS HC A02/MF A01 CSCL 20A

Closed form solutions are presented for sound propagation from a line source in or near a shear layer. The analysis was exact for all frequencies and was developed assuming a linear velocity profile in the shear layer. This assumption allowed the solution to be expressed in terms of parabolic cyclinder functions. The solution is presented for a line monopole source first embedded in the uniform flow and then in the shear layer. Solutions are also discussed for certain types of dipole and quadrupole sources. Asymptotic expansions of the exact solutions for small and large values of Strouhal number gave expressions which correspond to solutions previously obtained for these limiting cases. Author

N78-22880*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

REDUCTION OF FAN NOISE IN AN ANECHOIC CHAMBER BY REDUCING CHAMBER WALL INDUCED INLET FLOW DISTURBANCES

J. H. Dittmar, M. J. Mackinnon, and R. P. Woodward 1978 20 p refs Presented at Acoust. Soc. Am. Meeting, Providence, R. I., 16-19 May 1978

(NASA-TM-78854; E-9580) Avail: NTIS HC A02/MF A01 CSCL 20A

The difference between the flight and ground static noise of turbofan engines presents a significant problem in engine noise testing. The additional noise for static testing has been attributed to inlet flow disturbances or turbulence interacting with the fan rotor. In an attempt to determine a possible source of inflow disturbances entering fans tested in the Lewis Research Center anechoic chamber, the inflow field was studied using potential flow analysis. These potential flow calculations indicated that there was substantial flow over the wall directly behind the fan inlet that could produce significant inflow disturbances. Fan noise tests were run with various extensions added to the fan inlet to move the inlet away from this backwall and thereby reduce the inlet flow disturbances. Significant noise reductions were observed with increased inlet length. Over 5 db reduction of the blade passage tone sound power level was observed between the shortest and longest inlets at 90% fan speed and the first overtone was reduced 9 db. High frequency broadband noise was also reduced. Author

N78-24897*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ACOUSTIC EVALUATION OF A NOVEL SWEPT-ROTOR FAN

James G. Lucas, Richard P. Woodward, and Michael J. Mackinnon 1978 24 p refs Proposed for Presentation at 11th Fluid and Plasma Dyn. Conf., Seattle, 10-12 Jul. 1978; sponsored by AIAA

(NASA-TM-78878; E-9612; AIAA-Paper-78-1121) Avail: NTIS HC A02/MF A01 CSCL 20A

Inlet noise and aerodynamic performance are presented for a high tip speed fan designed with rotor blade leading edge sweep that gives a subsonic component of inlet Mach number normal to the edge at all radii. The intent of the design was to minimize the generation of rotor leading edge shock waves thereby minimizing multiple pure tone noise. Sound power level and spectral comparisons are made with several high-speed fans of conventional design. Results show multiple pure tone noise at levels below those of some of the other fans and this noise was initiated at a higher tip speed. Aerodynamic performance of the fan did not meet design goals for this first build which applied conventional design procedures to the swept fan geometry. Author

N78-24898*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THREE-DIMENSIONAL EFFECTS ON PURE TONE FAN NOISE DUE TO INFLOW DISTORTION

Hiroshi Kobayashi 1978 26 p refs Proposed for presentation at the Eleventh Fluid and Plasma Dyn. Conf., Seattle, 10-12 Jul. 1978, sponsored by AIAA

(NASA-TM-78885; E-9618) Avail: NTIS HC A03/MF A01 CSCL 20A

Two dimensional, quasi three dimensional and three dimensional theories for the prediction of pure tone fan noise due to the interaction of inflow distortion with a subsonic annular blade row were studied with the aid of an unsteady three dimensional lifting surface theory. The effects of compact and noncompact source distributions on pure tone fan noise in an annular cascade were investigated. Numerical results show that the strip theory and quasi three-dimensional theory are reasonably adequate for fan noise prediction. The quasi three-dimensional method is more accurate for acoustic power and model structure prediction with an acoustic power estimation error of about plus or minus 2 db. Author

N78-28878*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

VARIATION OF FAN TONE STEADINESS FOR SEVERAL INFLOW CONDITIONS

J. R. Balombin Jul. 1978 19 p refs Presented at the 11th Fluid and Dyn. Conf., Seattle, 10-12 Jul. 1978; sponsored by AIAA

(NASA-TM-78886; E-9621; AIAA-Paper-78-1119) Avail: NTIS HC A02/MF A01 CSCL 20A

An amplitude probability density function analysis technique for quantifying the degree of fan noise tone steadiness has been applied to data from a fan tested under a variety of inflow conditions. The test conditions included typical static operation, inflow control by a honeycomb/screen device and forward velocity in a wind tunnel simulating flight. The ratio of mean square sinusoidal-to-random signal content in the fundamental and second harmonic tones was found to vary by more than an order-of-magnitude. Some implications of these results concerning the nature of fan noise generation mechanisms are discussed.

Author

N78-28888*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PRELIMINARY STUDY OF THE EFFECT OF THE TURBULENT FLOW FIELD AROUND COMPLEX SURFACES ON THEIR ACOUSTIC CHARACTERISTICS

W. A. Olsen and D. Boldman 1978 32 p refs Presented at the 11th Fluid and Plasma Dyn. Conf., Seattle, 10-12 Jul. 1978; sponsored by AIAA

(NASA-TM-78944; E-9691; AIAA-78-1123) Avail: NTIS HC A03/MF A01 CSCL 20A

Fundamental theories for noise generated by flow over surfaces exist for only a few simple configurations. The role of turbulence in noise generation by complex surfaces should be essentially the same as for simple configurations. Examination of simple surface theories indicates that the spatial distributions of the mean velocity and turbulence properties are sufficient to define the noise emission. Measurements of these flow properties were made for a number of simple and complex surfaces. The configurations were selected because of their acoustic characteristics are quite different. The spatial distribution of the turbulent flow properties around the complex surfaces and approximate theory are used to locate and describe the noise sources, and to qualitatively explain the varied acoustic characteristics. L.S.

N78-31871*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CORRELATION OF COMBUSTOR ACOUSTIC POWER LEVELS INFERRED FROM INTERNAL FLUCTUATING PRESSURE MEASUREMENTS

U. H. VonGlahn 1978 26 p refs Proposed for presentation at the 96th Meeting of the Acoust. Soc. of Am., Honolulu, Hawaii, 26 Nov. - 1 Dec. 1978

(NASA-TM-78986; E-9764) Avail: NTIS HC A03/MF A01 CSCL 20A

Combustion chamber acoustic power levels inferred from internal fluctuating pressure measurements are correlated with operating conditions and chamber geometries over a wide range. The variables include considerations of chamber design (can, annular, and reverse-flow annular) and size, number of fuel nozzles, burner staging and fuel split, airflow and heat release rates, and chamber inlet pressure and temperature levels. The correlated data include those obtained with combustion component development rigs as well as engines. Author

A78-20735 * # Optimum wall impedance for spinning modes - A correlation with mode cut-off ratio. E. J. Rice (NASA, Lewis Research Center, V-STOL and Noise Div., Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting 16th, Huntsville, Ala., Jan. 16-18, 1978, Paper 78-193.* 10 p. 18 refs.

A correlating equation relating the optimum acoustic impedance for the wall lining of a circular duct to the acoustic mode cut-off ratio is presented and compared to exact calculations. The optimum impedance was correlated with cut-off ratio because the cut-off ratio appears to be the fundamental parameter governing the propagation of sound in the duct. Modes with similar cut-off ratios respond in a similar way to the acoustic liner. The correlating equation is useful for the design of suppressors for aircraft engine inlets having a steady mean flow with a boundary layer and spinning mode noise source excitation. The correlation is a semi-empirical expression developed from an empirical modification of an equation originally derived from sound propagation theory in a thin boundary layer. Exact calculations of the optimum wall impedance were made over a wide range of frequency parameters, boundary layer thicknesses and flow Mach numbers to develop and verify the correlation. This correlating equation represents a part of a simplified liner design method, based upon modal cut-off ratio, for multimodal noise propagation.

(Author)

A78-20738 * # Propagation of sound waves through a linear shear layer - A closed form solution. J. N. Scott (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting 16th, Huntsville, Ala., Jan. 16-18, 1978, Paper 78-196.* 15 p. 19 refs

Closed form solutions are presented for sound propagation from a line source in or near a shear layer. The analysis is exact for all frequencies and is developed assuming a linear velocity profile in the shear layer. This assumption allows the solution to be expressed in terms of parabolic cylinder functions. The solution is presented for a line monopole source first embedded in the uniform flow and then in the shear layer. Solutions are also discussed for certain types of dipole and quadrupole sources. Asymptotic expansions of the exact solutions for small and large values of Strouhal number give expressions which correspond to solutions previously obtained for these limiting cases. (Author)

A78-20763 * # EBF noise suppression and aerodynamic penalties. L. J. McKinzie, Jr. (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 16th, Huntsville, Ala., Jan. 16-18, 1978, Paper 78-240.* 13 p. 15 refs.

Acoustic tests were conducted at model scale to determine the noise produced in the flyover and sideline planes at reduced separation distances between the nozzle exhaust plane and the flaps of an under-the-wing (UTW) externally blown flap (EBF) configuration in its approach attitude. Tests were also made to determine the noise suppression effectiveness of two types of passive devices which were located on the jet impingement surfaces of the configuration. In addition, static aerodynamic performance data were obtained to evaluate the penalties produced by these suppression devices. Broadband low frequency noise reductions were achieved by reducing the separation distance between the nozzle and flaps. However, mid and high frequency noise was produced which exceeded that of the reference configuration. Two passive noise suppression devices located on the flaps produced moderate to large noise reductions at reduced separation distances. Consideration of the static aerodynamic performance data obtained for the configurations tested suggests that specific broadband noise suppression characteristics may be obtained through a trade-off with aerodynamic performance penalties by the careful selection of suppression devices. (Author)

A78-24876 * # Far-field multimodal acoustic radiation directivity. A. V. Saule and E. J. Rice (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 94th, Miami Beach, Fla., Dec. 13-16, 1977, Paper.* 21 p. 8 refs.

A comparison is made between approximate equations for far-field acoustic radiation patterns and exact equations for single and multimodal excitations in order to determine the validity range for the approximate approach. It is found that for single-mode cases: (1) the gross behavior of the primary lobes is adequately described by the approximate equations, (2) some error is found for lower and zero radial order modes, and (3) some agreement is yielded between exact and approximate sidelobes, although the approximate equation was not intended to simulate sidelobes. Multimodal approximate equations are compared to exact equations for various distributions of modal power; for all cases excellent agreement is found. For multimodal patterns it is noted that many modes influence the final level and shape of the directivity curve, although the major contributions are from the higher radial order modes. S.C.S.

A78-31224 * # Sound production in a moving stream. A. P. Dowling, J. E. Ffowcs Williams (Cambridge University, Cambridge, England), and M. E. Goldstein (NASA, Lewis Research Center, Cleveland, Ohio). *Royal Society (London), Philosophical Transactions, Series A*, vol. 288, no. 1353, Mar. 23, 1978, p. 321-349. 26 refs.

Jet noise is modeled by particle-attached quadrupoles convected with the velocity of the actual fluid but positioned near a hypothetical instability-free vortex sheet. The strength of each quadrupole is Lighthill's stress tensor per unit mass. The work of Mani (1976) has shown that this type of model agrees well with experiment, and the present work establishes some of the equivalent sources needed for an exact analogy. The instability waves of the shear layer, as they grow into turbulence, are heard as sound that builds up as a precursor of the main turbulence-driven field. The circular compact jet is examined in some detail, and it is found that when the jet is very light it can provide a waveguide in which the

effects of source activity persist for some time but eventually leak out as sound. This interaction greatly distorts the free field characteristics of the turbulent sources, so that Reynolds-stress-induced waves have an intensity that scales with the fourth power of jet velocity. P.T.H.

A78-37681 * # Reduction of fan noise in an anechoic chamber by reducing chamber wall induced inlet flow disturbances. J. H. Dittmar, M. J. Mackinnon, and R. P. Woodward (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 95th, Providence, R.I., May 16-19, 1978, Paper.* 19 p. 11 refs.

The difference between the flight and ground static noise of turbofan engines has been identified as a significant problem in engine noise testing. The additional noise for static testing has been attributed to inlet flow disturbances or turbulence interacting with the fan rotor. In an attempt to determine a possible source of inflow disturbances entering fans tested in the Lewis Research Center anechoic chamber the inflow field was studied using potential flow analysis. These potential flow calculations indicated that there was substantial flow over the wall directly behind the fan inlet that could produce significant inflow disturbances. Fan noise tests were run with various extensions added to the fan inlet to move the inlet away from this backwall and thereby reduce the inlet flow disturbances. Significant noise reductions were observed with increased inlet length. Over 5 dB reduction of the blade passage tone sound power level was observed between the shortest and longest inlets at 90% fan speed and the first overtone was reduced 9 dB. High frequency broadband noise was also reduced. (Author)

A78-37682 * # Numerical spatial marching techniques for estimating duct attenuation and source pressure profiles. K. J. Baumeister (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 95th, Providence, R.I., May 16-19, 1978, Paper.* 37 p. 27 refs.

A numerical method is developed that could predict the pressure distribution of a ducted source from far-field pressure inputs. Using an initial value formulation, the two-dimensional homogeneous Helmholtz wave equation (no steady flow) is solved using explicit marching techniques. The Von Neumann method is used to develop relationships which describe how sound frequency and grid spacing effect numerical stability. At the present time, stability considerations limit the approach to high frequency sound. Sample calculations for both hard and soft wall ducts compare favorably to known boundary value solutions. In addition, assuming that reflections in the duct are small, this initial value approach is successfully used to determine the attenuation of a straight soft wall duct. Compared to conventional finite difference or finite element boundary value approaches, the numerical marching technique is orders of magnitude shorter in computation time and required computer storage and can be easily employed in problems involving high frequency sound. (Author)

A78-41829 * # Variation of fan tone steadiness for several inflow conditions. J. R. Balombin (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 11th, Seattle, Wash., July 10-12, 1978, Paper 78-1119.* 12 p. 11 refs.

An amplitude probability density function analysis technique for quantifying the degree of fan noise tone steadiness has been applied to data from a fan tested under a variety of inflow conditions. The test conditions included typical static operation, inflow control by a honeycomb screen device and forward velocity in a wind tunnel simulating flight. The ratio of mean square sinusoidal to random signal content in the fundamental and second harmonic tones was found to vary by more than an order of magnitude. Some implications of these results concerning the nature of fan noise generation mechanisms are discussed. (Author)

A78-41830 * # Three-dimensional effects on pure tone fan noise due to inflow distortion. H. Kobayashi (NASA, Lewis Research Center, Cleveland, Ohio; National Aerospace Laboratory, Tokyo, Japan). *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 11th, Seattle, Wash., July 10-12, 1978, Paper 78-1120.* 16 p. 18 refs.

A theoretical analysis of pure tone fan noise generated by inflow distortion rotor interaction is carried out with the aid of the three-dimensional unsteady lifting surface theory developed by Namba (1977, 1974). Particular attention is given to a study of the accuracy of available two-dimensional theory for the prediction of pure tone fan noise due to the interaction of inflow distortion with a subsonic annular blade row. The theoretical model considered consists of a single three-dimensional annular cascade rotating at constant angular velocity in an annular rigid-wall duct of infinite axial extent. Attention is given to the fluctuating pressure induced by a rotor blade row, the fluctuating velocity induced by it, an inflow distortion with only an axial velocity component, the determination of acoustic dipole distribution, the pure tone acoustic power, and two-dimensional theory and quasi-three-dimensional theory. G.R.

A78-41831 * # Acoustic evaluation of a novel swept-rotor fan. J. G. Lucas, R. P. Woodward, and M. J. MacKinnon (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 11th, Seattle, Wash., July 10-12, 1978, Paper 78-1121.* 13 p. 12 refs.

Inlet noise and aerodynamic performance are presented for a high tip speed fan designed with rotor blade leading edge sweep that gives a subsonic component of inlet Mach number normal to the edge at all radii. The intent of the design was to minimize the generation of rotor leading edge shock waves thereby minimizing multiple pure tone noise. Sound power level and spectral comparisons are made with several high-speed fans of conventional design. Results showed multiple pure tone noise at levels below those of some of the other fans and this noise was initiated at a higher tip speed. Aerodynamic performance of the fan did not meet design goals for this first build which applied conventional design procedures to the swept fan geometry. (Author)

A78-45129 * # Preliminary study of the effect of the turbulent flow field around complex surfaces on their acoustic characteristics. W. A. Olsen and D. Boldman (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 11th, Seattle, Wash., July 10-12, 1978, Paper 78-1123.* 32 p. 19 refs.

Fairly extensive measurements have been conducted of the turbulent flow around various surfaces as a basis for a study of the acoustic characteristics involved. In the experiments the flow from a nozzle was directed upon various two-dimensional surface configurations such as the three-flap model. A turbulent flow field description is given and an estimate of the acoustic characteristics is provided. The developed equations are based upon fundamental theories for simple configurations having simple flows. Qualitative estimates are obtained regarding the radiation pattern and the velocity power law. The effect of geometry and turbulent flow distribution on the acoustic emission from simple configurations are discussed. G.R.

N78-20920*# United Technologies Research Center, East Hartford, Conn.

A METHOD FOR CALCULATING EXTERNALLY BLOWN FLAP NOISE Final Report

Martin R Fink Mar 1978 130 p refs

(Contract NAS3-17863)

(NASA-CR-2954; R77-911739-17) Avail: NTIS HC A07/MF A01 CSCL 20A

Several basic noise components were described These components are: (1) compact lift dipoles associated with the wing and flaps, (2) trailing edge noise associated with the last trailing edge, and (3) quadrupole noise associated with the undeflected exhaust jet and the free jet located downstream of

the trailing edge. These noise components were combined to allow prediction of directivity and spectra for under the wing (UTW) slotted flaps with conventional or mixer nozzles, UTW slotless flaps, upper surface blowing (USB) slotless flaps, and engine in front of the wing slotted flaps. A digital computer program listing was given for this calculation method. Directivities and spectra calculated by this method were compared with free field data for UTW and USB configurations. The UTRC method best predicted the details of the measured noise emission, but the ANOP method best estimated the noise levels directly below these configurations. Author

N78-20921*# United Technologies Research Center, East Hartford, Conn.
A METHOD FOR CALCULATING STRUT AND SPLITTER PLATE NOISE IN EXIT DUCTS: THEORY AND VERIFICATION Final Report
Martin R. Fink Mar. 1978 81 p refs
(Contract NAS3-17863)
(NASA-CR-2955; R77-911739-18) Avail: NTIS HC A05/MF A01 CSCL 20A

Portions of a four-year analytical and experimental investigation relative to noise radiation from engine internal components in turbulent flow are summarized. Spectra measured for such airfoils over a range of chord, thickness ratio, flow velocity, and turbulence level were compared with predictions made by an available rigorous thin-airfoil analytical method. This analysis included the effects of flow compressibility and source noncompactness. Generally good agreement was obtained. This noise calculation method for isolated airfoils in turbulent flow was combined with a method for calculating transmission of sound through a subsonic exit duct and with an empirical far-field directivity shape. These three elements were checked separately and were individually shown to give close agreement with data. This combination provides a method for predicting engine internally generated aft-radiated noise from radial struts and stators, and annular splitter rings. Calculated sound power spectra, directivity, and acoustic pressure spectra were compared with the best available data. These data were for noise caused by a fan exit duct annular splitter ring, larger-chord stator blades, and turbine exit struts. Author

N78-25827*# Avco Lycoming Div., Stratford, Conn.
YF 102 IN-DUCT COMBUSTOR NOISE MEASUREMENT, VOLUME 1 Final Report, 24 Jul. 1976 - 31 Aug. 1977
Craig A. Wilson Nov. 1977 72 p refs 3 Vol.
(Contract NAS3-20052)
(NASA-CR-135404-Vol-1; LYC-77-56-Vol-1) Avail: NTIS HC A04/MF A01 CSCL 20A

The combustion chamber from a YF 102 gas turbine engine was instrumented with semi-infinite acoustic wave guide probes and installed in a test rig to complement the combustor noise test. These combustor rig tests are described and the recorded data are listed. Internal dynamic pressure level measurements were made at the same locations and at the same operating conditions of the NASA YF 102 test. In addition, the combustor was operated at various off-designed points where one parameter at a time was varied. Background noise recordings were made to determine the magnitude of facility or test rig noise present. Author

N78-25828*# Avco Lycoming Div., Stratford, Conn.
YF 102 IN-DUCT COMBUSTOR NOISE MEASUREMENT, VOLUME 2 Final Report, 24 Jul. 1976 - 31 Aug. 1977
Craig A. Wilson Nov. 1977 193 p 3 Vol.
(Contract NAS3-20052)
(NASA-CR-135404-Vol-2; LYC-77-56-Vol-2) Avail: NTIS HC A09/MF A01 CSCL 20A
For abstract, see N78-25827.

N78-25829*# Avco Lycoming Div., Stratford, Conn.
YF 102 IN-DUCT COMBUSTOR NOISE MEASUREMENT, VOLUME 3 Final Report
Craig A. Wilson Nov. 1977 194 p 3 Vol.
(Contract NAS3-20052)
(NASA-CR-135404-Vol-3; LYC-77-56-Vol-3) Avail: NTIS HC A09/MF A01 CSCL 20A
For abstract, see N78-25827.

N78-29867*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
FLIGHT EFFECTS ON THE AERODYNAMIC AND ACOUSTIC CHARACTERISTICS OF INVERTED PROFILE COANNULAR NOZZLES, VOLUME 1 Final Report
Hilary Kozlowski and Allan B. Packman Jun. 1978 174 p 3 Vol.
(Contract NAS3-17866)
(NASA-CR-135189-Vol-1; PWA-5509-Vol-1) Avail: NTIS HC A08/MF A01 CSCL 20A

Jet noise spectra obtained at static conditions from an acoustic wind tunnel and an outdoor facility are compared. Data curves are presented for (1) the effect of relative velocity on OASPL directivity (all configurations); (2) the effect of relative velocity on noise spectra (all configurations); (3) the effect of velocity on PNL directivity (coannular nozzle configurations); (4) nozzle exhaust plume velocity profiles; and (5) the effect of relative velocity on aerodynamic performance. A.R.H.

N78-29868*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
FLIGHT EFFECTS ON THE AERODYNAMIC AND ACOUSTIC CHARACTERISTICS OF INVERTED PROFILE COANNULAR NOZZLES, VOLUME 2 Final Report
Hilary Kozlowski and Allan B. Packman Jun. 1978 478 p 3 Vol.
(Contract NAS3-17866)
(NASA-CR-135189-Vol-2; PWA-5509-Vol-2) Avail: NTIS HC A21/MF A01 CSCL 20A

Data from the acoustic tests of the convergent reference nozzle and the 0.75 area ratio coannular nozzle are presented in tables. Data processing routines used to scale the acoustic data and to correct the data for atmospheric attenuation are included. A.R.H.

N78-29869*# Pratt and Whitney Aircraft Group, East Hartford, Conn. Commercial Products Div.
FLIGHT EFFECTS ON THE AERODYNAMIC AND ACOUSTIC CHARACTERISTICS OF INVERTED PROFILE COANNULAR NOZZLES, VOLUME 3 Final Report
Hilary Kozlowski and Allan B. Packman Jun. 1978 433 p 3 Vol.
(Contract NAS3-17866)
(NASA-CR-135189-Vol-3; PWA-5509-Vol-3) Avail: NTIS HC A19/MF A01 CSCL 20A

Acoustic data from tests of the 0.75 area ratio coannular nozzle with ejector and the 1.2 area ratio coannular are presented in tables. Aerodynamic data acquired for the four test configurations are included. A.R.H.

A78-41852 * # Calculation of far-field jet noise spectra from near-field measurements using true source location. K. K. Ahuja, B. J. Tester, and H. K. Tanna (Lockheed-Georgia Co., Marietta, Ga.). *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 11th, Seattle, Wash., July 10-12, 1978, Paper 78-1153.* 8 p. 10 refs. Contract No. NAS3-20050.

Jet mixing noise data at different measurement distances are compared with values calculated from the Lockheed prediction method. Although the method does not include any acoustic near-field effects, the measured and predicted results agree well where the measured data deviates from the inverse square law. It is therefore suggested that departures from the inverse square law are primarily the result of (1) the non-negligible distance between the nozzle exit plane and the true axial source location and (2) the jet mixing noise directionality, as modeled in the prediction method. Allowing for these effects, jet noise data at 8 and 96 diameters over a wide range of frequencies, angles and jet conditions are shown to collapse with reasonable accuracy. (Author)

72 ATOMIC AND MOLECULAR PHYSICS

Includes atomic structure and molecular spectra.

N78-19867*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ATOMIC HYDROGEN STORAGE METHOD AND APPARATUS Patent Application
John A. Woolam, inventor to (NASA) Filed 29 Sep. 1977 10 p
(NASA-Case-LEW-12081-2; US-Patent-Appl-SN-837794) Avail: NTIS HC A02/MF A01 CSCL 20H

Atomic hydrogen, for use as a fuel or as an explosive, is stored in the presence of a strong magnetic field in exfoliated layered compounds such as molybdenum disulfide or an elemental layer material such as graphite. The compound is maintained at liquid helium temperatures and the atomic hydrogen is collected on the surfaces of the layered compound which are exposed during delamination (exfoliation). The strong magnetic field and the low temperature combine to prevent the atoms of hydrogen from recombining to form molecules. NASA

A78-16069 * **Metastable states of small rare gas crystallites.** R. D. Etters (NASA, Lewis Research Center, Cleveland, Ohio; Amsterdam, Universiteit, Amsterdam, Netherlands; Colorado State University, Fort Collins, Colo.), R. Danilowicz (Utica College, Utica, N.Y.), and J. Kaelberer (TRW, Inc., Redondo Beach, Calif.). *Journal of Chemical Physics*, vol. 67, Nov. 1, 1977, p. 4145-4148. 15 refs. Grant No. NGR-06-002-159.

Metastable states of rare gas crystallites containing N atoms are investigated for N = 5,6,7, and 8. In particular, the stability, structures, structural transformation, and binding energy versus temperature are determined using a Monte Carlo method. The square pyramid isomer for N = 5 is found to be unstable at any finite temperature. The other metastable isomers are all found to make spontaneous transitions to the ground state if the temperature is greater than about one half that of meltings. Comparisons with previous work are also made. (Author)

N78-19883*# Colorado State Univ., Fort Collins. Dept. of Physics.
INDUSTRIAL ION SOURCE TECHNOLOGY Annual Report
Harold R. Kaufman Nov. 1977 161 p refs
(Grant NsG-3086)
(NASA-CR-135353) Avail: NTIS HC A08/MF A01 CSCL 20H

Plasma probe surveys were conducted in a 30-cm source to verify that the uniformity in the ion beam is the result of a corresponding uniformity in the discharge-chamber plasma. A 15 cm permanent magnet multipole ion source was designed, fabricated, and demonstrated. Procedures were investigated for texturing a variety of seed and surface materials for controlling secondary electron emission, increasing electron absorption of light, and improved attachment of biological tissue for medical implants using argon and tetrafluoromethane as the working gases. The cross section for argon-argon elastic collisions in the ion-beam energy range was calculated from interaction potentials and permits calculation of beam interaction effects that can determine system pumping requirements. The data also indicate that different optimizations of ion-beam machines will be advantageous for long and short runs, with 1 mA-hr/cm being the rough dividing line for run length. The capacity to simultaneously optimize components in an ion-beam machine for a single application, a capacity that is not evident in competitive approaches such as diode sputtering is emphasized. Author

N78-32838*# Pratt and Whitney Aircraft Group, East Hartford, Conn.
FLIGHT EFFECTS ON THE AERODYNAMIC AND ACOUSTIC CHARACTERISTICS OF INVERTED PROFILE COANNULAR NOZZLES Final Report
Hilary Kozlowski and Allan B. Packman Aug. 1978 197 p refs
(Contract NAS3-17866)
(NASA-CR-3018; PWA-5501) Avail: NTIS HC A09/MF A01 CSCL 20A

The effect of forward flight on the jet noise of coannular exhaust nozzles, suitable for Variable Stream Control Engines (VSCE), was investigated in a series of wind tunnel tests. The primary stream properties were maintained constant at 300 mps and 394 K. A total of 230 acoustic data points was obtained. Force measurement tests using an unheated air supply covered the same range of tunnel speeds and nozzle pressure ratios on each of the nozzle configurations. A total of 80 points was taken. The coannular nozzle OASPL and PNL noise reductions observed statically relative to synthesized values were basically retained under simulated flight conditions. The effect of fan to primary stream area ratio on flight effects was minor. At take-off speed, the peak jet noise for a VSCE was estimated to be over 6 PNdB lower than the static noise level. High static thrust coefficients were obtained for the basic coannular nozzles, with a decay of 0.75 percent at take-off speeds. L.S.

73 NUCLEAR AND HIGH-ENERGY PHYSICS

Includes elementary and nuclear particles; and reactor theory.

For space radiation see *93 Space Radiation.*

N78-17886*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

OPTIMIZE OUT-OF-CORE THERMIONIC ENERGY CONVERSION FOR NUCLEAR ELECTRIC PROPULSION

James F. Morris Sep. 1977 15 p refs Proposed for presentation at Intern. Conf. on Plasma Sci., Monterey, Calif., 15-17 May 1978; sponsored by IEEE

(NASA-TM-73892) Avail: NTIS HC A02/MF A01 CSCL 18E

Current designs for out of core thermionic energy conversion (TEC) to power nuclear electric propulsion (NEP) were evaluated. Approaches to improve out of core TEC are emphasized and probabilities for success are indicated. TEC gains are available with higher emitter temperatures and greater power densities. Good potentialities for accommodating external high temperature, high power density TEC with heat pipe cooled reactors exist.

Author

75 PLASMA PHYSICS

Includes magnetohydrodynamics and plasma fusion.
For ionospheric plasmas see *46 Geophysics*. For space plasmas see *90 Astrophysics*.

N78-10883*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INWARD TRANSPORT OF A TOROIDALLY CONFINED PLASMA SUBJECT TO STRONG RADIAL ELECTRIC FIELDS
J. Reece Roth, Walter M. Krawczonek, Edward J. Powers (Texas Univ., Austin), Jae Hong (Texas Univ., Austin), and Young Kim (Texas Univ., Austin) 1977 14 p refs Presented at Ann. Meeting of the Plasma Phys. Div. of the Am. Phys. Soc., Atlanta, 7-11 Nov. 1977
(NASA-TM-73800) Avail: NTIS HC A02/MF A01 CSCL 20I

Digitally implemented spectral analysis techniques were used to investigate the frequency-dependent fluctuation-induced particle transport across a toroidal magnetic field. When the electric field pointed radially inward, the transport was inward and a significant enhancement of the plasma density and confinement time resulted. Author

N78-10884*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A MODEL FOR PARTICLE CONFINEMENT IN A TOROIDAL PLASMA SUBJECT TO STRONG RADIAL ELECTRIC FIELDS
J. Reece Roth 1977 25 p refs Presented at Ann. Meeting of the Plasma Phys. Div. of the Am. Phys. Soc., Atlanta, 7-11 Nov. 1977
(NASA-TM-73814; E-9401) Avail: NTIS HC A02/MF A01 CSCL 20I

A toroidal plasma is confined and heated by the simultaneous application of strong d.c. magnetic fields and electric fields. Strong radial electric fields (about 1 kilovolt per centimeter) are imposed by biasing the plasma with up to 12 negative electrode rings which surround its minor circumference. The plasma containment is consistent with a balance of two processes: a radial infusion of ions in those sectors not containing electrode rings, resulting from the radially inward electric fields; and ion losses to the electrode rings, each of which acts as a sink and draws ions out the plasma in the manner of a Langmuir probe in the ion saturation regime. The highest density on axis which has been observed so far in this steady-state plasma is 6.2 x 10 to the 12th power particles per cubic centimeter, for which the particle containment time is 2.5 milliseconds. The deuterium ion kinetic temperature for these conditions was in the range of 360 to 520 eV. Author

N78-13880*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH-TEMPERATURE, HIGH-POWER-DENSITY THERMIONIC ENERGY CONVERSION FOR SPACE
James F. Morris 23 Nov. 1977 17 p refs
(NASA-TM-73844; E-9431) Avail: NTIS HC A02/MF A01 CSCL 20I

Theoretic converter outputs and efficiencies indicate the need to consider thermionic energy conversion (TEC) with greater power densities and higher temperatures within reasonable limits for space missions. Converter-output power density, voltage, and efficiency as functions of current density were determined for 1400-to-2000 K emitters with 725-to-1000 K collectors. The results encourage utilization of TEC with hotter-than-1650 K emitters and greater-than-6W sq cm outputs to attain better efficiencies, greater voltages, and higher waste-heat-rejection temperatures for multihundred-kilowatt space-power applications. For example, 1800 K, 30 A sq cm TEC operation for NEP compared with the 1650 K, 5 A/sq cm case should allow much lower radiation weights, substantially fewer and/or smaller emitter heat pipes, significantly reduced reactor and shield-related weights, many fewer converters and associated current-collecting bus bars, less power conditioning, and lower transmission losses. Integration of these effects should yield considerably reduced NEP specific weights. Author

N78-15905*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PROBE STUDIES IN A MODIFIED PENNING DISCHARGE
Chitra Sen 1976 15 p refs Presented at 18th Ann. Meeting on Plasma Phys., San Francisco, 14-18 Nov. 1976; Sponsored by Am. Phys. Soc.
(NASA-TM-X-73631; E-9128) Avail: NTIS HC A02/MF A01 CSCL 20I

The axial and radial floating potential distribution in a modified Penning discharge were studied at different values of the background pressure, discharge voltage, and magnetic field. An array of small disc probes arranged radially with their planes perpendicular to the magnetic field and movable along the axial direction was inserted in the plasma through one open end of the magnetic mirror system. Results show that depending on the operating conditions, the discharge can undergo different mode transitions in which the plasma can sustain different floating potentials in the radial as well as in the axial directions. Preliminary results of measurement, using RF probes in the modified Penning discharge plasma are also discussed. Author

N78-15936*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LOWER HYBRID EMISSION DIAGNOSTICS ON THE NASA LEWIS BUMPY TORUS
R. Mallavarpu 1977 14 p refs Presented at 19th Ann. Meeting of the Plasma Phys. Div. of the Am. Physical Soc., Atlanta, Ga., 7-11 Jul 1977
(NASA-TM-73858; E-9447) Avail: NTIS HC A02/MF A01 CSCL 20I

The feasibility of using RF emission near the lower hybrid frequency of the NASA Lewis Bumpy Torus plasma for diagnostic purposes is examined. The emission is detected using a spectrum analyzer and a 50 omega miniature coaxial antenna that is sensitive to the polarization of the incoming signal. The frequency shift of the lower hybrid emission peak is monitored as a function of the background pressure, electrode voltage, electrode ring configuration and the strength of the toroidal dc magnetic field. Simultaneous measurements of the average plasma density are made with a polarization diplexing microwave interferometer. Data derived from the experiment are discussed with reference to the following: (1) the strength of the dc magnetic field in the emitting region; (2) comparison of the lower hybrid plasma density with the average plasma density; and (3) validity of the cold plasma lower hybrid resonance formula in the high density operating regime of the bumpy torus plasma. Author

N78-20868*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
TEMPERATURE DISTRIBUTIONS OF A CESIUM-SEEDED HYDROGEN-OXYGEN SUPERSONIC FREE JET
Shih-Ying Wang and J. Martin Smith Feb. 1978 24 p refs (NASA-TP-1162; E-9267) Avail: NTIS HC A02/MF A01 CSCL 20I

The hydrogen-oxygen plasma was generated at combustion chamber pressures ranging from 0.5 to 2.0 megapascals and for various seed ratios (1 to 10 percent). The plasma was observed as the atmospheric exhaust from a Mach 2 rocket test facility. Transverse profiles of the absolute integrated intensity were measured with the optically thin CsI lines (0.5664 and 0.5636 microns) at a range of axial positions downstream of the 5-cm-diameter combustor nozzle exit. Radial profiles of the emission coefficient were obtained from the measured transverse profiles of intensity by Abel inversion. Temperatures were then determined from the emission coefficients for conditions of local thermodynamic equilibrium using particle densities generated by a two-dimensional free jet computer program. Temperature results show the inherent effects of compression and expansion pressure waves characteristic of a free jet exiting from a supersonic nozzle. Author

N78-23823*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

PARAMETRIC DEPENDENCE OF ION TEMPERATURE AND RELATIVE DENSITY IN THE NASA LEWIS SUMMA FACILITY

A. Snyder, M. R. Lauver, and R. W. Patch 1978 36 p refs Presented at 18th Ann. Meeting on Plasma Phys., San Francisco, 14-18 Nov. 1976; sponsored by Am. Phys. Soc.
(NASA-TM-73770; E-9563) Avail: NTIS HC A03/MF A01 CSCL 20I

Further hot-ion plasma experiments were conducted in the SUMMA superconducting magnetic mirror facility. A steady-state ExB plasma was formed by applying a strong radially inward dc electric field between cylindrical anodes and hollow cathodes located near the magnetic mirror maxima. Extending the use of water cooling to the hollow cathodes, in addition to the anodes, resulted in higher maximum power input to the plasma. Steady-state hydrogen plasmas with ion kinetic temperatures as high as 830 eV were produced. Functional relations were obtained empirically among the plasma current, voltage, magnetic flux density, ion temperature, and relative ion density. The functional relations were deduced by use of a multiple correlation analysis. Data were obtained for midplane magnetic fields from 0.5 to 3.37 tesla and input power up to 45 kW. Also, initial absolute electron density measurements are reported from a 90 deg Thomson scattering laser system. Author

N78-26826*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A FLUCTUATION-INDUCED PLASMA TRANSPORT DIAGNOSTIC BASED UPON FAST-FOURIER TRANSFORM SPECTRAL ANALYSIS

E. J. Powers (Texas Univ., Austin), Y. C. Kim (Texas Univ., Austin), J. Y. Hong (Texas Univ., Austin), J. R. Roth, and W. M. Krawczonek 1978 18 p refs Presented at the Intern. Conf. on Plasma Sci., Monterey, Calif., 15-18 May 1978; sponsored by IEEE
(NASA-TM-78932; E-9675) Avail: NTIS HC A02/MF A01 CSCL 20I

A diagnostic, based on fast Fourier-transform spectral analysis techniques, that provides experimental insight into the relationship between the experimentally observable spectral characteristics of the fluctuations and the fluctuation-induced plasma transport is described. The model upon which the diagnostic technique is based and its experimental implementation is discussed. Some characteristic results obtained during the course of an experimental study of fluctuation-induced transport in the electric field dominated NASA Lewis bumpy torus plasma are presented.
A.R.H.

N78-26827*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

FLUCTUATION SPECTRA IN THE NASA LEWIS BUMPY-TORUS PLASMA

Chandra M. Singh, Walter M. Krawczonek, J. Reece Roth, Jae Y. Hong, and Edward J. Powers Jun. 1978 31 p refs
(NASA-TP-1257; E-8696) Avail: NTIS HC A03/MF A01 CSCL 20I

The electrostatic potential fluctuation spectrum in the NASA Lewis bumpy-torus plasma was studied with capacitive probes in the low pressure (high impedance) mode and in the high pressure (low impedance) mode. Under different operating conditions, the plasma exhibited electrostatic potential fluctuations (1) at a set of discrete frequencies, (2) at a continuum of frequencies, and (3) as incoherent high-frequency turbulence. The frequencies and azimuthal wave numbers were determined from digitally implemented autopower and cross-power spectra. The azimuthal dispersion characteristics of the unstable waves were examined by varying the electrode voltage, the polarity of the voltage and the neutral background density at a constant magnetic field strength. Author

N78-27914*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

MICROWAVE RADIATION MEASUREMENTS NEAR THE ELECTRON PLASMA FREQUENCY OF THE NASA LEWIS BUMPY TORUS PLASMA

R. Mallavarpu and J. R. Roth 1978 21 p refs Presented at the meeting of the Plasma Phys. Div. of the Am. Phys. Soc., Colorado Springs, Colo., 30 Oct.-3 Nov. 1978
(NASA-TM-78940; E-9686) Avail: NTIS HC A02/MF A01 CSCL 20I

Microwave emission near the electron plasma frequency was observed, and its relation to the average electron density and the dc toroidal magnetic field was examined. The emission was detected using a spectrum analyzer and a 50 omega miniature coaxial probe. The radiation appeared as a broad amplitude peak that shifted in frequency as the plasma parameters were varied. The observed radiation scanned an average plasma density ranging from 10 million/cu cm to 8 hundred million/cu cm. A linear relation was observed betweeen the density calculated from the emission frequency and the average plasma density measured with a microwave interferometer. With the aid of a relative density profile measurement of the plasma, it was determined that the emissions occurred from the outer periphery of the plasma.
A.R.H.

N78-30944*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LOW-FREQUENCY FLUCTUATION SPECTRA AND ASSOCIATED PARTICLE TRANSPORT IN THE NASA LEWIS BUMPY-TORUS PLASMA

Chandra M. Singh, Walter M. Krawczonek, J. Reece Roth, Jae Y. Hong (Texas Univ., Austin), Young C. Kim (Texas Univ., Austin), and Edward J. Powers (Texas Univ., Austin) Aug. 1978 53 p refs
(NASA-TP-1258; E-9565) Avail: NTIS HC A04/MF A01 CSCL 20I

The strong radial electric field associated with the Penning discharge and the strong toroidal magnetic field give rise to a diversity of E/B phenomena, such as rotating waves and spokes, which in turn manifest themselves as space-time fluctuations of the plasma density and potential. Work is done to further understand the nature and origin of the fluctuations and their connection with fluctuation-induced transport. The approach is to monitor the density and potential fluctuations, to digitize the data, and to generate, with the aid of a computer, various spectral properties by means of the fast fourier transform. Of particular interest is the computer-generated transport spectrum that indicates in a quantitative way which fluctuation spectral components contribute to transport and which do not. All experimental measurements of the spectral characteristics of the plasma are given in absolute units rather than as relative values. Preliminary measurements of the transport spectrum of the ion population are given, and it is shown that the fluctuation induced transport is in order-of-magnitude agreement with that inferred from the steady state current flowing to the electrodes that generate the plasma.
L.S.

A78-24890* # Inward transport of a toroidally confined plasma subject to strong radial electric fields. J. R. Roth, W. M. Krawczonek (NASA, Lewis Research Center, Cleveland, Ohio), E. J. Powers, J. Hong, and Y. Kim (Texas, University, Austin, Tex.). *American Physical Society, Annual Meeting, Atlanta, Ga., Nov. 7-11, 1977, Paper.* 13 p. 11 refs.

The paper aims at showing that the density and confinement time of a toroidal plasma can be enhanced by radial electric fields far stronger than the ambipolar values, and that, if such electric fields point into the plasma, radially inward transport can result. The investigation deals with low-frequency fluctuation induced transport using digitally implemented spectral analysis techniques and with the role of strong applied radial electric fields and weak vertical magnetic fields on plasma density and particle confinement times in a Bumpy Torus geometry. Results indicate that application of sufficiently strong radially inward electric fields results in radially inward fluctuation-induced transport into the toroidal electrostatic potential well; this inward transport gives rise to higher average electron densities and longer particle confinement times in the toroidal plasma.
S.D.

A78-24891 * # A model for particle confinement in a toroidal plasma subject to strong radial electric fields. J. R. Roth (NASA, Lewis Research Center, Cleveland, Ohio). *American Physical Society, Annual Meeting, Atlanta, Ga., Nov. 7-11, 1977, Paper.* 24 p. 21 refs.

The approach adopted in the NASA Lewis Bumpy Torus experiment is to confine and heat a toroidal plasma by the simultaneous application of strong dc magnetic fields and electric fields. Strong radial electric fields (about 1 kV/cm) are imposed by biasing the plasma with up to 12 negative electrode rings which surround its minor circumference. The plasma containment is consistent with a balance of two processes: a radial infusion of ions in those sectors not containing electrode rings, resulting from the radially inward electric fields; and ion losses to the electrode rings, each of which acts as a sink and draws ions out the plasma in the manner of a Langmuir probe in the ion saturation regime. The highest density on axis which has been observed so far in this steady-state plasma is 6.2 trillion particles per cu cm, for which the particle containment time is 2.5 msec. The deuterium ion kinetic temperature for these conditions was in the range of 360 to 520 eV. (Author)

A78-24904 * # Probe studies in a modified Penning discharge. C. Sen (NASA, Lewis Research Center, Cleveland, Ohio). *American Physical Society, Annual Meeting on Plasma Physics, 18th, San Francisco, Calif., Nov. 14-18, 1976, Paper.* 14 p. 16 refs.

The axial and radial floating potential distribution in a modified Penning discharge have been studied at different values of the background pressure, discharge voltage, and magnetic field. An array of small disc probes arranged radially with their planes perpendicular to the magnetic field and movable along the axial direction was inserted in the plasma through one open end of the magnetic mirror system. Results show that depending on the operating conditions, the discharge can undergo different mode transitions in which the plasma can sustain different floating potentials in the radial as well as in the axial directions. Preliminary results of measurement, using RF probes in the modified Penning discharge plasma are also discussed. (Author)

A78-29332 * # Lower hybrid emission diagnostics on the NASA Lewis Bumpy Torus. R. Mallavarpu (NASA, Lewis Research Center, Cleveland, Ohio). *American Physical Society, Annual Meeting, 19th, Atlanta, Ga., July 7-11, 1977, Paper.* 13 p.

The feasibility of using RF emission near the lower-hybrid frequency of the NASA Lewis Bumpy Torus plasma for diagnostic purposes is examined. The emission is detected using a spectrum analyzer and a 50-ohm miniature coaxial antenna that is sensitive to the polarization of the incoming signal. The frequency shift of the lower-hybrid emission peak is monitored as a function of the background pressure, electrode voltage, electrode ring configuration, and the strength of the toroidal dc magnetic field. Simultaneous measurements of the average plasma density are made with a polarization diplexing microwave interferometer. The experimental results extend previous work to include negative electrode voltages and plasma densities up to 1 trillion per cu cm. The information derived from the experiment is discussed with reference to: (1) the strength of the dc magnetic field in the emitting region, (2) a comparison of the lower-hybrid plasma density with the average plasma density, and (3) the validity of the cold-plasma lower-hybrid resonance formula in the high-density operating regime of the bumpy-torus plasma. (Author)

A78-34631 * Preliminary results on the conversion of laser energy into electricity. R. W. Thompson, E. J. Manista, and D. L. Alger (NASA, Lewis Research Center, Cleveland, Ohio). *Applied Physics Letters*, vol. 32, May 15, 1978, p. 610, 611. 11 refs.

A preliminary experiment was performed to investigate conversion of 10.6 micron laser energy to electrical energy via a laser-sustained argon plasma. Short-circuit currents of 0.7 A were measured between a thoriated-tungsten emitter and collector electrodes immersed in the laser-sustained argon plasma. Open-circuit voltages of about 1.5 V were inferred from the current-voltage load characteristics. The dominant mechanism of laser energy conversion is uncertain at this time. Much higher output powers appear possible. (Author)

A78-36966 * Effects of applied dc radial electric fields on particle transport in a bumpy torus plasma. J. R. Roth (NASA, Lewis Research Center, Cleveland, Ohio). *IEEE Transactions on Plasma Science*, vol. PS-6, June 1978, p. 158-165. 22 refs.

The influence of applied dc radial electric fields on particle transport in a bumpy torus plasma is studied. The plasma, magnetic field, and ion heating mechanism are operated in steady state. Ion kinetic temperature is more than a factor of ten higher than electron temperature. The electric fields raise the ions to energies on the order of kilovolts and then point radially inward or outward. Plasma number density profiles are flat or triangular across the plasma diameter. It is suggested that the radial transport processes are nondiffusional and dominated by strong radial electric fields. These characteristics are caused by the absence of a second derivative in the density profile and the flat electron temperature profiles. If the electric field acting on the minor radius of the toroidal plasma points inward, plasma number density and confinement time are increased. S.C.S.

A78-37679 * # Parametric dependence of ion temperature and relative density in the NASA Lewis SUMMA facility. A. Snyder, M. R. Lauver, and R. W. Patch (NASA, Lewis Research Center, Cleveland, Ohio). *American Physical Society, Annual Meeting on Plasma Physics, 18th, San Francisco, Calif., Nov. 14-18, 1976, Paper.* 35 p. 18 refs.

Further hot-ion plasma experiments were conducted in the SUMMA superconducting magnetic mirror facility. A steady-state plasma with mutually perpendicular magnetic and electric fields was formed by applying a strong radially inward dc electric field between cylindrical anodes and hollow cathodes located near the magnetic mirror maxima. Extending the use of water cooling to the hollow cathodes, in addition to the anodes, resulted in higher maximum power input to the plasma. Steady-state hydrogen plasmas with ion kinetic temperatures as high as 830 eV were produced. Functional relations were obtained empirically among the plasma current, voltage, magnetic flux density, ion temperature, and relative ion density. The functional relations were deduced by use of a multiple correlation analysis. Data were obtained for midplane magnetic fields from 0.5 to 3.37 tesla and input power up to 45 kW. Also, initial absolute electron density measurements are reported from a 90 deg Thomson scattering laser system. (Author)

A78-39835 * A hollow cathode hydrogen ion source. J. S. Sovey and M. J. Mirtich (NASA, Lewis Research Center, Cleveland, Ohio). In: Symposium on Engineering Problems of Fusion Research, 7th, Knoxville, Tenn., October 25-28, 1977, Proceedings. Volume 1. (A78-39783 17-75) Piscataway, N.J., Institute of Electrical and Electronics Engineers, Inc., 1977, p. 315-321. 18 refs.

High current density ion sources have been used to heat plasmas in controlled thermonuclear reaction experiments. High beam currents imply relatively high emission currents from cathodes which have generally taken the form of tungsten filaments. This paper describes a hydrogen ion source which was primarily developed to assess the emission current capability and design requirements for hollow cathodes for application in neutral injection devices. The hydrogen source produced ions by electron bombardment via a single hollow cathode. Source design followed mercury ion thruster technology, using a weak magnetic field to enhance ionization efficiency. A 1.3-cm-diam hollow cathode using a low work function material dispenser performed satisfactorily over a discharge current range of 10-90 A. Cylindrical probe measurements taken without ion extraction indicate maximum ion number densities on the order of 10 trillion/cu cm. Discharge durations ranged from 30 sec to

continuous operation. Tests with beam extraction at 2.5 keV and 30 A discharge current yield average ion beam current densities of 0.1 A/sq cm over a 5-cm extraction diameter. Results of this study can be used to supply the baseline information needed to scale hollow cathodes for operation at discharge currents of hundreds of amperes using distributed cathodes. (Author)

A78-46189 * Model for interpreting Doppler broadened optical line emission measurements on axially symmetric plasma. G. W. Englert, R. W. Patch, and J. J. Reinmann (NASA, Lewis Research Center, Cleveland, Ohio). *Plasma Physics*, vol. 20, May 1978, p. 451-473. 19 refs.

A plasma model, previously developed to interpret neutral-particle analyzer measurements on E x B heating devices, is adapted to analyze Doppler broadened charge-exchange neutral lines measured by an optical monochromator. Comparison of theoretical with experimental results indicates that azimuthal drift as well as cyclotron motion are quite influential in determining line shapes and widths, and thus important in temperature determination, even when the monochromator line of sight is intersecting the plasma axis of symmetry. At this central sighting position, however, results are quite insensitive to radial ion density distribution when time lag between the charge-exchange-excitation events and emission is neglected. Line shapes and widths obtained by sighting across chords of plasma at various distances from the plasma axis of symmetry indicate a strong dependence on time lag. (Author)

A78-52146 * Alternative approaches to plasma confinement. J. R. Roth (NASA, Lewis Research Center, Cleveland, Ohio). *IEEE Transactions on Plasma Science*, vol. PS-6, Sept. 1978, p. 270-295. 78 refs.

The paper discusses 20 plasma confinement schemes each representing an alternative to the tokamak fusion reactor. Attention is given to (1) tokamak like devices (TORMAC, Topolotron, and the Extrap concept), (2) stellarator like devices (Torsatron and twisted coil stellarators), (3) mirror machines (Astron and reversed field devices, the 2XII B experiment, laser heated solenoids, the LITE experiment, the Kaktus-Surmac concept), (4) bumpy tori (hot electron bumpy torus, toroidal minimum B configurations), (5) electrostatically assisted confinement (electrostatically stuffed cusps and mirrors, electrostatically assisted toroidal confinement), (6) the Migma concept, and (7) wall confined plasmas. The plasma parameters of the devices are presented and the advantages and disadvantages of each are listed. S.C.S.

A78-33143 * Design and calculated performance and cost of the ECAS Phase II open cycle MHD power generation system. L. P. Harris (General Electric Co., Schenectady, N.Y.). *American Society of Mechanical Engineers, Winter Annual Meeting, Atlanta, Ga., Nov. 27-Dec. 2, 1977, Paper 77-WA/Ener-5*. 12 p. Members, $1.50; nonmembers, $3.00. ERDA-NSF-sponsored research; Contract No. NAS3-19406.

A 2000 MWe MHD/steam plant for central station applications has been designed and costed as part of the Energy Conversion Alternatives Study (ECAS). This plant is fueled by Illinois No. 6 coal, rejects heat through mechanical draft wet cooling towers, and includes coal processing equipment, seed reprocessing, electrical inversion of the MHD generator output and emission controls to current EPA standards. It yields an estimated overall efficiency of 0.483 (7066 Btu/kWe-hr), a capital cost of $718 per kWe (1975 dollars), and a cost of electricity at 65% capacity factor of 32 mills per kWe-hr. If the assumed life and reliability could be achieved with these performance parameters, the MHD system should prove attractive. (Author)

76 SOLID-STATE PHYSICS

Includes superconductivity.

For related information see also *33 Electronics and Electrical Engineering* and *36 Lasers and Masers.*

N78-13016*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

CRYSTAL FIELD AND MAGNETIC PROPERTIES

D J Flood 1977 12 p refs Presented at 23d Ann Conf. on Magnetism and Magnetic Materials, Minneapolis, Minn., 8-11 Nov 1977; sponsored by Am. Inst. of Physics and IEEE (NASA-TM-73837; E-9330) Avail: NTIS HC A02/MF A01 CSCL 20B

Magnetization and magnetic susceptibility measurements have been made in the temperature range 1.3 to 4.2 K on powdered samples of ErH3. The susceptibility exhibits Curie-Weiss behavior from 4.2 to 2 K, and intercepts the negative temperature axis at theta = 1.05 + or - 0.05 K, indicating that the material is antiferromagnetic. The low field effective moment is 6.77 + or - 0.27 Bohr magnetons per ion. The magnetization exhibits a temperature independent contribution, the slope of which is (5 + or - 1.2) x 10 to the -6th Weber m/kg Tesla. The saturation moment is 3.84 + or - 0.15 Bohr magnetons per ion. The results can be qualitatively explained by the effects of crystal fields on the magnetic ions. No definitive assignment of a crystal field ground state can be given, nor can a clear choice between cubically or hexagonally symmetric crystal fields be made. For hexagonal symmetry, the first excited state is estimated to be 86 to 100 K above the ground state. For cubic symmetry, the splitting is on the order of 160 to 180 K. Author

A78-14423 * **Upper limit for magnetoresistance in silicon bronze and phosphor bronze wire.** R. Feldman, L. Talley, M. Rojeski, T. Vold (Oberlin College, Oberlin, Ohio), and J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio). *Cryogenics*, vol. 17, Jan. 1977, p. 31, 32. 10 refs.

The electrical resistivity of silicon bronze and phosphor bronze was measured in magnetic fields from 0 to 14 T and at temperatures between 2 and 300 K. At any fixed temperature, the change in resistivity to 14 T was less than a few parts in 100,000. Thus, these bronzes are excellent for use in high magnetic fields where constant resistance is required. Welding leads to the sample was found to be superior to soldering. The soldered contacts were subject to spurious resistivity changes that resulted from superconducting transitions in the solder. (Author)

A78-24907 * # **Crystal field and magnetic properties of ErH3.** D. J. Flood (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Physics and Institute of Electrical and Electronics Engineers, Annual Conference on Magnetism and Magnetic Materials, 23rd, Minneapolis, Minn., Nov. 8-11, 1977, Paper.* 11 p. 6 refs.

Magnetization and magnetic susceptibility measurements have been made in the temperature range 1.3 to 4.2 K on powdered samples of ErH3. The susceptibility exhibits Curie-Weiss behavior from 4.2 to 2 K, and intercepts the negative temperature axis at 1.05 + or - 0.05 K, indicating that the material is antiferromagnetic. The low field effective moment is 6.77 + or - 0.27 Bohr magnetons per ion. The magnetization exhibits a temperature independent contribution, the slope of which is (5 + or - 1.2) times 10 to the minus 6 Weber m/kg Tesla. The saturation moment is 3.84 + or - 0.15 Bohr magnetons per ion. The results can be qualitatively explained by the effects of crystal fields on the magnetic ions. No definitive assignment of a crystal field ground state can be given, nor can a clear choice between cubically or hexagonally symmetric crystal fields be made. For hexagonal symmetry, the first excited state is estimated to be 86 to 100 K above the ground state. For cubic symmetry, the splitting is of the order of 160 to 180 K. (Author)

A78-27727 * **Physics and chemistry of MoS2 intercalation compounds.** J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio) and R. B. Somoano (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). *Materials Science and Engineering*, vol. 31, Dec. 1977, p. 289-295. 27 refs.

An investigation is made of the physics and chemistry of MoS2 intercalation compounds. These compounds may be separated into two groups according to their stoichiometry, structure and superconducting properties. The first group consists of Na, Ca, and Sr intercalates, and the second group consists of K, Rb, and Cs intercalates. Particular attention is given to the structure of the electronic energy band and to the normal state and superconducting properties of these compounds. S.C.S.

A78-45368 * **Critical currents in sputtered PbMo6S8.** S. A. Alterovitz, J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio), L. Kammerdiner, and H.-L. Luo (California, University, La Jolla, Calif.). *Applied Physics Letters*, vol. 33, Aug. 1, 1978, p. 264-266. 12 refs. NSF-supported research.

Critical currents in sputtered Chevrel-phase lead molybdenum sulfide have been measured at several temperatures as a function of applied magnetic field up to 19 T. A critical current density of approximately 50 million A/sq m was obtained at 15 T and 1.8 K, and the effective upper critical field was estimated to be 30 T. The pinning force at low fields was found to be dependent on the amount of free lead. (Author)

A78-45500 * **Critical currents and scaling laws in sputtered copper molybdenum sulfide.** S. A. Alterovitz, J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio), L. Kammerdiner, and H. L. Luo (California, University, La Jolla, Calif.). *Journal of Low Temperature Physics*, vol. 30, no. 5-6, 1978, p. 797-812. 25 refs. Grant No. NsG-3103.

A78-53626 * **Upper critical field of copper molybdenum sulfide.** S. A. Alterovitz and J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio). *Solid-State Communications*, vol. 25, no. 2, 1978, p. 141-144. 18 refs.

The upper critical field of sintered and sputtered copper molybdenum sulfide Cu(x)Mo6S8 was measured and found to exceed the Werthamer, Helfand, and Hohenberg (1966) value for a type II superconductor characterized by dirty limit, weak isotropic electron-phonon coupling, and no paramagnetic limiting. It is suggested that the enhancement results from anisotropy or clean limit or both. Other ternary molybdenum sulfides appear to show similar anomalies. M.L.

A78-41922 * # **Superconducting Nb3Ge for high field magnets.** A. I. Braginski, M. R. Daniel, C. W. Roland (Westinghouse Research and Development Center, Pittsburgh, Pa.), and J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio). *Institute of Electrical and Electronics Engineers, International Magnetics Conference, Florence, Italy, May 9-12, 1978, Paper.* 3 p. 15 refs. Contracts No. F44620-74-C-0042; No. NAS3-20233

Superconducting Nb3Ge tape conductors 5 to 10 m long were fabricated by chemical vapor deposition. Such tapes could be used in high field magnet applications. Average tape properties set the upper performance limit of a magnet at 17 teslas (4.2 K). Highest critical current densities obtained in thin and layered films set the upper performance limit at 20 teslas (4.2 K). (Author)

81 ADMINISTRATION AND MANAGEMENT

Includes management planning and research.

N78-13038*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE MINE PROJECT: MINORITY INVOLVEMENT IN NASA ENGINEERING
Harrison Allen, Jr. 1977 8 p Presented at 48th Ann. Meeting of the Natl. Technical Assoc., Inc., Hampton, Va., 2-5 Aug. 1977
(NASA-TM-73811; E-9397) Avail: NTIS HC A02/MF A01 CSCL 05A

The Mine Project developed by Lewis Research Center (LRC) along with Tennessee State University and Tuskegee Institute, is described. The project calls for LRC to assemble on-going NASA university affairs programs aimed at benefiting the school, its faculty, and its student body. The schools receive grants to pursue research and technology projects that are relevant to NASA's missions. Upon request from the universities, LRC furnishes instructors and lecturers. The schools have use of surplus government equipment and access to NASA research facilities for certain projects. Both the faculty and students of the universities are eligible for summer employment at LRC through special programs. The MINE Project is designed to establish a continuing active relationship of 3 to 5 years between NASA and the universities, and will afford LRC with an opportunity to increase its recruitment of minority and women employees.
Author

82 DOCUMENTATION AND INFORMATION SCIENCE

Includes information storage and retrieval technology; micrography; and library science.

For computer documentation see *61 Computer Programming and Software.*

N78-17821* + National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

BIBLIOGRAPHY OF LEWIS RESEARCH CENTER TECHNICAL CONTRIBUTIONS ANNOUNCED IN 1976

Dec. 1977 192 p

(NASA-TM-73860; E-9449) Avail: NTIS HC A09 CSCL 05B

Abstracts of Lewis authored publications and publications resulting from Lewis managed contracts which were announced in the 1976 issues of STAR (Scientific and Technical Aerospace Reports) and IAA (International Aerospace Abstracts) are presented. Research reports, journal articles, conference presentations, patents and patent applications, and theses are included. The arrangement is by NASA subject category. Citations indicate report literature (identified by their N-numbers) and the journal and conference presentations (identified by their A-numbers). A grouping of indexes helps locate specific publications by author (including contractor authors), contractor organization, contract number, and report number. Author

N78-28986*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

BIBLIOGRAPHY OF LEWIS RESEARCH CENTER TECHNICAL PUBLICATIONS ANNOUNCED IN 1977

Washington May 1978 348 p

(NASA-TM-78918; E-9449-2) Avail: NTIS HC A15/MF A01 CSCL 05B

This compilation of abstracts describes and indexes over 780 technical reports resulting from the scientific and engineering work performed and managed by the Lewis Research Center in 1977. All the publications were announced in the 1977 issues of STAR (Scientific and Technical Aerospace Reports) and/or IAA (International Aerospace Abstracts). Documents cited include research reports, journal articles, conference presentations, patents and patent applications, and theses. A.R.H.

85 URBAN TECHNOLOGY AND TRANSPORTATION

Includes applications of space technology to urban problems; technology transfer; technology assessment; and surface and mass transportation.

For related information see *03 Air Transportation and Safety, 16 Space Transportation,* and *44 Energy Production and Conversion.*

N78-16828*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BASELINE TESTS OF THE C. H. WATERMAN RENAULT 5 ELECTRIC PASSENGER VEHICLE
Noel B. Sargent, Edward F. McBrien, and Ralph Slavik Oct. 1977 58 p refs
(Contract EC-77-A-31-1011)
(NASA-TM-73759; E-9434; CONS/1011-4) Avail: NTIS HC A04/MF A01 CSCL 13F

The Waterman vehicle, a four passenger Renault 5 GTL, performance test results are presented and characterized the state-of-the-art of electric vehicles. It was powered by sixteen 6-volt traction batteries through a two-step contactor controller actuated by a foot throttle to change the voltage applied to the 6.7 -kilowatt motor. The motor output shaft was connected to a front-wheel-drive transaxle that contains a four-speed manual transmission and clutch. The braking system was a conventional hydraulic braking system. Author

N78-17933*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BASELINE TESTS OF THE AM GENERAL DJ-5E ELECTRUCK ELECTRIC DELIVERY VAN
Miles O. Dustin, Henry B. Tryon, and Noel B. Sargent Oct. 1977 45 p refs
(Contract EC-77-A-31-1011)
(NASA-TM-73758; E-9383; CONS/1011-3) Avail: NTIS HC A03/MF A01 CSCL 13F

An electric quarter ton truck designed for use as a postal delivery vehicle was tested to characterize the state of the art of electric vehicles. Vehicle performance test results are presented. It is powered by a single-module, 54 volt industrial battery through a silicon controlled rectifier continuously adjustable controller with regenerative braking applied to a direct current compound wound motor. Author

N78-17934*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BASELINE TESTS OF THE ZAGATO ELCAR ELECTRIC PASSENGER VEHICLE
Noel B. Sargent, Edward A. Maslowski, Ralph J. Slavick, and Richard F. Soltis Oct. 1977 36 p refs
(Contract EC-77-A-31-1011)
(NASA-TM-73764; CONS/1011-9; E-9442) Avail: NTIS HC A03/MF A01 CSCL 13F

The Elcar vehicle performance test results are presented. The Elcar Model 2000 is a two passenger vehicle with a reinforced fiberglass body. It is powered by eight 12-volt batteries. The batteries are connected to the motor through an arrangement of contactors operated from a foot pedal in conjunction with a hand-operated switch. These contactors change the voltage applied to the 2-kilowatt motor. Acceleration tests, operating characteristics, and instrumentation are described. Author

N78-17935*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PHOTOVOLTAIC HIGHWAY APPLICATIONS: ASSESSMENT OF THE NEAR-TERM MARKET
Louis Rosenblum, Larry R. Scudder, William J. Bifano, and William A. Poley Dec. 1977 12 p ref
(Contract E(49-26)-1022)
(NASA-TM-73863; DOE/NASA/1022-77/22; E-9452) Avail: NTIS HC A02/MF A01 CSCL 05B

A preliminary assessment of the near-term market for photovoltaic highway applications is presented. Among the potential users, two market sectors are considered: government and commercial. Within these sectors, two possible application areas, signs and motorist aids, are discussed. Based on judgemental information, obtained by a brief survey of representatives of the two user sectors, the government sector appears more amenable to the introduction of photovoltaic power sources for highway applications in the near-term. However, considerable interest and potential opportunities were also found to exist in the commercial sector. Further studies to quantify the market for highway applications appear warranted. Author

N78-17936*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BASELINE TESTS OF THE POWER-TRAIN ELECTRIC DELIVERY VAN
Stacy Lumannick, Miles O. Dustin, and John M. Bozek Nov. 1977 60 p
(Contract EC-77-A-31-1011)
(NASA-TM-73765; E-9470; CONS/1011-10) Avail: NTIS HC A04/MF A01 CSCL 13F

Vehicle maximum speed, range at constant speed, range over stop-and-go driving schedules, maximum acceleration, gradeability, gradeability limit, road energy consumption, road power, indicated energy consumption, braking capability, battery charger efficiency, and battery characteristics were determined for a modified utility van powered by sixteen 6-volt batteries connected in series. A chopper controller actuated by a foot accelerator pedal changes the voltage applied to the 22- kilowatt (30-hp) series-wound drive motor. In addition to the conventional hydraulic braking system, the vehicle has hydraulic regenerative braking. Cycle tests and acceleration tests were conducted with and without hydraulic regeneration. Author

N78-17937*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TEST AND EVALUATION OF 23 ELECTRIC VEHICLES FOR STATE-OF-THE-ART ASSESSMENT
Miles O. Dustin and Robert J. Denington 3 Mar. 1978 24 p refs Presented at the 1978 SAE Congr., Detroit, Mich., 27 Feb. - 3 Mar. 1978
(Contract EC-77-A-31-1011)
(NASA-TM-73850; E-9438; CONS/1011-21) Avail: NTIS HC A02/MF A01 CSCL 13F

Eleven of the electric vehicles were passenger cars and 12 were commercial vans. Tests were conducted in accordance with an ERDS test procedure which is based on the SAE J227a Test Procedure. Tests included range, acceleration, coast-down, and braking. The results of the tests are presented, and comments on reliability are made. Author

N78-17938*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BASELINE TESTS OF THE EVA CHANGE-OF-PACE COUPE ELECTRIC PASSENGER VEHICLE
John M. Bozek, Edward A. Maslowski, and Miles O. Dustin Nov. 1977 53 p refs
(Contract EC-77-A-31-1011)
(NASA-TM-73763; E-9469; CONS/1011-8) Avail: NTIS HC A04/MF A01 CSCL 13F

The EVA Change-of-Pace Coupe, is an electric passenger vehicle, to characterize the state-of-the-art of electric vehicles. The EVA Change-of-Pace Coupe is a four passenger sedan that has been coverted to an electric vehicle. It is powered by twenty 6 volt traction batteries through a silicon controlled rectifier chopper controller actuated by a foot throttle to change the voltage applied to the series wound, direct current motor. Braking is accomplished with a vacuum assist hydraulic braking system. Regenerative braking is also provided. Author

N78-17939*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BASELINE TESTS OF THE EVA CONTRACTOR ELECTRIC PASSENGER VEHICLE
John M. Bozek, Henry B. Tryon, and Ralph J. Slavick Nov. 1977 57 p refs
(Contract EC-77-A-31-1011)
(NASA-TM-73762; E-9481; CONS/1011-7) Avail: NTIS HC A04/MF A01 CSCL 13F

The EVA Contactor four door sedan, an electric passenger vehicle, was tested to characterize the state-of-the-art of electric vehicles. It is a four passenger sedan that was converted to an electric vehicle. It is powered by 16 series connected 6 volt electric vehicle batteries through a four step contactor controller actuated by a foot accelerator pedal. The controller changes the voltage applied to a separately excited DC motor. The braking system is a vacuum assisted hydraulic braking system. Regenerative braking is provided. Author

N78-17940*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BASELINE TESTS OF THE BATTRONIC MIDIVAN ELECTRIC DELIVERY VAN
Miles O. Dustin, Richard F. Soltis, John M. Bozek, and Edward A. Maslowski Dec. 1977 52 p refs
(Contract EC-77-A-31-1011)
(NASA-TM-73781; E-9483; CONS/1011-6) Avail: NTIS HC A04/MF A01 CSCL 13F

An electric passenger vehicle was tested to develop data characterizing the state of the art of electric and hybrid vehicles. The test measured vehicle maximum speed, range at constant speed, range over stop-and-go driving schedules, maximum acceleration, gradeability and limit, road energy consumption, road power, indicated energy consumption, braking capability and battery charge efficiency. The data obtained are to serve as a baseline to compare improvements in electric and hybrid vehicle technologies and to assist in establishing performance standards. G.Y.

N78-17941*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MAKING AEROSPACE TECHNOLOGY WORK FOR THE AUTOMOTIVE INDUSTRY, INTRODUCTION
Walter T. Olson 1978 11 p Presented at the 1978 Congr. and Exposition of the Soc. of Automotive Engr., Detroit, 27 Feb. - 3 Mar. 1978
(NASA-TM-73870) Avail: NTIS HC A02/MF A01 CSCL 05A

NASA derived technology already in use in the automotive industry include: (1) developments in electronics design, computer systems, and quality control methods for line testing of cars and trucks; (2) a combustion analysis computer program for automotive engine research and development; (3) an infrared scanner and television display for analyzing tire design and performance, and for studying the effects of heat on the service life of V-belts, shock mounts, brakes, and rubber bearings; (4) exhaust gas analyzers for trouble shooting and emissions certification; (5) a device for reducing noise from trucks; and (6) a low cost test vehicle for measuring highway skid resistance. Services offered by NASA to facilitate access to its technology are described. Author

N78-17942*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BASELINE TESTS OF THE C. H. WATERMAN DAF ELECTRIC PASSENGER VEHICLE
Noel B. Sargent, Edward A. Maslowski, Richard F. Soltis, and Richard M. Schuh Oct 1977 113 p
(Contract EC-77-A-31-1011)
(NASA-TM-73757; CONS/1011-2; E-9388) Avail: NTIS HC A06/MF A01 CSCL 13F

An electric vehicle was tested as part of an Energy Research Development Administration (ERDA) project to characterize the state-of-the-art of electric vehicles. The Waterman vehicle performance test results are presented in this report. The vehicle is a converted four-passenger DAF 46 sedan. It is powered by sixteen 6-volt traction batteries through a three-step contactor controller actuated by a foot throttle to change the voltage applied to the 6.7 kW motor. The braking system is a conventional hydraulic braking system. Author

N78-18088*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STATE-OF-THE-ART ASSESSMENT OF ELECTRIC VEHICLES AND HYBRID VEHICLES
Sep. 1977 596 p refs
(Contract EC-77-A-31-1011)
(NASA-TM-73756; CONS/1011-1; E-9308) Avail: NTIS HC A25/MF A01 CSCL 13F

The Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976 (PL 94-413) requires that data be developed to characterize the state of the art of vehicles powered by an electric motor and those propelled by a combination of an electric motor and an internal combustion engine or other power sources. Data obtained from controlled tests of a representative number of sample vehicles, from information supplied by manufacturers or contained in the literature, and from surveys of fleet operators of individual owners of electric vehicles is discussed. The results of track and dynamometer tests conducted by NASA on 22 electric, 2 hybrid, and 5 conventional vehicles, as well as on 5 spark-ignition-engine-powered vehicles, the conventional counterparts of 5 of the vehicles, are presented. Author

N78-20021*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BASELINE TESTS OF THE VOLKSWAGEN TRANSPORTER ELECTRIC DELIVERY VAN
Richard F. Soltis, Edward McBrien, John M. Bozek, and Francis Gourash Jan. 1978 56 p refs
(Contract EC-77-A-31-1011)
(NASA-TM-73766; CONS/1011-11; E-9506) Avail: NTIS HC A04/MF A01 CSCL 13F

The Volkswagen Transporter, an electric delivery van, was tested as part of an Energy Research and Development Administration (ERDA) project to characterize the state of the art of electric vehicles. The Volkswagen Transporter is a standard Volkswagen van that has been converted to an electric vehicle. It is powered by a 144-volt traction battery. A direct current (dc) chopper controller, actuated by a conventional accelerator pedal, regulates the voltage or power applied to the 16-kilowatt (21-hp) motor. The braking system uses conventional hydraulic braking in combination with an electric regenerative braking system. The Volkswagen vehicle performance test results are presented. Author

N78-20022*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE OF CONVENTIONALLY POWERED VEHICLES TESTED TO AN ELECTRIC VEHICLE TEST PROCEDURE
Ralph J. Slavik, Miles O. Dustin, and Stacy Lumennick Dec. 1977 62 p refs
(Contract EC-77-A-31-1011)
(NASA-TM-73768; E-9482; CONS/1011-13) Avail: NTIS HC A04/MF A01 CSCL 13F

A conventional Volkswagen transporter, a Renault 5, a Pacer, and a U. S. Postal Service general DJ-5 delivery van were treated to an electric vehicle test procedure in order to allow direct comparison of conventional and electric vehicles. Performance test results for the four vehicles are presented. Author

N78-20022*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RESPONSE OF LEAD-ACID BATTERIES TO CHOPPER-CONTROLLED DISCHARGE: PRELIMINARY RESULTS
Robert L. Cataldo Feb. 1978 9 p refs
(Contract EC-77-31-1044)
(NASA-TM-73834; CONS/1044-1; E-9421) Avail: NTIS HC A02/MF A01 CSCL 10C

The preliminary results of simulated electric vehicle, chopper, speed controller discharge of a battery show energy output losses up to 25 percent compared to constant current discharges at the same average discharge current of 100 amperes. These energy losses are manifested as temperature rises during discharge, amounting to a two-fold increase for a 400-ampere pulse compared to the constant current case. Because of the potentially large energy inefficiency, the results suggest that electric vehicle battery/speed controller interaction must be carefully considered in vehicle design. Author

N78-21010*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
BASELINE TESTS OF THE EPC HUMMINGBIRD ELECTRIC PASSENGER VEHICLE
Ralph J. Slavik, Edward A. Maslowski, Noel B. Sargent, and Arthur Birchenough Dec. 1977 46 p Prepared for DOE
(Contract EC-77-A-31-1011)
(NASA-TM-73760; E-9485; CONS-1011-5) Avail: NTIS HC A03/MF A01 CSCL 13F

The rear-mounted internal combustion engine in a four-passenger Volkswagen Thing was replaced with an electric motor made by modifying an aircraft generator and powered by 12 heavy-duty, lead-acid battery modules. Vehicle performance tests were conducted to measure vehicle maximum speed, range at constant speed, range over stop-and-go driving schedules, maximum acceleration, gradeability limit, road energy consumption, road power, indicated energy consumption, braking capability, battery charger efficiency, and battery characteristics. Test results are presented in tables and charts. Author

N78-25010*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RESPONSE OF LEAD-ACID BATTERIES TO CHOPPER-CONTROLLED DISCHARGE
Robert L. Cataldo [1978] 11 p refs Proposed for presentation at the 13th Intersoc. Energy Conversion Eng. Conf., San Diego, Calif., 20-25 Aug. 1978 Revised
(Contract EC-77-A-31-1044)
(NASA-TM-73834-Rev. E-9421; CONS/1044-1) Avail: NTIS HC A02/MF A01 CSCL 13F

The preliminary results of simulated electric vehicle, chopper, speed controller discharge of a battery show energy output losses at up to 25 percent compared to constant current discharges at the same average discharge current of 100 A. These energy losses are manifested as temperature rises during discharge, amounting to a two-fold increase for a 400-A pulse compared to the constant current case. Because of the potentially large energy inefficiency, the results suggest that electric vehicle battery/speed controller interaction must be carefully considered in vehicle design. Author

N78-26995*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN INVERTER/CONTROLLER SUBSYSTEM OPTIMIZED FOR PHOTOVOLTAIC APPLICATIONS
Roy Pickrell, George OSullivan (Abacus Controls, Inc., Somerville, N. J.), and Walter C. Merrill 1978 11 p refs Presented at 13th Photovoltaic Specialists Conf., Washington, D.C., 5-8 Jun. 1978; sponsored by IEEE
(Contract E(49-26)-1022)
(NASA-TM-78903; DOE/NASA/1022-78/31; E-9639) Avail: NTIS HC A02/MF A01 CSCL 13F

Conversion of solar array dc power to ac power stimulated the specification, design, and simulation testing of an inverter/controller subsystem tailored to the photovoltaic power source characteristics. Optimization of the inverter/controller design is discussed as part of an overall photovoltaic power system designed for maximum energy extraction from the solar array. The special

N78-26998*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A CYCLE TIMER FOR TESTING ELECTRIC VEHICLES
Richard F. Soltis 1978 11 p Proposed for presentation at the 5th Intern. Elec. Vehicle Symp., Philadelphia, 2-5 Oct. 1978; sponsored by the Elec. Vehicle Council
(Contract EC-77-A-31-1011)
(NASA-TM-78934; E-9677; DOE/NASA/1011-78/27) Avail: NTIS HC A02/MF A01 CSCL 13F

A cycle timer was developed to assist the driver of an electric vehicle in more accurately following and repeating SAE driving schedules. These schedules require operating an electric vehicle in a selected stop-and-go driving cycle and repeating this cycle pattern until the vehicle ceases to meet the requirements of the cycle. The heart of the system is a programmable read-only memory (PROM) that has the required test profiles permanently recorded on plug-in cards, one card for each different driving schedule. The PROM generates a direct current analog signal that drives a speedometer displayed on one scale of a dual movement meter. The second scale of the dual movement meter displays the actual speed of the vehicle as recorded by the fifth wheel. The vehicle operator controls vehicle speed to match the desired profile speed. The PROM controls the recycle start time as well as the buzzer activation. The cycle programmer is powered by the test vehicle's 12-volt accessory battery, through a 5-volt regulator and a 12-volt dc-to-dc converter. Author

N78-27003*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STATE-OF-THE-ART ASSESSMENT OF ELECTRIC AND HYBRID VEHICLES
Jan. 1978 596 p refs
(Contract EX-76-A-31-1011)
(NASA-TM-79509; HCP/M1011-01) Avail: NTIS HC A25/MF A01 CSCL 13F

Data are presented that were obtained from the electric and hybrid vehicles tested, information collected from users of electric vehicles, and data and information on electric and hybrid vehicles obtained on a worldwide basis from manufacturers and available literature. The data given include: (1) information and data base (electric and hybrid vehicle systems descriptions, sources of vehicle data and information, and sources of component data); (2) electric vehicles (theoretical background, electric vehicle track tests, user experience, literature data, and summary of electric vehicle status); (3) electric vehicle components (tires, differentials, transmissions, traction motors, controllers, batteries, battery chargers, and component summary); and (4) hybrid vehicles (types of hybrid vehicles, operating modes, hybrid vehicles components, and hybrid vehicles performance characteristics). ERA

N78-29004*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A STIRLING ENGINE COMPUTER MODEL FOR PERFORMANCE CALCULATIONS Final Report
Roy Tew, Kent Jefferies, and David Miao Jul. 1978 102 p refs
(Contract EC-77-A-31-1011)
(NASA-TM-78884; DOE/NASA/1011-78/24; E-9613) Avail: NTIS HC A06/MF A01 CSCL 10B

To support the development of the Stirling engine as a possible alternative to the automobile spark-ignition engine, the thermodynamic characteristics of the Stirling engine were analyzed and modeled on a computer. The modeling techniques used are presented. The performance of an existing rhombic-drive Stirling engine was simulated by use of this computer program, and some typical results are presented. Engine tests are planned in order to evaluate this model. Author

A78-33359 * Making aerospace technology work for the automotive industry - Introduction. W. T. Olson (NASA, Lewis Research Center, Cleveland, Ohio). *Society of Automotive Engineers, Congress and Exposition, Detroit, Mich., Feb. 27-Mar. 3, 1978, Paper.* 10 p.

In many cases it has been found that advances made in one technical field can contribute to other fields. An investigation is in this connection conducted concerning subjects from contemporary NASA programs and projects which might have relevance and potential usefulness to the automotive industry. Examples regarding aerospace developments which have been utilized by the automotive industry are related to electronic design, computer systems, quality control experience, a NASA combustion scanner and television display, exhaust gas analyzers, and a device for suppressing noise propagated through ducts. Projects undertaken by NASA's center for propulsion and power research are examined with respect to their value for the automotive industry. As a result of some of these projects, a gas turbine engine and a Stirling engine might each become a possible alternative to the conventional spark ignition engine. G.R.

A78-33382 * Test and evaluation of 23 electric vehicles for state-of-the-art assessment. M. O. Dustin and R. J. Denington (NASA, Lewis Research Center, Cleveland, Ohio). *Society of Automotive Engineers, Congress and Exposition, Detroit, Mich., Feb. 27-Mar. 3, 1978, Paper 780290.* 12 p. 18 refs.

Data developed by ERDA used to evaluate the performance parameters of modern electric vehicles is presented with reference to range, acceleration, coast-down, and braking. Eight of the tested vehicles had some type of regenerative braking system, which provided range increases from 1 to 31 percent. In comparison with conventional vehicles, performance was found to be lower, and reliability poorer. Energy consumption was the same, but electric power is less damaging to the environment than hydrocarbon fuels, and does not use up an increasingly scarce resource. D.M.W.

N78-22970*# Ford Motor Co., Dearborn, Mich.
AUTOMOTIVE STIRLING ENGINE DEVELOPMENT PROGRAM Quarterly Technical Progress Report, Oct. 1977 - Dec. 1977
Ernest W. Kitzner Jan. 1978 98 p Sponsored in part by NASA
(Contract EC-77-C-02-4396)
(NASA-CR-135331; CONS/4396-1; QTPR-1) Avail: NTIS HC A05/MF A01 CSCL 13F

The Ford/DOE automotive Stirling engine development program is directed towards establishing the technological and developmental base that would enable a decision on whether an engineering program should be directed at Stirling engine production. The fuel economy assessment aims to achieve, with a high degree of confidence, the ERDA proposal estimate of 20.6 MPG (gasoline) for a 4500 lb IWC Stirling engine passenger car. The current M-H fuel economy projection for the 170 HP Stirling engine is 15.7 MPG. The confidence level for this projection is 32%. A confidence level of 29% is projected for a 22.1 MPG estimate. If all of the planned analyses and test work is accomplished at the end of the one year effort, and the projected improvements are substantiated, the confidence levels would rise to 59% for the 20.6 MPG projection and 54% for the 22.1 MPG projection. Progress achieved thus far during the fuel economy assessment is discussed. Author

N78-23999*# Joint Center for Graduate Study, Richland, Wash.
STIRLING ENGINE DESIGN MANUAL Final Report
William R. Martini Apr. 1978 389 p refs
(Grant NsG-3152; Contract EC-77-A-31-1011)
(NASA-CR-135382; DOE/NASA/3152-78/1) Avail: NTIS HC A16/MF A01 CSCL 21G

This manual is intended to serve both as an introduction to Stirling engine analysis methods and as a key to the open literature on Stirling engines. Over 800 references are listed and these are cross referenced by date of publication, author and subject. Engine analysis is treated starting from elementary principles and working through cycles analysis. Analysis methodologies are classified as first, second or third order depending upon degree of complexity and probable application; first order for preliminary engine studies, second order for performance prediction and engine optimization, and third order for detailed hardware evaluation and engine research. A few comparisons between theory and experiment are made. A second order design procedure is documented step by step with calculation sheets and a worked out example to follow. Current high power engines are briefly described and a directory of companies and individuals who are active in Stirling engine development is included. Much remains to be done. Some of the more complicated and potentially very useful design procedures are now only referred to. Future support will enable a more thorough job of comparing all available design procedures against experimental data which should soon be available. Author

N78-25988*# Ford Motor Co., Dearborn, Mich.
CERAMIC REGENERATOR SYSTEMS DEVELOPMENT PROGRAM Progress Report, 1 Oct. 1976 - 30 Sep. 1977
J. A. Cook, C. A. Fucinari, J. N. Lingscheit, and C. J. Rahnke Dec. 1977 129 p refs Prepared for DOE
(Contract DEN-3-8)
(NASA-CR-135330; CONS/0008-1) Avail: NTIS HC A07/MF A01 CSCL 13F

Ceramic regenerator cores are considered that can be used in passenger car gas turbine engines, Stirling engines, and industrial/truck gas turbine engines. Improved materials and design concepts aimed at reducing or eliminating chemical attack were placed on durability test in Ford 707 industrial gas turbine engines. The results of 19,600 hours of turbine engine durability testing are described. Two materials, aluminum silicate and magnesium aluminum silicate, continue to show promise toward achieving the durability objectives of this program. A regenerator core made from aluminum silicate showed minimal evidence of chemical attack damage after 6935 hours of engine test at 800 C and another showed little distress after 3510 hours at 982 C. Results obtained in ceramic material screening tests, aerothermodynamic performance tests, stress analysis, cost studies, and material specifications are also included. Author

N78-26897*# Ford Motor Co., Dearborn, Mich.
CERAMIC REGENERATOR SYSTEMS DEVELOPMENT PROGRAM Progress Report, 1 Jan. - 31 Mar. 1978
J. A. Cook, C. A. Fucinari, J. N. Lingscheit, C. J. Rahnke, and V. D. Rao May 1978 108 p refs
(Contracts DEN3-8; EC-77-A-31-1040)
(NASA-CR-135430; CONS-0008-3) Avail: NTIS HC A06/MF A01 CSCL 11C

Ceramic regenerator cores are considered that can be used in passenger car gas turbine engines, Stirling engines, and industrial/truck gas turbine engines. Improved materials and design concepts aimed at reducing or eliminating chemical attack were placed on durability tests/in industrial gas turbine engines. A regenerator core made from aluminum silicate shows minimal evidence of chemical attack damage after 7804 hours of engine test at 800 C and another showed little distress after 4983 hours at 982 C. The results obtained in ceramic material screening tests, aerothermodynamic performance tests, stress analysis, cost studies, and material specifications are also included. G.G.

N78-29882*# Booz-Allen and Hamilton, Inc., Cleveland, Ohio. Design and Development Div.

PRELIMINARY POWER TRAIN DESIGN FOR A STATE-OF-THE-ART ELECTRIC VEHICLE Final Report

Phillip Mighdoll and William F. Hahn Apr. 1978 144 p refs (Contracts NAS3-20595; EC-77-A-31-1044)

(NASA-CR-135341; DOE/NASA/0595-78/1) Avail: NTIS HC A07/MF A01 CSCL 13F

Power train designs which can be implemented within the current state-of-the-art were identified by means of a review of existing electric vehicles and suitable off-the-shelf components. The affect of various motor/transmission combinations on vehicle range over the SAE J227a schedule D cycle was evaluated. The selected, state-of-the-art power train employs a dc series wound motor, SCR controller, variable speed transmission, regenerative braking, drum brakes and radial ply tires. Vehicle range over the SAE cycle can be extended by approximately 20% by the further development of separately excited, shunt wound DC motors and electrical controllers. Approaches which could improve overall power train efficiency, such as AC motor systems, are identified. However, future emphasis should remain on batteries, tires and lightweight structures if substantial range improvements are to be achieved. Author

88 SPACE SCIENCES (GENERAL)

N78-32014*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SPACECRAFT CHARGING CONTROL BY THERMAL FIELD EMISSION WITH LANTHANUM-HEXABORIDE EMITTERS

James F. Morris Aug. 1978 26 p refs

(NASA-TM-78990; E-9773) Avail: NTIS HC A03/MF A01 CSCL 22B

Thermal, field emitters of lanthanum (or perhaps cerium) hexaboride (LaB_6) with temperature variability up to about 1500 K are suggested for spacecraft charging control. Such emitters operate at much lower voltages with considerably more control and add plasma-diagnostic versatility. These gains should outweigh the additional complexity of providing heat for the LaB_6 thermal, field emitter. LS.

92 SOLAR PHYSICS

Includes solar activity, solar flares, solar radiation and sunspots.

N78-26028*# National Aeronautics and Space Administration. Lewis Research Center Cleveland, Ohio.

EVALUATION OF MODELS TO PREDICT INSOLATION ON TILTED SURFACES

Thomas M. Klucher Mar. 1978 30 p refs

(Contract E(49-26)-1022)

(NASA-TM-78842; E-9556) Avail: NTIS HC A03/MF A01 CSCL 10A

An empirical study was performed to evaluate the validity of various insolation models which employ either an isotropic or an anisotropic distribution approximation for sky light when predicting insolation on tilted surfaces. Data sets of measured hourly insolation values were obtained over a six-month period using pyranometers which received diffuse and total solar radiation on a horizontal plane and total radiation on surfaces tilted toward the equator at 37 deg and 60 deg angles above the horizon. Data on the horizontal surfaces were used in the insolation models to predict insolation on the tilted surface; comparisons of measured versus calculated insolation on the tilted surface were examined to test the validity of the sky light approximations. It was found that the Liu-Jordan isotropic distribution model provides a good fit to empirical data under overcast skies but underestimates the amount of solar radiation incident on tilted surface under clear and partly cloudy conditions. The anisotropic-clear-sky distribution model by Temps and Coulson provides a good prediction for clear skies but overestimates the solar radiation when used for cloudy days. An anisotropic-all-sky model was formulated in this effort which provided excellent agreement between measured and predicted insolation throughout the six-month period. Author

99 GENERAL

N78-23032*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESIGN AND PERFORMANCE OF HEART ASSIST OR ARTIFICIAL HEART CONTROL SYSTEMS e62

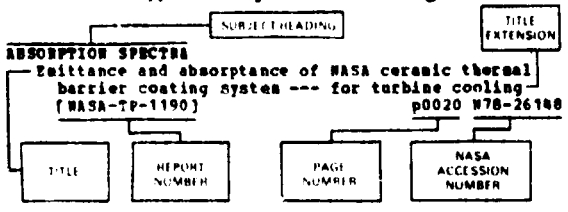
John A. Webb, Jr. and Vernon D. Gebben *In* NASA, Washington Fourth Inter-Center Control Systems Conf. Jan. 1978 p 495-506 refs (For availability see N78-23010 13-99)

Avail: NTIS HC A22/MF A01 CSCL 12B

The factors leading to the design of a controlled driving system for either a heart assist pump or artificial heart are discussed. The system provides square pressure waveform to drive a pneumatic-type blood pump. For assist usage the system uses an R-wave detector circuit that can detect the R-wave of the electrocardiogram in the presence of electrical disturbances. This circuit provides a signal useful for synchronizing an assist pump with the natural heart. It synchronizes a square wave circuit, the output of which is converted into square waveforms of pneumatic pressure suitable for driving both assist device and artificial heart. The pressure levels of the driving waveforms are controlled by means of feedback channels to maintain physiological regulation of the artificial heart's output flow. A more compact system that could achieve similar regulatory characteristics is also discussed. Author

SUBJECT INDEX

Typical Subject Index Listing



The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of the document content, a title extension is added separated from the title by three hyphens. The STAR or IAA accession number is included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. The page and accession numbers are located beneath and to the right of the title. Under any one subject heading the accession numbers are arranged in sequence with the IAA accession numbers appearing first.

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  5200 cycle of an 8-cm diameter Hg ion thruster
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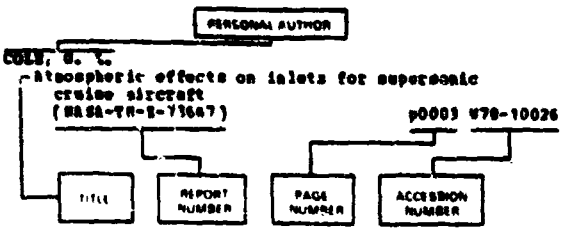
PERSONAL AUTHOR INDEX

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 listed (e.g., NASA report, translation, NASA contractor report). The page and accession numbers are located beneath and to the right of the title (e.g., p0003 N78-10026). Under any one author's name, the accession numbers are arranged in sequence with the IAA accession numbers appearing first.

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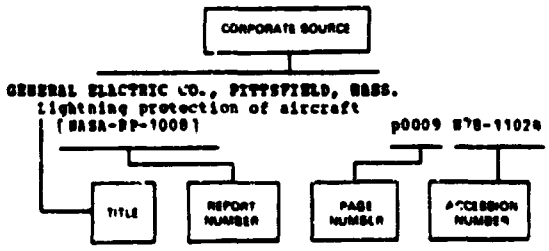

The title of the document is used to provide a brief description of the subject matter. The page number and NASA or AIAA accession number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

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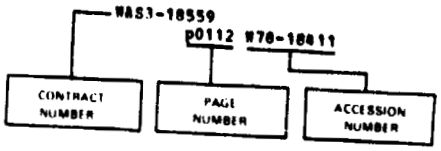

Listings in this index are arranged alphanumerically by contract number. Under each contract number the accession numbers denoting documents that have been produced as a result of research done under that contract are arranged in ascending order with the /A4 accession numbers appearing first. Preceding the accession number is the page number in the abstract section in which the citation may be found.

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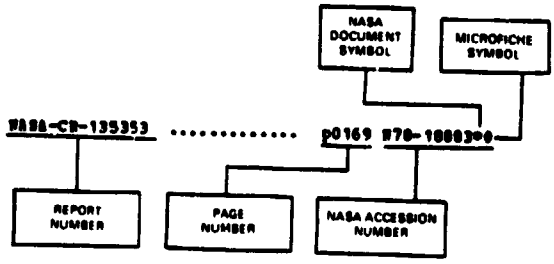

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