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BIBLIOGRAPHY OF LEWIS RESEARCH CENTER TECHNICAL CONTRIBUTIONS ANNOUNCED IN 1976

Lewis Research Center
Cleveland, Ohio 44135

December 1977

PREFACE

This is a compilation 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). It includes research reports, journal articles, conference presentations, patents and patent applications, and theses.

The arrangement is by NASA subject category as noted in the CONTENTS. For example, abstracts of publications on energy production and conversion are on pages 99-114. The Lewis authored items are listed first in each category followed by the contractor items. Within each of these groups is listed report literature, identified by their N-numbers, and then 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.

CONTENTS

01 AERONAUTICS (GENERAL)

N76-11026* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PROPULSION AIRFRAME INTEGRATION c05
D Mikkelson *In* Kansas Univ Proc of the NASA, Ind, Univ, Gen Aviation Drag Reduction Workshop 1975 p 387-402 (For availability see N76-10997 02-01)
CSCL 01C

Wind tunnel simulation tests are reported that utilize a 20 inch powered nacelle for airframe integration studies. Considered are: effects of boattail positioning, nacelle size, aft fuselage drag, over-the-wing half span model installation, and turboprop and ducted fan configurations. G G

N76-31154* National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio
A DIGITAL COMPUTER PROPULSION CONTROL FACILITY: DESCRIPTION OF CAPABILITIES AND SUMMARY OF EXPERIMENTAL PROGRAM RESULTS c05
John R Zeller, Dale J Arpasi, and Bruce Lehtinen *In its* Advanced Control Technol and its Potential for Future Transport Aircraft Aug 1976 p 477-501 refs (For availability see N76-31135 22-01)
CSCL 01C

Flight weight digital computers are being used today to carry out many of the propulsion system control functions previously delegated exclusively to hydromechanical controllers An operational digital computer facility for propulsion control mode studies has been used successfully in several experimental programs This paper describes the system and some of the results concerned with engine control, inlet control, and inlet engine integrated control Analytical designs for the digital propulsion control modes include both classical and modern/optimal techniques Author

N76-31155* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
DESCRIPTION AND TEST RESULTS OF A DIGITAL SUPERSONIC PROPULSION SYSTEM INTEGRATED CONTROL c07
Peter G. Batterton, Dale J Arpasi, and Robert J Baumbick *In its* Advanced Control Technol and its Potential for Future Transport Aircraft Aug 1976 p 503-524 refs (For availability see N76-31135 22-01)
CSCL 01C

A digitally implemented integrated inlet/engine control system was developed and tested on a mixed compression Mach 2 5, supersonic inlet and augmented turbofan engine The control matched engine airflow to available inlet airflow so that in steady state, the shock would be at the desired location, and the overboard bypass doors would be closed During engine induced transients, such as augmentor lights and cutoffs, the inlet operating point was momentarily changed to a more supercritical point to minimize unstarts. The digital control also provided automatic inlet restart Author

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.*

N76-10004*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
POPPET VALVE CONTROL OF THROAT STABILITY BYPASS TO INCREASE STABLE AIRFLOW RANGE OF A MACH 2.5. INLET WITH 60 PERCENT INTERNAL CONTRACTION
Glenn A Mitchell and Bobby W. Sanders Washington Oct 1975 49 p refs
(NASA-TM-X-3297; E-8382) Avail: NTIS HC $3.75 CSCL 20D

The throat of a Mach 2 5 inlet with a coldpipe termination was fitted with a stability-bypass system System variations included several stability bypass entrance configurations. Poppet valves controlled the bypass airflow. The inlet stable airflow range achieved with each configuration was determined for both steady state conditions and internal pulse transients. Results are compared with those obtained without a stability bypass system Transient results were also obtained for the inlet with a choke point at the diffuser exit and for the inlet with large and small stability bypass plenum volumes. Poppet valves at the stability bypass exit provided the inlet with a stable airflow range of 20 percent or greater at all static and transient conditions
Author

N76-10027* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
TIME-DEPENDENT TRANSONIC FLOW SOLUTIONS FOR AXIAL TURBOMACHINERY
John Erdos (Advanced Technol Labs., Inc.), Edgar Alzner (Advanced Technol Labs., Inc.), Paul Kalben (Advanced Technol. Labs., Inc.), William McNally, and Simon Slutsky (Polytechnic Inst of New York) *In its* Aerodynamic Analyses Requiring Advanced Computers, Pt 1 1975 p 587-621 refs (For availability see N76-10007 01-02)
CSCL 20D

Three-dimensional unsteady transonic flow through an axial turbomachine stage is described in terms of a pair of two-dimensional formulations pertaining to orthogonal surfaces, namely, a blade-to-blade surface and a hub-to-casing surface The resulting systems of nonlinear, inviscid, compressible equations of motion are solved by an explicit finite-difference technique The blade-to-blade program includes the periodic interaction between rotor and stator blade rows Treatment of the boundary conditions and of the blade slipstream motion by a characteristic type procedure is discussed in detail Harmonic analysis of the acoustic far field produced by the blade row interaction, including an arbitrary initial transient, is outlined Results from the blade-to-blade program are compared with experimental measurements of the rotating pressure field at the tip of a high-speed fan The hub-to-casing program determines circumferentially averaged flow properties on a meridional plane Blade row interactions are neglected in this formulation, but the force distributions over the entire blade surface for both the rotor and stator are obtained Results from the hub-to-casing program are compared with a relaxation method solution for a subsonic rotor Results are also presented for a quiet fan stage which includes transonic flow in both the rotor and stator and a normal shock in the stator
Author

N76-16018*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EFFECTS OF FOUR INLET AND OUTLET TIP-ANNULUS-AREA BLOCKAGE CONFIGURATIONS ON THE PERFORMANCE OF AN AXIAL-FLOW FAN ROTOR
Walter M Osborn and Roy D Hager Jan 1976 29 p refs
(NASA-TN-D-8131, E-8466) Avail NTIS HC $4 00 CSCL 01A

An axial-flow fan rotor was tested with four configurations of tip-annulus-area blockage to speeds as high as 0 8 of design speed The rotor performance with the four blockage configurations is compared with the unblocked rotor performance and with blockage configurations previously investigated The blockage configurations enable the rotor to operate in a stable condition, to much lower flows than the unblocked rotor, with no evidence of rotating stall The blockage configurations were effective in reducing rotor torque and weight flow but were accompanied by reductions in pressure ratio and efficiency
Author

N76-17023*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
PERFORMANCE OF INLET STAGE OF TRANSONIC COMPRESSOR
Donald C. Urasek, Ronald J. Steinke, and George W. Lewis, Jr. Washington Feb 1976 72 p refs
(NASA-TM-X-3345, E-8056) Avail. NTIS HC $4 50 CSCL 01A

The overall and blade-element performances are presented over the stable flow operating range of the stage at the design tip speed of 426 m/sec Stage peak efficiency of 0 83 was obtained at a weight flow of 28 8 kg/sec and a pressure ratio of 1.52. The stall margin for the stage was 8 percent based on weight flow and pressure ratio at peak efficiency and stall. The rotor appears to be stalling prematurely as evidenced by high rotor tip losses
Author

N76-17024*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PERFORMANCE OF A LOW-PRESSURE FAN STAGE WITH REVERSE FLOW
Royce D Moore, George W Lewis, Jr., and Edward R Tysl Washington Feb 1976 63 p refs
(NASA-TM-X-3349, E-8482) Avail: NTIS HC $4.50 CSCL 01A

The reverse flow aerodynamic performance of a 51-centimeter-diameter fan stage is presented The stage was tested with the variable pitch rotor blades set through feather at -75 deg, -80 deg, and -85 deg from design setting angle. Of the three tested the stage with the rotor blades set at -75 deg exhibited the highest pressure ratio and highest flow For all three configurations, there was little or no flow in the inner third of the exit passage due to the rotor blade being almost perpendicular to the axial direction in the hub region
Author

N76-17073*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PERFORMANCE OF LOW-PRESSURE-RATIO LOW-TIP-SPEED FAN STAGE WITH BLADE TIP SOLIDITY OF 0 65
George Kovich and Ronald J Steinke Washington Feb 1976 97 p refs
(NASA-TM-X-3341; E-7604) Avail. NTIS HC $5 00 CSCL 01A

The overall and blade-element performance of a low pressure ratio, low tip speed fan stage is presented over the stable operating range at rotative speeds from 90 to 120 percent of design speed Stage peak efficiency of 0 927 was obtained at a weight flow of 32 4 kg/sec (190 31 kg/sec/sq m of annulus area) and a pressure ratio of 1 134 The stall margin at design speed and peak efficiency was 15 3 percent
Autho

N76-18071*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EFFECT OF CASING TREATMENT ON PERFORMANCE OF AN INLET STAGE FOR A TRANSONIC MULTISTAGE COMPRESSOR
Donald C Urasek, George W. Lewis, Jr., and Royce D. Moore Washington Feb 1976 125 p refs
(NASA-TM-X-3347, E-8183) Avail. NTIS HC $5 50 CSCL 01A

An inlet stage of a transonic compressor was tested with three rotor tip casing treatment configurations blade angle slots circumferential grooves, and axial skewed slots Significant

increases in both rotor and stage total pressure ratio total temperature ratio, efficiency, flow range, and very large improvements in stall margin were obtained with all three casing treatment configurations The greatest improvement in performance was achieved with axial skewed slots Author

N76-18076*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
OVERALL AND BLADE ELEMENT PERFORMANCE OF A 1 20 PRESSURE RATIO FAN STAGE WITH ROTOR BLADES RESET -7 DEG
George W Lewis, Jr and George Kovich Washington Mar 1976 81 p refs
(NASA-TM-X-3342, E-8063) Avail NTIS HC $5 00 CSCL 01A

A 51-cm-diam model of a fan stage for short haul aircraft was tested in a single stage compressor research facility The rotor blades were set 7 deg toward the axial direction (opened) from the design setting angle Surveys of the air flow conditions ahead of the rotor, between the rotor and stator and behind the stator were made over the stable operating range of the stage At the design speed and a weight flow of 30 9 kg/sec, the stage pressure ratio and efficiency were 1 205 and 0 85 respectively, The design speed rotor peak efficiency of 0 90 occurred at a flow rate of 32 5 kg/sec Author

N76-18077*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
OVERALL AND BLADE ELEMENT PERFORMANCE OF A 1.20-PRESSURE-RATIO FAN STAGE WITH ROTOR BLADES RESET -5 DEG
George W Lewis, Jr, Walter M Osborn, and Royce D Moore Washington Mar 1976 91 p refs
(NASA-TM-X-3338; E-8057) Avail NTIS HC $5 00 CSCL 01A

A 51-cm-diam model of a fan stage for a short haul aircraft was tested in a single stage-compressor research facility The rotor blades were set 5 deg toward the axial direction (opened) from design setting angle Surveys of the air flow conditions ahead of the rotor, between the rotor and stator, and behind the stator were made over the stable operating range of the stage At the design speed of 213 3 m/sec and a weight flow of 31 5 kg/sec, the stage pressure ratio and efficiency were 1.195 and 0 88, respectively The design speed rotor peak efficiency of 0 91 occurred at the same flow rate Author

N76-20080*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
BOUNDARY LAYER BLEED SYSTEM STUDY FOR A FULL-SCALE, MIXED-COMPRESSION INLET WITH 45 PERCENT INTERNAL CONTRACTION
Robert J Shaw, Joseph F Wasserbauer, and Harvey E Neumann Washington Mar 1976 72 p refs
(NASA-TM-X-3358, E-8494) Avail NTIS HC $4 50 CSCL 01A

The results of an experimental bleed development study for a full-scale Mach 2.5, axisymmetric, mixed-compression inlet were presented. The inlet was designed to satisfy the airflow requirements of the TF30-P-3 turbofan engine Capabilities for porous bleed on the cowl surface and ram-scoop/flush-slot bleed on the centerbody were provided A configuration with no bleed on the cowl achieved a minimum stable, diffuser exit, total pressure recovery of 0 894 with a centerbody-bleed mass flow ratio of 0 02. Configurations with cowl bleed had minimum stable recoveries as high as 0 900 but suffered range decrement penalties from the increased bleed mass flow removal Limited inlet stability and unstart angle-of-attack data are presented Author

N76-22156*# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio
EFFECTS OF PERFORATED FLAP SURFACES AND SCREENS ON ACOUSTICS OF A LARGE EXTERNALLY BLOWN FLAP MODEL
Robert J Burns, Daniel J McKinzie, Jr, and Jack M Wagner Washington Apr 1976 41 p refs
(NASA-TM-X-3335 E-8559) Avail NTIS HC $4 00 CSCL 01A

Various model geometries and combinations of perforated flap surfaces and screens mounted close to the flap surfaces were studied for application to jet-flap noise attenuation for externally blown flap under-the-wing aircraft The efforts to reduce jet-flap interaction noise were marginally successful Maximum attenuations of less than 4 db in overall sound pressure level were obtained in the flyover plane Noise reductions obtained in the low-to-middle-frequency ranges (up to 7 db) were generally offset by large increases in high-frequency noise (up to 20 db) Author

N76-22161*# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio
EFFECT OF COOLANT FLOW EJECTION ON AERODYNAMIC PERFORMANCE OF LOW-ASPECT-RATIO VANES 1: PERFORMANCE WITH COOLANT EJECTION HOLES PLUGGED
Jeffrey E Haas and Milton G Kofskey Washington Apr 1976 18 p refs Prepared in cooperation with Army Air Mobility Res and Development Lab Cleveland Ohio
(NASA-TM-X-3395, E-8611) Avail NTIS HC $3 50 CSCL 01A

The aerodynamic performance of a low aspect ratio turbine vane designed with coolant flow ejection holes on the vane surfaces was experimentally determined in a full-annular cascade with the coolant ejection holes plugged The purpose was to establish a baseline for comparison with tests where flow is ejected from the vane surfaces. The vanes were tested over a mean-section ideal critical velocity ratio range of 0 64 to 0 98 This ideal critical velocity ratio corresponds to the vane inlet total to vane aftermixed static pressure ratio at the mean section The variations in vane efficiency and aftermixed flow conditions with circumferential and radial position were obtained Author

N76-24153*# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio
AERODYNAMIC PERFORMANCE OF 0 4066-SCALE MODEL TO JT8D REFAN STAGE
Royce D Moore, George Kovich, and Edward R Tysl Washington Mar 1976 157 p refs
(NASA-TM-X-3356, E-8040) Avail NTIS HC $6 75 CSCL 01A

The aerodynamic performance of a scale model of the split flow JT8D refan stage is presented over a range of flows at speeds from 40 to 100 percent design. The bypass stage peak efficiency of 0 800 occurred at a total weight flow of 35.82 kilograms per second and a pressure ratio of 1 697 The stall margin was 15 percent based on pressure ratio and weight flow at stall and peak efficiency conditions The data indicated that the hub region of the core stators was choked at design speed over the entire flow range tested Author

N76-25199* National Aeronautics and Space Administration Lewis Research Center Cleveland Ohio
THE PASSAGE OF A DISTORTED VELOCITY FIELD THROUGH A CASCADE OF AIRFOILS
John J Adamczyk *In* AGARD Unsteady Phenomena in Turbomachinery Apr. 1976 11 p refs (For availability see N76-25169 16-07)

N76-26154*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
AERODYNAMIC PERFORMANCE OF TWO VARIABLE-PITCH FAN STAGES
Royce D Moore and George Kovich 1976 12 p refs Proposed for Presentation at the 10th Congr of the Intern Council of the Aeronautical Sciences, Ottawa, 3-8 Oct 1976, sponsored by the Am Inst of Aeronautics and Astronautics
(NASA-TM-X-73416 E-8658) Avail NTIS HC $3 50 CSCL

01A

The NASA-Lewis Research Center is investigating a variety of fan stages applicable for short haul aircraft These low-pressure-ratio low-speed fan stages may require variable-pitch rotor blades to provide optimum performance for the varied flight demands and for thrust reversal on landing A number of the aerodynamic and structural compromises relating to the variable-pitch rotor blades are discussed The aerodynamic performance of two variable-pitch fan stages operated at several rotor blade setting angles for both forward and reverse flow application are presented Detailed radial surveys are presented for both forward and reverse flow. Author

N76-26155*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ACOUSTIC AND AERODYNAMIC EFFECTS OF ROTOR PITCH ANGLES FOR A VARIABLE PITCH, 6 FOOT DIAMETER FAN STAGE Technical Paper

Richard P. Woodward and Frederick W. Glaser 1976 20 p refs Presented at the 3rd Aero-Acoustics Conf., 20-23 Jul 1976, Palo Alto, Calif. Sponsored by AIAA

(NASA-TM-X-73418, E-8753) Avail: NTIS CSCL 01A

An externally driven, 1 2 pressure ratio full-scale fan stage with an adjustable pitch rotor was tested in an outdoor facility at the Lewis Research Center Rotor pitch angles resulting in minimum sideline perceived noise levels are defined as a function of stage thrust. Thrust-corrected fan noise variations are examined for operation at constant thrust, rotor tip speed, and stage work coefficient At constant stage thrust, reducing the rotor pitch angle below design values increased the fan noise with the greatest change occurring in the blade passing tone level At constant fan speed the minimum noise occurred at a particular rotor pitch angle, which was not the minimum thrust condition. With constant stage work coefficient, rear quadrant noise increased at above-design speed conditions. Author

N76-27167*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

NOZZLE AND WING GEOMETRY EFFECTS ON OTW AERODYNAMIC CHARACTERISTICS

U. VonGlahn and D Groesbeck 1976 28 p refs Presented at the 12th Propulsion Conf, Palo Alto, Calif, 26-29 Jul 1976, sponsored by AIAA and SAE

(NASA-TM-X-73420, E-8758) Avail NTIS HC $4 00 CSCL 01A

The effects of nozzle geometry and wing size on the aerodynamic performance of several 5 1 aspect ratio slot nozzles are presented for over-the-wing (OTW) configurations Nozzle geometry variables include roof angle, sidewall cutback, and nozzle chordwise location Wing variables include chord size, and flap deflection Several external deflectors also were included for comparison The data indicate that good flow turning may not necessarily provide the best aerodynamic performance The results suggest that a variable exhaust nozzle geometry offers the best solution for a viable OTW configuration Author

N76-27168*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

AERODYNAMIC AND ACOUSTIC PERFORMANCE OF A CONTRACTING COWL HIGH THROAT MACH NUMBER INLET INSTALLED ON NASA QUIET ENGINE C

Harry E Blommer and John W Schaefer 1976 20 p refs Presented at the 3d Aero-Acoustic Conf, Palo Alto, Calif, 20-23 Jul 1976; sponsored by AIAA

(NASA-TM-X-73424, E-8762) Avail NTIS HC $3 50 CSCL 01A

The approach and takeoff performance was evaluated of a contracting cowl variable geometry design inlet installed on a high-bypass-ratio turbofan engine. The design was finalized after consideration of aerodynamic, acoustic and mechanical factors which would lead to a viable flight worthy concept The aerodynamic results are presented in terms of inlet recovery and distortion parameter as functions of throat Mach number, and acoustic results in terms of Perceived Noise Level The contracting cowl high throat Mach number inlet is shown to be an attractive means to reduce forward radiated noise from a high bypass ratio turbofan engine Author

N76-27169*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

WING SHIELDING OF HIGH VELOCITY JET AND SHOCK-ASSOCIATED NOISE WITH COLD AND HOT FLOW JETS

U VonGlahn, D Groesbeck, and J Wagner 1976 22 p refs Presented at 3d Aero-Acoustics Conf Palo Alto, Calif 20-23 Jul 1976, sponsored by AIAA

(NASA-TM-X-73428; E-8771) Avail NTIS HC $3 50 CSCL 01A

Jet exhaust noise shielding data are presented for cold and hot flows (ambient to 1,100 K) and pressure ratios from 1 7 to 2.75 A nominal 9 5-cm diameter conical nozzle was used with simple shielding surfaces that were varied in length from 28 8 to 114 3 cm The nozzle was located 8 8 cm above the surfaces The acoustic data with the various shielding lengths are compared to each other and to that for the nozzle alone In general, short shielding surfaces that provided shielding for subsonic jets did not provide as much shielding for jets with shock noise, however, long shielding surfaces did shield shock noise effectively Author

N76-30155*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

BOUNDARY LAYER THICKNESS EFFECT ON BOATTAIL DRAG

B J Blaha, R Chamberlain, and L J Bober 1976 23 p refs Presented at the 12th Propulsion Conf, Palo Alto, Calif, 26-29 Jul. 1976; sponsored by AIAA, and SAE

(NASA-TM-X-73443 E-8797) Avail: NTIS HC $3 50 CSCL 01A

A combined experimental and analytical program was conducted to investigate the effects of boundary layer changes on the flow over high angle boattail nozzles The tests were run on an isolated axisymmetric sting mounted model Various boattail geometries were investigated at high subsonic speeds over a range of boundary-layer thicknesses. In general, boundary layer effects were small at speeds up to Mach 0 8 However, at higher speeds significant regions of separated flow were present on the boattail When separation was present large reductions in boattail drag resulted with increasing boundary layer thickness The analysis predicts both of these trends Author

N76-30156*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

EFFECT OF EXTERNAL JET-FLOW DEFLECTOR GEOMETRY ON OTW AERO-ACOUSTIC CHARACTERISTICS

U VonGlahn and D Groesbeck 1976 33 p refs Presented at the 3d Aero-Acoustics Conf, Palo Alto, Calif, 20-23 Jul 1976, sponsored by AIAA

(NASA-TM-X-73460; E-8823) Avail NTIS HC $4 00 CSCL 01A

The effect of geometry variations in the design of external deflectors for use with over-the-wing (OTW) configurations was studied at model scale and subsonic jet velocities Included in the variations were deflector size and angle as well as wing size and flap setting A conical nozzle (5 2-cm diameter) mounted at 0 1 chord above and downstream of the wing leading edges was used The data indicate that external deflectors provide satisfactory takeoff and approach aerodynamic performance and acoustic characteristics for OTW configurations These characteristics together with expected good cruise aerodynamics, since external deflectors are storable, may provide optimum OTW design configurations Author

N76-31197*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

VELOCITY SURVEYS IN A TURBINE STATOR ANNULAR-CASCADE FACILITY USING LASER DOPPLER TECHNIQUES

Louis J. Goldman, Richard G Seasholtz, and Kerry L. McLallin Washington Sep 1976 27 p refs
(NASA-TN-D-8269, E-8637) Avail NTIS HC S4 00 CSCL 01A

A laser Doppler velocimeter (LDV) was used to determine the flow conditions downstream of an annular cascade of stator blades operating at an exit critical velocity ratio of 0 87 Two modes of LDV operation (continuous scan and discrete point) were investigated Conventional pressure probe measurements were also made for comparison with the LDV results Biasing errors that occur in the LDV measurement of velocity components were also studied In addition, the effect of pressure probe blockage on the flow conditions was determined with the LDV. Photographs and descriptions of the test equipment used are given Author

N76-31198*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EFFECT OF SIMULATED FORWARD AIRSPEED ON SMALL-SCALE-MODEL EXTERNALLY BLOWN FLAP NOISE
Jack H Goodykoontz Robert G Dorsch, and William A Olsen Washington Sep 1976 58 p refs
(NASA-TN-D-8305, E-8697) Avail NTIS HC S4 50 CSCL 01A

Noise tests were conducted on a small-scale model of an externally blown flap lift augmentation system The nozzle/wing model was subjected to external flow that simulated takeoff and landing flight velocities by placing it in a 33-centimeter-diameter free jet. The results showed that external flow attenuated the noise associated with the various configurations tested The amount of attenuation depended on flap setting More attenuation occurred with a trailing-flap setting of 20 deg than with one of 60 deg Noise varied with relative velocity as a function of the trailing-flap setting and the angle from the nozzle inlet Author

N76-33135*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
AERODYNAMIC PERFORMANCE OF A 1 20-PRESSURE RATIO FAN STAGE DESIGNED FOR LOW NOISE
George W. Lewis, Jr and Royce D Moore Washington Oct 1976 113 p refs
(NASA-TM-X-3430, E-8575) Avail NTIS HC S5 50 CSCL 21E

The aerodynamic design and the overall blade element performance of a 51 centimeter diameter fan stage is presented. The stage was designed to minimize the noise generated by rotor stator interactions The design pressure ratio was 1 20 at a flow of 30 6 kilograms per second and a rotor blade tip speed of 228 6 meters per second At design speed the rotor peak efficiency was 0 935 The peak efficiency of the stage, however was 0 824 The radial distribution of rotor performance parameters at peak efficiency and design speed indicated excellent agreement with design values Author

N76-33144*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
COOLED-TURBINE AERODYNAMIC PERFORMANCE PREDICTION FROM REDUCED PRIMARY TO COOLANT TOTAL-TEMPERATURE-RATIO RESULTS
Louis J Goldman Washington Oct 1976 43 p refs
(NASA-TN-D-8312; E-8600) Avail NTIS HC $4 00 CSCL 21E

The prediction of the cooled aerodynamic performance, for both stators and turbines, at actual primary to coolant inlet total temperature ratios from the results obtained at a reduced total temperature ratio is described. Theoretical and available experimental results were compared for convection film and transpiration cooled stator vanes and for a film cooled, single stage core turbine For these tests the total temperature ratio varied from near 1 0 to about 2.7 The agreement between the theoretical and the experimental results was, in general, reasonable. Author

A76-10360 * **Subsonic flow past an oscillating cascade with steady blade loading - Basic formulation.** J M Verdon, J R. Caspar (United Technologies Research Laboratories, East Hartford, Conn.), and J J Adamczyk (NASA, Lewis Research Center, Cleveland, Ohio). In: Unsteady aerodynamics, Proceedings of the Symposium, Tucson, Ariz, March 18-20, 1975. Volume 2. (A76-10326 01-02) Tucson, Ariz., University of Arizona, 1975, p. 827-851 16 refs Research supported by the United Technologies Corp

A nonlinear boundary value problem governing the subsonic flow in a single, extended, blade passage region of a high-deflection, two dimensional, oscillating cascade is derived The blades are assumed to be undergoing identical harmonic motions of small amplitude with constant phase angle between the motion of adjacent blades. An asymptotic perturbation approach is used to determine the velocity potential This formulation can be used in the numerical determination of unsteady potential and thus the unsteady aerodynamic force and moment under various combinations of cascade and flow parameters. B J

A76-13992 * # **Cascade with subsonic leading edge locus.** M E Goldstein (NASA, Lewis Research Center, Cleveland, Ohio) *AIAA Journal*, vol 13, Aug 1975, p 1117-1119

The paper investigates a two-dimensional oscillating cascade with a subsonic leading edge locus in a supersonic flow The blades are assumed to be of small thickness and camber, and are undergoing small amplitude-harmonic oscillations The problem is reduced to the solution of a functional integral equation, and an expression is given for the kernel function. B.J.

A76-21916 * # **Experimental verification of film-cooling concepts on a turbine vane.** H. J Gladden and J. W Gauntner (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Winter Annual Meeting, Houston, Tex , Nov 30-Dec 4, 1975, Paper 75-WA/GT-21* 8 p 10 refs Members, $1 50; nonmembers, $3.00

An investigation was conducted to verify some film cooling concepts applied to gas turbine vanes. The film cooling air was ejected from a single row of holes on the convex surface and a double row of holes of the concave surface. Tests were conducted at a gas temperature of 1260 K, a gas pressure of 3 atmospheres, and a coolant temperature of 280 K. Mass-velocity ratios were varied between 0 and 2.0. Data were taken without film-cooling holes, with film-cooling holes but without blowing, and with blowing. A small amount of blowing into a nonturbulent boundary layer caused an increase in vane temperatures. Film cooling when combined with convection cooling was verified to be more effective than either film or convective cooling alone (Author)

A76-25141 * # **Installation and airspeed effects on jet shock-associated noise.** U. von Glahn and J. Goodykoontz (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 90th, San Francisco, Calif., Nov. 3-7, 1975, Paper.* 25 p. 6 refs.

Experimental acoustic data are presented to illustrate, at model scale, the effect of varying the nozzle-wing installation on shock-associated noise, statically and with airspeed. The variation in installations included nozzle only, nozzle under-the-wing, and nozzle over-the-wing. With the nozzle only, shock wave noise dominated the spectra in the forward quadrant, while jet mixing noise dominated in the rearward quadrant Similar trends were observed when a wing (flaps retracted) was included Shock noise was attenuated with an over-the-wing configuration and increased with an under-the-wing configuration (due to reflection from the wing surface). With increasing flap deflection (under-the-wing configuration), the jet-flap interaction noise exceeded the shock noise and became dominant in both quadrants. The free jet results showed that airspeed had no effect on shock noise. (Author)

A76-25143 * # Geometry effects on STOL engine-over-the-wing acoustics with 5:1 slot nozzles. U. von Glahn and D. Groesbeck (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 90th, San Francisco, Calif., Nov. 3-7, 1975, Paper.* 27 p. 6 refs.

The correspondence of far field acoustic trend with changes in the characteristics of the flow field at the wing trailing edge caused by alterations in the nozzle-wing geometry were determined at model scale with a 5:1 slot nozzle for several STOL-OTW configurations. Nozzle-roof angles of 10 to 40 deg were tested with and without cutback of the nozzle sidewalls. With increasing wing size, representing several airframe/engine installations, the jet noise shielding benefits increased. With increasing nozzle roof angle, the jet velocity at the trailing edge was decreased, causing a decrease in trailing-edge and fluctuating lift noise. Cutback of the nozzle sides improved flow attachment and reduced far-field noise. The best flow attachment and least trailing-edge noise generally were obtained with a 40-deg external deflector configuration and a cutback nozzle with a 40-deg roof angle. (Author)

A76-25144 * # Acoustics of attached and partially attached flow for simplified OTW configurations with 5:1 slot nozzle. U. von Glahn and D. Groesback (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 90th, San Francisco, Calif., Nov. 3-7, 1975, Paper.* 20 p. 5 refs,

The acoustics of simple engine over-the-wing configurations, with complete and partially attached jet flow to the shielding surface, were studied at model scale. The nozzle consisted of a 5:1 slot nozzle operated at a nominal jet Mach number of 0.6, with the flow directed parallel to and at angles up to 10 deg toward the shielding surface. The shielding length of the surface and the nozzle height above the surface were varied. The aerodynamic results indicate that, with attached flow, the jet flow field is stretched in the flow direction resulting in locally higher velocities than those for partially attached flow or nozzle only flow. The stretching of the flow field increased the noise levels for the attached flow cases compared to those with only partially attached flow. With attached flow, the shielding benefits were substantially reduced compared with fully detached flow. Increasing the impingement angle of the jet flow from 0 to 10 deg generally caused the noise levels to increase in the mid and high frequencies. (Author)

A76-33121 * # Inlets for high angles of attack. B A Miller (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Aircraft*, vol 13, Apr 1976, p. 319, 320 6 refs

Different inlet designs for high angle of attack STOL and VTOL applications were tested in a subsonic wind tunnel. Three removable entry lips having contraction ratios of 1 30, 1 34 and 1 38 were tested with a single diffuser The internal contour of each entry lip was an ellipse with a major to minor axis of 2.0 Each lip and diffuser assembly was tested to determine its tolerance to angle of attack, first with a conventional centerbody and then with an extended centerbody Results indicate that a large improvement in separation angle (determined as a function of lip contraction ratio and inlet flow) was obtained for the extended centerbody for all contraction ratios Improved inlet tolerance to angle of attack was obtained by reducing the adverse pressure gradient downstream of the throat

B J.

A76-34552 * A complete second-order theory for the unsteady flow about an airfoil due to a periodic gust. M E Goldstein (NASA, Lewis Research Center, Cleveland, Ohio) and H Atassi (Notre Dame, University, Notre Dame, Ind) *Journal of Fluid Mechanics*, vol 74, Apr. 22, 1976, p. 741-765 15 refs.

A uniformly valid second-order theory is developed for calculating the unsteady incompressible flow that occurs when an airfoil is subjected to a convected sinusoidal gust Explicit formulas for the airfoil response functions (i e., fluctuating lift) are given The theory accounts for the effect of the distortion of the gust by the steady-state potential flow around the airfoil, and this effect is found to have an important influence on the response functions. A number of results relevant to the general theory of the scattering of vorticity waves by solid objects are also presented (Author)

A76-37060 * # Characteristics procedure for supersonic flows including consideration of viscous contributions to flow rotationality. B H Anderson (NASA, Lewis Research Center, Cleveland, Ohio), Y. Tassa, and E Reshotko (Case Western Reserve University, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-426.* 7 p. 8 refs NASA-supported research.

A characteristics procedure has been developed which includes viscous and conductive transport terms normal to streamlines. By introducing the transport terms as corrections, the equations retain their hyperbolic character The solutions have been developed using an inverse grid scheme in a streamline-normal network. Inclusion of the transport terms enables tracing of shock waves through the supersonic portion of the boundary layer so that shock reflections are well-located. Excellent agreement is obtained with the results of other characteristics procedures and with the experimental pressure distributions for the waisted body of Winter, Smith and Rotta. (Author)

A76-38059 * # Aerodynamic and acoustic performance of a contracting cowl high throat Mach number inlet installed on NASA Quiet Engine 'C'. H E. Bloomer and J. W. Schaefer (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-540* 12 p. 10 refs.

The purpose of this experimental program was to evaluate the approach and takeoff performance of a contracting cowl variable geometry design inlet installed on a high-bypass-ratio turbofan engine The design was finalized after consideration of aerodynamic, acoustic, and mechanical factors which would lead to a viable flight-worthy inlet concept The aerodynamic results are presented in terms of inlet recovery and distortion parameter as functions of throat Mach number, and acoustic results in terms of Perceived Noise Level. The contracting cowl high throat Mach number inlet is shown to be an attractive means to reduce forward radiated noise from a high bypass ratio turbofan engine. (Author)

A76-38174 * # Nozzle and wing geometry effects on OTW aerodynamic characteristics. U von Glahn and D Groesbeck (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif, July 26-29, 1976, AIAA Paper 76-622.* 15 p. 6 refs

The effects of nozzle geometry and wing size on the aerodynamic performance of several 5 1 aspect ratio slot nozzles are presented for OTW configurations Nozzle geometry variables include roof angle, sidewall cutback, and nozzle chordwise location Wing variables include chord size, and flap deflection. Several external deflectors also were included for comparison The data indicate that good flow turning may not necessarily provide the best aerodynamic performance The results of the study suggest that a variable exhaust nozzle geometry offers the best solution for a viable OTW configuration (Author)

A76-38217 * # A method to account for variation of average compressor inlet pressure during instantaneous distortion analyses. P L. Burstadt and L M. Wenzel (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif , July 26-29, 1976, AIAA Paper 76-703* 9 p 5 refs.

Instantaneous distortion analyses compare a time-varying value of an index (or 'surge margin used up') with a critical level (or

'available surge margin' of the compressor) to determine inlet-engine compatibility. Unless freestream conditions or propulsion system controls are changing, it is generally assumed that the available surge margin of the compressor is accurately determined from the steady-state operating point. Results are presented which show that variations of average compressor inlet pressure may occur without changes in freestream conditions or propulsion system controls. The volume dynamics of the compressor will cause these pressure variations to be attenuated and delayed by the time they reach the exit. This will cause the compressor pressure ratio (and available surge margin) to vary with time A method is presented to calculate the available surge margin as a function of time and incorporate it into an instantaneous distortion analysis Results show that inlet pressure variations which cause only a small change at the compressor exit can cause a significant variation in the available surge margin. (Author)

A76-38218 * # **A method of distortion pattern synthesis for high response data screening** R. W King (United Technologies Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn) and H. E. Neumann (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif , July 26-29, 1976, AIAA Paper 76-704.* 8 p. 5 refs

An empirically derived method of estimating maximum levels of instantaneous inlet total pressure distortion from steady state measurements is presented The estimation procedure uses steady state total pressure and root mean square turbulent pressure data measurements to synthesize instantaneous distortion patterns The synthesis method is tailored to intensify distortion patterns in a manner consistent with the characteristics of the particular index to be used in evaluating inlet/engine compatability. The maximum expected value of distortion, a statistically determined function of the length of time of inlet operation, is used to constrain the amount of pattern intensification. Comparison with an independent set of data is presented for verification of the synthesis method. (Author)

A76-41377 * # **Effect of external jet-flow deflector geometry on OTW aero-acoustic characteristics.** U von Glahn and D. Groesbeck (NASA, Lewis Research Center, V/STOL and Noise Div , Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-499* 33 p 7 refs

The effect of geometry variations in the design of external deflectors for use with OTW configurations was studied at model scale and subsonic jet velocities Included in the variations were deflector size and angle as well as wing size and flap setting. A conical nozzle (5 2-cm diameter) mounted at 0 1 chord above and downstream of the wing leading edges was used. The data indicate that external deflectors provide satisfactory take-off and approach aerodynamic performance and acoustic characteristics for OTW configurations. These characteristics together with expected good cruise aerodynamics, since external deflectors are storable, may provide optimum OTW design configurations. (Author)

A76-41379 * # **Noise generated by impingement of turbulent flow on airfoils of varied chord, cylinders, and other flow obstructions** W A. Olsen (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-504.* 35 p 20 refs.

Noise spectra were measured in three dimensions for several surfaces immersed in turbulent flow from a jet and over a range of flow conditions The data are free field and were corrected to remove the small contributions of jet noise, atmospheric attenuation and feedback tones These broadband data were compared with the results of available theories which are only strictly applicable to simple geometries over a limited range of conditions. The available theories proved to be accurate over the range of flow, chord length, thickness, angle of attack, and surface geometries defined by the experiments These results apply to the noise generated by fixed surfaces in engine passages, the lifting surfaces of aircraft and also to fan noise (Author)

A76-41761 * **Vortex shedding from a blunt trailing edge with equal and unequal external mean velocities.** D. R. Boldman, P F. Brinich, and M E Goldstein (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Fluid Mechanics,* vol. 75, June 25, 1976, p 721-735 5 refs

A flow-visualization study has shown that strong Karman vortices develop behind the blunt trailing edge of a plate when the free-stream velocities over both surfaces are equal and that the vortices tend to disappear when the surface velocities are unequal. This observation provides an explanation for the occurence and disappearance of certain discrete tones often found to be present in the noise spectra of coaxial jets Both the vortex formation and the tones occur at a Strouhal number based on the lip thickness and the average of the external steady-state velocities of about 0.2. Results from theoretical calculations of the vortex formation, based on an inviscid incompressible analysis of the motion of point vortices, were in good agreement with the experimental observations (Author)

A76-47385 * # **Aerodynamic performance of two variable-pitch fan stages** R D. Moore and G Kovich (NASA, Lewis Research Center, Cleveland, Ohio). *International Council of the Aeronautical Sciences, Congress, 10th, Ottawa, Canada, Oct. 3-8, 1976, Paper 76-41* 8 p 11 refs

NASA-Lewis Research Center is investigating a variety of fan stages applicable for short-haul aircraft These low-pressure-ratio low-speed fan stages may require variable-pitch rotor blades to provide optimum performance for the varied flight demands and for thrust reversal on landing A number of the aerodynamic and structural compromises relating to variable-pitch rotor blades are discussed The aerodynamic performance of two variable-pitch fan stages operated at several rotor-blade setting angles is evaluated for both forward- and reverse-flow application Detailed radial surveys are presented for both forward and reverse flow (Author)

N76-26162*# Pratt and Whitney Aircraft, East Hartford, Conn
ANALYSIS OF DISTORTION DATA FROM TF30-P-3 MIXED COMPRESSION INLET TEST Final Report
R W King, J A Schuerman, and R G Muller Washington Jun. 1976 160 p refs
(Contract NAS3-19076)
(NASA-CR-2686) Avail. NTIS HC $6 75 CSCL 01A

A program was conducted to reduce and analyze inlet and engine data obtained during testing of a TF30-P-3 engine operating behind a mixed compression inlet Previously developed distortion analysis techniques were applied to the data to assist in the development of a new distortion methodology Instantaneous distortion techniques were refined as part of the distortion methodology development. A technique for estimating maximum levels of instantaneous distortion from steady state and average turbulence data was also developed as part of the program
Author

A76-20921 * # **Turbulence measurements in subsonic and supersonic axisymmetric jets in a moving stream.** P J. Morris (Lockheed-Georgia Co., Marietta, Ga). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 14th, Washington, D.C., Jan. 26-28, 1976, Paper 76-25.* 15 p. 33 refs. Research supported by the Lockheed-Georgia Co.; Contracts No. NAS3-18540; No. F33615-73-C-2032.

Measurements of mean and fluctuating velocity components are made in an unheated axisymmetric jet mounted in a low speed wind tunnel. The measurements are made with a backscatter laser velocimeter Velocity measurements are presented for jet exit Mach numbers in the range .47 to 1.67 and tunnel velocity to jet exit velocity ratios in the range .1 to .5. The effects of velocity ratio and jet exit Mach number on the jet spreading and the turbulence levels

are examined. The mean velocity, turbulence intensity, and axial velocity skewness and kurtosis are shown to agree with jets into still air measurements using an appropriate local radial coordinate based on the vorticity thickness (Author)

A76-21997 * # **Dynamic blade row compression component model for stability studies.** W. A Tesch and W. G Steenken (General Electric Co , Aircraft Engine Group, Cincinnati, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 14th, Washington, D.C., Jan. 26-28, 1976, Paper 76-203.* 9 p. 11 refs. Contracts No. F33615-75-C-2029; No. NAS3-18526.

This paper describes a generalized dynamic model which has been developed for use in compression component aerodynamic stability studies The model is a one-dimensional, pitch-line, blade row, lumped volume system. Arbitrary placement of blade free volumes upstream, within, and downstream of the compression component as well as the removal of bleed flow from the exit of any rotor or stator are model options. The model has been applied to a two-stage fan and an eight-stage compressor. The clean inlet pressure ratio/flow maps and the surge line have been reproduced, thereby validating the capability of the dynamic model to reproduce the steady-flow characteristics of the compression component A method for determining the onset of an aerodynamic instability which is associated with surge is described. Sinusoidally time-varying inlet and exit boundary conditions have been applied to the eight stage compressor as examples of the manner in which this model may be used for stability studies. (Author)

A76-37019 * # **Numerical solution of periodic transonic flow through a fan stage.** J I. Erdos, E. Alzner (General Applied Science Laboratories, Inc., Westbury, N Y), and W. McNally (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif , July 14-16, 1976, Paper 76-369.* 17 p 17 refs Contract No. NAS3-16807.

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)

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.*

N76-25153*# Franklin Inst Research Labs Philadelphia, Pa Dept of Science Information Services

DIRECTORY OF AEROSPACE SAFETY SPECIALIZED INFORMATION SOURCES, VOLUME 2

Richard I Rubinstein, James J Pinto, and Sanford Z Meschkow Apr 1976 246 p

(Contract NAS3-19082)

(NASA-CR-134929) Avail NTIS HC $8.00 CSCL 01C

A handbook of organizations and experts in specific and well-defined areas of safety technology is presented It is designed for the safety specialist as an aid for locating both information sources and individual points of contact (experts) in engineering related fields The file covers sources of data in aerospace design tests and operations, as well as information on hazard and failure cause identification, accident analysis, and materials characteristics. Other related areas include the handling and transportation of hazardous chemicals, radioactive isotopes, and liquified natural gases Author

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.*

N76-14112*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

THERMAL CONDUCTANCE OF AND HEAT GENERATION IN TIRE-PAVEMENT INTERFACE AND EFFECT ON AIRCRAFT BRAKING

C David Miller Washington Jan 1976 61 p refs

(NASA-TN-D-8094; E-8357) Avail NTIS HC $4 50 CSCL 11J

A finite-difference analysis was performed on temperature records obtained from a free rolling automotive tire and from pavement surface A high thermal contact conductance between tire and asphalt was found on a statistical basis Average slip due to squirming between tire and asphalt was about 1 5 mm Consequent friction heat was estimated as 64 percent of total power absorbed by bias-ply, belted tire Extrapolation of results to aircraft tire indicates potential braking improvement by even moderate increase of heat absorbing capacity of runway surface Author

N76-16065*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

OH-58 HELICOPTER TRANSMISSION FAILURE ANALYSIS

D P Townsend, J J Coy (Army Air Mobility Res and Develop Lab , Cleveland), and B. R Hatvani Jan 1976 35 p refs

(NASA-TM-X-71867 E-8633) Avail NTIS HC $4 00 CSCL 01C

The OH-58 main transmission gearbox was run at varying output torques, speeds, and oil cooling rates The gearbox was subsequently run to destruction by draining the oil from the gearbox while operating at a speed of 6200 revs per minute and 36,000 inch-pounds output torque Primary cause of gearbox failure was overheating and melting of the planet bearing aluminum cages Complete failure of the gearbox occurred in 28 1/2 minutes after the oil pressure dropped to zero The alternating and maximum stresses in the gearbox top case were approximately 10 percent of the endurance limit for the material Deflection of the bevel gear at 67000 inch-pounds output torque indicate a marginal stiffness for the bevel gear supporting system Author

N76-30201*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

INVESTIGATION OF UPPER-SURFACE-BLOWING NACELLE INTEGRATION AT CRUISE SPEEDS UTILIZING POWERED ENGINE SIMULATORS

E T Meleason and O. D. Wells (McDonnell-Douglas Corp , Long Beach, Calif) 1976 23 p refs Presented at the 12th Propulsion Conf., Palo Alto, Calif., 26-29 Jul 1976, sponsored by AIAA and SAE

(NASA-TM-X-73447, E-8806) Avail NTIS HC $3 50 CSCL 01C

Various overwing nacelle designs were investigated on a representative four engine short haul aircraft configuration during a combined analytical and experimental program Design conditions were M sub o = 0 7 and C sub L = 0 4 All nacelles had D shaped nozzle exits and included a streamline contoured design, a low boattail angle reference configuration, and a high boattail angle powered lift design Testing was done with the design four engine airplane configuration as well as with only inboard nacelles installed Turbopowered engine simulators were used to provide realistic representation of nacelle flows Performance trends are compared for the various nacelle designs In addition, comparisons are presented between analytical and experimental pressure distributions and between flow through and powered simulator results Author

A76-25142 * # On the effects of flight on jet engine exhaust noise J. R. Stone (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 90th, San Francisco, Calif., Nov 3-7, 1975, Paper.* 25 p. 31 refs

Recent flight data on jet engine exhaust noise do not agree with projections based on classical jet noise theories This paper demonstrates that these differences may be reconciled by considering the combined effects of jet mixing noise and internally-generated engine exhaust noise. The source strength of the internally-generated noise is assumed to be unaffected by flight, as has been shown in small-scale free-jet experiments. The directivity of the internally-generated noise is assumed to be the same statically as that given in the NASA interim prediction method for core engine noise However, it is assumed that in flight the internally generated noise is subject to the convective amplification effect of a simple source The absolute levels of the internally-generated noise are obtained from an empirical fit of some typical engine data The static and flight jet noise are predicted using the NASA interim prediction method for jet noise It is shown that in many cases, although jet mixing may be the dominant noise source statically, much of the flyover noise signature is dominated by internally-generated noise. (Author)

N76-13060*# Douglas Aircraft Co., Inc , Long Beach, Calif

DC-9 FLIGHT DEMONSTRATION PROGRAM WITH REFANNED JT8D ENGINES. VOLUME 1: SUMMARY Final Report

Jul 1975 75 p refs

(Contract NAS3-17841)

(NASA-CR-134857, MDC-J4526-Vol-1) Avail NTIS HC $4 50 CSCL 01C

The design, analysis, fabrication, and ground and flight testing of DC-9 airframe/nacelle hardware with prototype JT8D-109 engines are discussed The installation of the JT8D-109 engine on the DC-9 Refan airplane required new or modified hardware for the pylon, nacelle, and fuselage The acoustic material used in the nose cowl was bonded aluminum honeycomb sandwich and the exhaust duct acoustic material was Inconel 625 Stresskin The sea level static, standard day bare engine takeoff thrust, the cruise TSFC and the maximum available cruise thrust for the JT8D-109 engine were compared with those of the JT8D-9 engine. The range capabilities of the DC-9 Refan and the production DC-9 airplane were also compared The Refan airplane demonstrated flight characteristics similar to the production DC-9-30 and satisfied airworthiness requirements Flyover noise levels were determined for the DC-9 Refan and the DC-9 C-9A airplane for takeoff and landing conditions Cost estimates were also made Author

N76-13061*# Douglas Aircraft Co , Inc , Long Beach, Calif.

DC-9 FLIGHT DEMONSTRATION PROGRAM WITH REFANNED JT8D ENGINES. VOLUME 2: DESIGN AND CONSTRUCTION Final Report

Jul. 1975 133 p refs

(Contract NAS3-17841)

(NASA-CR-134858; MDC-J4510-Vol-2) Avail: NTIS HC $6 00 CSCL 01C

The nacelle configuration selected for the DC-9 had a 1595 6 mm Refan length inlet and an 1811 8 mm exhaust duct The inlet had 1234 4 mm of acoustic treatment and the tailpipe had 1305 5 mm of equivalent length acoustic treatment The pylon was reduced in width from 425.5 mm to 204 5 mm. Fuselage frames and titanium skin panels in the area of the pylon were reinforced or replaced to support the higher loads and engine thrust. Experimental type tooling, fabrication and assembly were used on all hardware The design is considered certifiable and representative of the hardware that would be built as retrofit kits Author

N76-13062*# Douglas Aircraft Co., Inc., Long Beach, Calif.

DC-9 FLIGHT DEMONSTRATION PROGRAM WITH REFANNED JT8D ENGINES. VOLUME 3: PERFORMANCE AND ANALYSIS Final Report

Jul. 1975 239 p refs

(Contract NAS3-17841)
(NASA-CR-134859, MDC-J4519-Vol-3) Avail. NTIS HC $8 00 CSCL 01C

The JT8D-109 engine has a sea level static, standard day bare engine takeoff thrust of 73,840 N At sea level standard day conditions the additional thrust of the JT8D-109 results in 2,040 kg additional takeoff gross weight capability for a given field length Range loss of the DC-9 Refan airplane for long range cruise was determined. The Refan airplane demonstrated stall, static longitudinal stability, longitudinal control, longitudinal trim, minimum control speeds, and directional control characteristics similar to the DC-9-30 production airplane and complied with airworthiness requirements. Cruise, climb, and thrust reverser performance were evaluated. Structural and dynamic ground test, flight test and analytical results substantiate Refan Program requirements that the nacelle, thrust reverser hardware, and the airplane structural modifications are flightworthy and certifiable and that the airplane meets flutter speed margins. Estimated unit cost of a DC-9 Refan retrofit program is 1 338 million in mid-1975 dollars with about an equal split in cost between airframe and engine. Author

N76-13063*# Douglas Aircraft Co., Inc., Long Beach, Calif
DC-9 FLIGHT DEMONSTRATION PROGRAM WITH REFANNED JT8D ENGINES. VOLUME 4: FLYOVER NOISE Final Report
Jul 1975 400 p refs
(Contract NAS3-17841)
(NASA-CR-134860, MDC-J4518-Vol-4) Avail NTIS HC $10 75 CSCL 01C

Flyover noise tests were conducted to determine the noise reductions achievable by modifying the engines and nacelles of DC-9-30 airplanes The two stage fan of the JT8D-9 engine was replaced with a larger diameter, single stage fan and sound absorbing materials were incorporated in the engines and nacelles. The noise levels were determined to be 95.3 EPNdB at the sideline, 96 2 EPNdB for a full thrust takeoff, 87 5 EPNdB for takeoff with thrust cutback, and 97.4 EPNdB for landing approach. The noise reductions relative to the hardwall JT8D-9 were 8 2 EPNdB for takeoff with cutback and 8.7 EPNdB for landing. The 90 EPNdB noise contour areas were reduced by 40% for missions requiring maximum design takeoff and landing weights. For typical mission weights, the reductions were 19% for full thrust takeoff and 34% for takeoff with cutback. The 95 EPNdB contour areas were reduced by 50% for takeoff and 30% for takeoff with cutback for both missions Author

N76-21189*# Boeing Commercial Airplane Co., Seattle, Wash
PHASE 2 PROGRAM ON GROUND TEST OF REFANNED JT8D TURBOFAN ENGINES AND NACELLES FOR THE 727 AIRPLANE VOLUME 3: GROUND TESTS Final Report
Dec 1975 350 p refs
(Contract NAS3-17842)
(NASA-CR-134799, D6-42440-3-Vol-3) Avail NTIS HC $10 00 CSCL 01C

The NASA Refan Program included full-scale performance and noise ground tests of both a current production (JT8D-15) and a refanned (JT8D-115) engine A description of the two ground tests including detailed propulsion, noise, and structural test results is presented The primary objectives of the total test program were comparison of JT8D-15 and JT8D-115 overall propulsion system performance and noise characteristics and determination of incremental component noise levels Other objectives of the test program included (1) determination of acoustic treatment effectiveness, (2) measurement of internal sound pressure levels, (3) measurement of inlet and exhaust hardware performance; (4) determination of center-engine surge margin, and (5) evaluation of certain structural characteristics associated with the 727 refan center-engine inlet duct and JT8D refan engine exhaust system The JT8D-15 and -115 tests were conducted during September 1974 and January to March 1975, respectively Analyses of the test data indicated that the JT8D-115, as compared to the JT8D-15, demonstrates a 12.5 percent to 13 2 percent reduction in static specific fuel consumption, and a reduction of 6 to 7 PNdB in a weighted average value of static tone corrected perceived noise level Separated into noise components, a significant reduction was shown for the inlet fan, aft fan, exhaust duct flow, turbine, and jet noises However, core noise was increased Photographs of test stands and test equipment are shown Author

N76-21190*# Boeing Commercial Airplane Co., Seattle, Wash
PHASE 2 PROGRAM ON GROUND TEST OF REFANNED JT8D TURBOFAN ENGINES AND NACELLES FOR THE 727 AIRPLANE VOLUME 4: AIRPLANE EVALUATION AND ANALYSIS Final Report
Dec 1975 323 p refs
(Contract NAS3-17842)
(NASA-CR-134800, D6-42440-4-Vol-4) Avail NTIS HC $9 75 CSCL 01C

The retrofit of JT8D-109 (refan) engines are evaluated on a 727-200 airplane in terms of airworthiness, performance, and noise Design of certifiable hardware, manufacture, and ground testing of the essential nacelle components is included along with analysis of the certifiable airplane design to ensure airworthiness compliance and to predict the in-flight performance and noise characteristics of the modified airplane The analyses confirm that the 727 refan airplane is certifiable The refan airplane range would be 15% less that of the baseline airplane and block fuel would be increased by 1 5% to 3% However, with this particular 727-200 model, with a brake release gross weight of 172,500 lb (78,245 kg), it is possible to operate the airplane (with minor structural modifications) at higher gross weights and increase the range up to 15% over the 727-200 (baseline) airplane The refan airplane FAR Part 36 noise levels would be 6 to 8 EPNdB (effective perceived noise in decibels) below the baseline Noise footprint studies showed that approach noise contour areas are small compared to takeoff areas The 727 refan realizes a 68% to 83% reduction in annoyance-weighted area when compared to the 727-200 over a range of gross weights and operational procedures 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*

N76-10126*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

THRUST PERFORMANCE OF ISOLATED 36-CHUTE SUPPRESSOR PLUG NOZZLES WITH AND WITHOUT EJECTORS AT MACH NUMBERS FROM 0 TO 0.45

Douglas E. Harrington, James J Schloemer (GE Co., Cincinnati), and Stanley A Skebe Washington Oct. 1975 47 p refs

(NASA-TM-X-3298, E-8334) Avail NTIS HC $3.75 CSCL 20A

Plug nozzles with chute-type noise suppressors were tested with and without ejector shrouds at free-stream Mach numbers from 0 to 0.45 and over a range of nozzle pressure ratios from 2 to 4 A 36-chute suppressor nozzle with an ejector had an efficiency of 94.6 percent at an assumed takeoff pressure ratio of 3.0 and a Mach number of 0.36 This represents only a 3.4 percent performance penalty when compared with the 98 percent efficiency obtained with a previously tested unsuppressed plug nozzle Author

N76-10132*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EFFECTS OF LONG-CHORD ACOUSTICALLY TREATED STATOR VANES ON FAN NOISE. 1: EFFECT OF LONG CHORD (TAPED STATOR)

James H Dittmar, James N Scott Bruce R Leonard, and Edward G. Stakolich Washington Oct 1975 48 p refs

(NASA-TN-D-8062, E-8331) Avail: NTIS HC $3.75 CSCL 21E

A set of long-chord stator vanes was designed to replace the vanes in an existing fan stage The long vanes consisted of a turning section and axial extension pieces, both of which incorporated acoustic damping material The acoustic damping material was made inactive for these tests by covering with metal tape, and the stator vanes were tested in three length configurations Compared to the values for the original stage, broadband noise was reduced in the middle to high frequencies with the long stator vanes, but a broadband noise increase was observed at the low frequencies No change was observed in the blade passage tone, but some aft end reduction in the overtones was observed Author

N76-12063*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

GEOMETRY EFFECTS ON STOL ENGINE-OVER-THE-WING ACOUSTICS WITH 5.1 SLOT NOZZLES

U. VonGlahn and D Groesbeck 1975 28 p refs Presented at 90th Meeting of the Acoust Soc of Am., San Francisco, 4-7 Nov 1975

(NASA-TM-X-71820, E-8519) Avail: NTIS HC $4.00 CSCL 20A

The correspondence of far field acoustic trends with changes in the characteristics of the flow field at the wing trailing edge caused by alterations in the nozzle-wing geometry were determined for several STOL-OTW configurations. Nozzle roof angles of 10 to 40 deg were tested with and without cutback of the nozzle sidewalls Three wing chord sizes were used baseline (33 cm with flaps retracted), 2/3-baseline, and 3/2-baseline Flap deflection angles of 20 and 60 deg were used The nozzle locations were at 21 and 46-percent of chord With increasing wing size the jet noise shielding benefits increased With increasing nozzle roof angle, the jet velocity at the trailing edge was decreased, causing a decrease in trailing-edge and fluctuating lift noise. Cutback of the nozzle sides improved flow attachment and reduced far-field noise The best flow attachment and least trailing-edge noise generally were obtained with a 40 deg external deflector configuration and a cutback nozzle with a 40 deg roof angle. Author

N76-12064*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

A REVIEW OF THE QCSEE PROGRAM

Carl C. Ciepluch 1975 29 p refs Presented at Aerospace Eng. and Manuf Meeting, Los Angeles, 17-20 Nov 1975, Soc of Automotive Engr.

(NASA-TM-X-71818; E-8516) Avail. NTIS HC $4.00 CSCL 21E

A description of the overall Quiet Clean Short-haul Experimental Engine Program is presented The design of the two experimental engines in the program is essentially completed The engine designs are described and projections of their performance presented Finally, the advanced technology elements being incorporated into the engines are discussed Author

N76-12065*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

REDUCTION OF NOISE FROM A FAN STAGE FOR A TURBOFAN ENGINE BY USE OF LONG-CHORD ACOUSTICALLY-TREATED STATOR VANES

J. H Dittmar and J. N Scott 1975 27 p refs Presented at 90th Meeting of the Acoust Soc of Am., San Francisco, 4-7 Nov. 1975

(NASA-TM-X-71811, E-8331) Avail. NTIS HC $4.00 CSCL 20A

A set of acoustically-treated long-chord vanes was designed to replace the vanes in an existing fan stage to investigate the noise reduction possibilities of both increased stator chord length and a method of incorporating acoustic damping material The vanes were tested with both active and inactive acoustic surfaces Results of the inactive tests show significant broadband noise effects with noise reductions in the middle to high frequencies and an increase at low frequencies No reduction in blade passage tone was observed, but decreases in the overtones were observed Results of the tests with the active acoustic treatment show large noise reductions over a wide frequency range Author

N76-12066*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

ON THE EFFECTS OF FLIGHT ON JET ENGINE EXHAUST NOISE

James R Stone 1975 26 p refs Presented at 90th Meeting of the Acoust. Soc of Am., San Francisco, 4-7 Nov. 1975

(NASA-TM-X-71819; E-8518) Avail NTIS HC $4.00 CSCL 20A

Differences between flight data and predictions of jet engine exhaust noise were reconciled by considering the combined effects of jet mixing noise and internally generated engine exhaust noise The source strength of the internally generated noise was assumed to be unaffected by flight, as experiments demonstrated The directivity of the internally generated noise was assumed to be the same statically as that given in the NASA interim prediction method for core engine noise However, it was assumed that in flight internally generated noise is subject to the convective amplification effect of a simple source The absolute levels of internally generated noise were obtained from an empirical fit of some typical engine data The static and flight jet noise were predicted using the above prediction method It was shown that in many cases much of the flyover noise signature is dominated by internally generated noise Author

N76-13095*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

DESIGN AND EVALUATION OF A SENSOR FAIL-OPERATIONAL CONTROL SYSTEM FOR A DIGITALLY CONTROLLED TURBOFAN ENGINE

Frank J Hrach, Dale J. Arpasi, and William M. Bruton Washington Dec. 1975 47 p refs

(NASA-TM-X-3260, E-8401) Avail NTIS HC $4.00 CSCL

21E

A self-learning, sensor fail-operational, control system for the TF30-P-3 afterburning turbofan engine was designed and evaluated The sensor fail-operational control system includes a digital computer program designed to operate in conjunction with the standard TF30-P-3 bill-of-materials control Four engine measurements and two compressor face measurements are tested If any engine measurements are found to have failed, they are replaced by values synthesized from computer-stored information The control system was evaluated by using a realtime, nonlinear, hybrid-computer engine simulation at sea level static condition, at a typical cruise condition, and at several extreme flight conditions Results indicate that the addition of such a system can improve the reliability of an engine digital control system.
Author

N76-13096*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PERFORMANCE OF A J85-13 COMPRESSOR WITH CLEAN AND DISTORTED INLET FLOW
Edward J Milner and Leon M Wenzel Dec 1975 33 p refs
(NASA-TM-X-3304, E-8311) Avail: NTIS HC $4 00 CSCL 21E

The results presented are of a series of experimental tests in which a J85-13 turbojet engine was subjected to both distorted and undistorted inlet total pressure conditions. A distinctive feature of the data base obtained is that it includes compressor interstage information not previously recorded for a J85-13 engine Each of the eight compressor stages was instrumented to obtain the characteristics of the individual stages for undistorted inlet conditions, and these data are documented in the report along with the undistorted compressor overall performance Also included in the report is the overall performance of the compressor exposed to 14 different distorted-inlet conditions - 10 circumferential patterns and 4 radial patterns The distortion patterns were introduced using screens that spoiled from 8 to 50 percent of the compressor face area; the distortion screen density, or the area blocked by the screen wire per unit area of screen, varied from 26 to 69 percent
Author

N76-13101*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PRELIMINARY EVALUATION OF A HEAT PIPE HEAT EXCHANGER ON A REGENERATIVE TURBOFAN
Gerald A Kraft Dec 1975 23 p refs
(NASA-TM-X-71853, E-8591) Avail NTIS HC $3 50 CSCL 21E

A preliminary evaluation was made of a regenerative turbofan engine using a heat pipe heat exchanger The heat exchanger had an effectiveness of 0 70, a pressure drop of 3 percent on each side, and used sodium for the working fluid in the stainless steel heat pipes The engine was compared to a reference turbofan engine originally designed for service in 1979 Both engines had a bypass ratio of 4 5 and a fan pressure ratio of 2 0 The design thrust of the engines was in the 4000 N range at a cruise condition of Mach 0 98 and 11.6 km It is shown that heat pipe heat exchangers of this type cause a large weight and size problem for the engine The penalties were too severe to be overcome by the small uninstalled fuel consumption advantage The type of heat exchanger should only be considered for small airflow engines in flight applications Ground applications might prove more suitable and flexible
Author

N76-13102*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE EXPERIMENTAL CLEAN COMBUSTOR PROGRAM: DESCRIPTION AND STATUS TO NOVEMBER 1975
Richard W Niedzwiecki Dec 1975 129 p refs Submitted for publication
(NASA-TM-X-71849, E-8581) Avail: NTIS HC $6 00 CSCL 21E

The generation of technology was studied for the development of advanced commercial CTOL aircraft engines with lower exhaust emissions than current aircraft The program is in three phases Phase 1, already completed, consisted of screening tests of low pollution combustor concepts Phase 2, currently in progress, consists of test rig refinement of the most promising combustor concepts Phase 2 test results are reported Phase 3, also currently in progress, consists of incorporating and evaluating the best combustors as part of a complete engine. Engine test plans and pollution sampling techniques are described in this report. Program pollution goals, specified at engine idle and take-off conditions, are idle emission index value of 20 and 4 for carbon monoxide (CO) and total unburned hydrocarbons (THC), respectively, and at take-off are an oxides of nitrogen (NOx) emission index level of 10 and a smoke number of 15. Pollution data were obtained at all engine operating conditions. Results are presented in terms of emission index and also in terms of the Environmental Protection Agency's 1979 Standards Parameter
Author

N76-14123*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
SWIRL-CAN COMBUSTOR PERFORMANCE TO NEAR-STOICHIOMETRIC FUEL-AIR RATIO
Larry A Diehl and James A Biaglow 1976 27 p refs Proposed for presentation at the 21st Ann Intern Gas Turbine Conf, New Orleans, 21-25 Mar. 1975; sponsored by ASME
(NASA-TM-X-71794, E-8471) Avail NTIS HC $4 00 CSCL 21E

Emissions and performance characteristics were determined for full-annulus swirl-can modular combustors operated to near stoichiometric fuel air ratios The purposes of the tests were to obtain stoichiometric data at inlet air temperatures up to 894 K and to determine the effect of module number by investigating 120 and 72 module swirl-can combustors The maximum average exit temperature obtained with the 120-module swirl-can combustor was 2465 K with a combustion efficiency of 95 percent at an inlet-air temperature of 894 K The 72-module swirl-can combustor reached a maximum average exit temperature of 2306 K with a combustion efficiency of 92 percent at an inlet air temperature of 894 K At a constant inlet air temperature, maximum oxides of nitrogen emission index values occurred at a fuel-air ratio of 0 037 for the 72-module design and 0 044 for the 120-module design The combustor average exit temperature and combustion efficiency were calculated from emissions measurements The measured emissions included carbon monoxide, unburned hydrocarbons, oxides of nitrogen, and smoke
Author

N76-14124*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
TURBINE BLADE METAL TEMPERATURE MEASUREMENT WITH A SPUTTERED THIN FILM CHROMEL-ALUMEL THERMOCOUPLE
Curt H Liebert, George A Mazaris, and Henry W. Brandhorst, Jr Dec. 1975 15 p refs
(NASA-TM-X-71844, E-8569) Avail: NTIS HC $3 50 CSCL 21E

A technique for fabricating Chromel and Alumel thin film thermocouples was developed Turbine blade metal temperatures measured with the thin film thermocouple installation were compared with those of a reference sheathed (wire) thermocouple Good agreement was obtained, and the results are encouraging
Author

N76-14127*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
NNEP: THE NAVY NASA ENGINE PROGRAM
Laurence H Fishbach and Michael J Caddy (Naval Air Develop. Center) Dec 1975 36 p refs
(NASA-TM-X-71857; E-8606) Avail NTIS HC $4 00 CSCL 21E

A computer code capable of simulating almost any conceivable turbine engine is described This code uses stacked component maps and multiple flowpaths to simulate variable cycle engines with variable component geometry It is capable of design and off-design (matching) calculations and can optimize free variables such as nozzle areas to minimize specific fuel consumption
Author

N76-14131*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
MEASUREMENT OF EXHAUST EMISSIONS FROM TWO J-58 ENGINES AT SIMULATED SUPERSONIC CRUISE FLIGHT CONDITIONS
James D Holdeman 1976 35 p refs To be presented at the 21st Intern Gas Turbine Conf, New Orleans, La, 21-25 Mar. 1976; sponsored by ASME
(NASA-TM-X-71826, E-8490) Avail. NTIS HC $4.00 CSCL 21E

Emissions of total oxides of nitrogen, unburned hydrocarbons, carbon monoxide, and carbon dioxide from two J-58 afterburning turbojet engines at simulated high-altitude flight conditions are reported Test conditions included flight speeds from Mach 2 to 3 at altitudes from 16 to 23 km For each flight condition, exhaust measurements were made for four or five power levels from maximum power without afterburning through maximum afterburning The data show that exhaust emissions vary with flight speed, altitude, power level, and radial position across the exhaust Oxides of nitrogen (NOX) emissions decreased with increasing altitude, and increased with increasing flight speed NOX emission indices with afterburning were less than half the value without afterburning Carbon monoxide and hydrocarbon emissions increased with increasing altitude, and decreased with increasing flight speed. Emissions of these species were substantially higher with afterburning than without Author

N76-15162*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
STATUS OF TECHNOLOGICAL ADVANCEMENTS FOR REDUCING AIRCRAFT GAS TURBINE ENGINE POLLUTANT EMISSIONS
Richard A. Rudey Dec 1975 50 p refs Submitted for publication
(NASA-TM-X-71846, E-8576) Avail. NTIS HC $4 00 CSCL 21E

Combustor test rig results indicate that substantial reductions from current emission levels of carbon monoxide (CO), total unburned hydrocarbons (THC), oxides of nitrogen (NOx), and smoke are achievable by employing varying degrees of technological advancements in combustion systems Minor to moderate modifications to existing conventional combustors produced significant reductions in CO and THC emissions at engine low power (idle/taxi) operating conditions but did not effectively reduce NOx at engine full power (takeoff) operating conditions Staged combusiton techniques were needed to simultaneously reduce the levels of all the emissions over the entire engine operating range (from idle to takeoff) Emission levels that approached or were below the requirements of the 1979 EPA standards were achieved with the staged combustion systems and in some cases with the minor to moderate modifications to existing conventional combustion systems Results from research programs indicate that an entire new generation of combustor technology with extremely low emission levels may be possible in the future Author

N76-16080*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
STATUS REVIEW OF NASA PROGRAMS FOR REDUCING AIRCRAFT GAS TURBINE ENGINE EMISSIONS
Richard A Rudey [1976] 23 p refs Presented at the 3d Intern Symp on Air Breathing Engines, Munich, 7-12 Mar 1976
(NASA-TM-X-71861, E-8620) Avail NTIS HC $3 50 CSCL 21E

Programs initiated by NASA to develop and demonstrate low emission advanced technology combustors for reducing aircraft gas turbine engine pollution are reviewed Program goals are consistent with urban emission level requirements as specified by the U. S Environmental Protection Agency and with upper atmosphere cruise emission levels as recommended by the U S Climatic Impact Assessment Program and National Research Council Preliminary tests of advanced technology combustors indicate that significant reductions in all major pollutant emissions should be attainable in present generation aircraft gas turbine engines without adverse effects on fuel consumption Preliminary test results from fundamental studies indicate that extremely low emission combustion systems may be possible for future generation jet aircraft The emission reduction techniques currently being evaluated in these programs are described along with the results and a qualitative assessment of development difficulty Author

N76-16081*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
EFFECTS OF AIRPLANE CHARACTERISTICS AND TAKE-OFF NOISE AND FIELD LENGTH CONSTRAINTS ON ENGINE CYCLE SELECTION FOR A MACH 2 32 CRUISE APPLICATION
John B Whitlow, Jr. Jan. 1976 49 p refs
(NASA-TM-X-71865, E-8631) Avail NTIS HC $4 00 CSCL 01C

Sideline noise and takeoff field length were varied for two types of Mach 2 32 cruise airplane to determine their effect on engine cycle selection One of these airplanes was the NASA/Langley-LTV arrow wing while the other was a Boeing modified delta-plus-tail derived from the earlier 2707-300 concept Advanced variable cycle engines were considered A more conventional advanced low bypass turbofan engine was used as a baseline for comparison. Appropriate exhaust nozzle modifications were assumed, where needed, to allow all engines to receive either an inherent co-annular or annular jet noise suppression benefit All the VCE's out-performed the baseline engine by substantial margins in a design range comparison regardless of airplane choice or takeoff restrictions The choice among the three VCE's considered, however, depends on the field length, noise level, and airplane selected Author

N76-16082*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
LIP NOISE GENERATED BY FLOW SEPARATION FROM NOZZLE SURFACES
W. Olsen and A Karchmer [1975] 29 p refs Presented at the 14th Aerospace Sci Meeting, Washington, D C 26-28 Jan 1976; sponsored by AIAA
(NASA-TM-X-71859; AIAA-Paper-76-3) Avail NTIS HC $4 00 CSCL 20D

The results of a series of experiments, performed to investigate flow separation and classic lip noise and to aid in understanding aeroacoustic noise generation are presented Several types of nozzle-lip configurations were used to study the high frequency noise generated by small regions of flow separation at the nozzle lip These included coaxial nozzles, and circular and slot nozzles with splitter plates The jet flow velocity was varied and far field noise was measured for all nozzle-lip geometries (coaxial and splitter plate) The effect of a velocity difference across the lip of the coaxial nozzle and the splitter plate on the far field noise was also measured Finally, an effort was made to find means to reduce the high frequency noise caused by flow separation at the lip Author

N76-17141*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
POTENTIAL USE OF CERAMIC COATING AS A THERMAL INSULATION ON COOLED TURBINE HARDWARE
Curt H Liebert and Francis S. Stepka Washington Feb 1976 24 p refs
(NASA-TM-X-3352, E-8557) Avail NTIS HC $3 50 CSCL 21E

An analysis was made to determine the potential benefits of using a ceramic thermal insulation coating of calcia-stabilized zirconia on cooled engine parts The analysis was applied to turbine vanes of a high temperature and high pressure core engine and a moderate temperature and low pressure research engine Measurements made during engine operation showed that the coating substantially reduced vane metal wall temperatures Evaluation of the durability of the coating on turbine vanes and blades in a furnace and engine were encouraging Author

N76-17143*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
ADVANCED TURBINE DISK DESIGNS TO INCREASE RELIABILITY OF AIRCRAFT ENGINES
Albert Kaufman 1976 32 p refs Proposed for presentation at Gas Turbine Conf., New Orleans, 21-25 Mar 1976, sponsored by ASME
(NASA-TM-X-71804; E-8491) Avail. NTIS HC $4 00 CSCL 21E

Results of analytical studies to improve the low cycle fatigue lives and reliability of turbine disks in high performance gas turbine engines are presented Advanced disk concepts were evaluated for the first stage high pressure turbines of the CF6-50 and JT8D-17 engines The advanced disk designs are compared to the existing disks on the bases of cycles to crack initiation and overspeed capability for initially unflawed disks, crack propagation cycles to failure for initially flawed disks, and available kinetic energy of disk burst fragments. Author

N76-17145*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
LOW SPEED WIND TUNNEL INVESTIGATION OF THE AERODYNAMIC AND ACOUSTIC PERFORMANCE OF SEVERAL SONIC INLET TAKEOFF AND APPROACH GEOMETRIES
John M. Abbott and Richard L Golladay Washington Feb 1976 50 p refs
(NASA-TM-X-3332; E-8445) Avail NTIS HC $4 00 CSCL 01A

A series of tests was conducted to determine the aerodynamic and acoustic performance of several sonic inlet takeoff and approach geometries The effects of inlet lip shape and diffuser length were also investigated The tests were conducted in a low-speed wind tunnel at free-stream velocities of 0 and 45 meters per second Inlet incidence angle was varied from 0 deg to 50 deg The inlets were sized to fit a 13 97-centimeter-diameter fan In terms of the highest level of inlet total pressure recovery for a given amount of noise suppression, a cylindrical centerbody takeoff geometry and a bulb-shaped centerbody approach geometry provided the best results over all conditions of free-stream velocity and incidence angle. Increasing inlet lip contraction ratio extended the maximum incidence angle for attached lip flow, while increasing inlet diffuser length resulted in a higher total pressure recovery for a given amount of noise suppression Author

N76-17146*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
COMPUTER PROGRAM FOR DESIGN ANALYSIS OF RADIAL-INFLOW TURBINES
Arthur J Glassman Washington Feb 1976 66 p refs
(NASA-TN-D-8164, E-8394) Avail NTIS HC $4 50 CSCL 21E

A computer program written in FORTRAN that may be used for the design analysis of radial-inflow turbines was documented The following information is included loss model (estimation of losses), the analysis equations, a description of the input and output data, the FORTRAN program listing and list of variables, and sample cases The input design requirements include the power, mass flow rate, inlet temperature and pressure, and rotational speed The program output data includes various diameters, efficiencies, temperatures, pressures, velocities, and flow angles for the appropriate calculation stations The design variables include the stator-exit angle, rotor radius ratios, and rotor-exit tangential velocity distribution The losses are determined by an internal loss model Author

N76-17147*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
EFFECT OF SLOTTED CASING TREATMENT ON PERFORMANCE OF A MULTISTAGE COMPRESSOR
John E Moss, Jr. Washington Feb. 1976 20 p refs
(NASA-TM-X-3350, E-8485) Avail NTIS HC $3 50 CSCL 21E

A J85-13 engine was equipped with a compressor case that allowed changes to the case wall over the rotor tips of six of its eight stages The engine was tested with four inlet configurations: uniform inlet flow, 180 degree circumferential distortion, hub radial distortion, and tip radial distortion. Slotted inserts were installed in the first three stages, and the compressor was mapped under similar conditions. Overall compressor performance obtained with tip treatment was inferior to the performance for the compressor's normal operating range Pumping capacity with the slotted inserts was reduced Overall compressor efficiency was reduced 1 to 2 percent with the slotted rings installed for 90 and 100 percent corrected engine speeds Author

N76-18122*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
PERFORMANCE OF A 1 57 PRESSURE-RATIO TRANSONIC FAN STAGE WITH A SCREEN-INDUCED 90 DEG CIRCUMFERENTIAL INLET FLOW DISTORTION
Nelson L Sanger Washington Feb 1976 76 p refs
(NASA-TN-D-8163, E-8218) Avail NTIS HC $5 00 CSCL 21E

A transonic fan stage having a design pressure ratio of 1 57 was tested with a 90 degree circumferential distortion imposed on the inlet flow The rotor diameter was approximately 50 8 cm, and the design pressure ratio was 1.60 at a tip speed of 425 m/sec Overall performance at 70 and 100 percent of design speed showed a loss of stall pressure ratio and flow range at design speed and no significant loss in stall pressure ratio at 70 percent of design speed Detailed flow measurements are presented to show the rotor-upstream flow interactions and the attenuation and amplification properties through the stage Author

N76-18125*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ADVANCES IN TURBINE BLADE TEMPERATURE MEASUREMENTS
Frank G Pollack 1976 8 p refs Proposed for presentation at the 22nd Intern Instrumentation Symp., San Diego, Calif., 25-27 May 1976, sponsored by Instr. Soc of Am
(NASA-TM-X-71878; E-8652) Avail NTIS HC $3 50 CSCL 21E

Radiation pyrometry principles and imaging methods like photography and photoelectric scanning are combined to make accurate research quality temperature measurements on turbine airfoils Two systems are described for obtaining detailed temperature distribution measurements an infrared photographic system for stationary vanes and a photoelectric scanning system for rotating blades An overview is presented outlining the design, calibration methods, and recent test results Author

N76-18126*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EXHAUST EMISSION CALIBRATION OF TWO J-58 AFTERBURNING TURBOJET ENGINES AT SIMULATED HIGH-ALTITUDE, SUPERSONIC FLIGHT CONDITIONS
James D. Holdeman Washington Feb 1976 73 p refs
(NASA-TN-D-8173, E-8490) Avail: NTIS HC $4 50 CSCL 21E

Emissions of total oxides of nitrogen, nitric oxide, unburned hydrocarbons, carbon monoxide, and carbon dioxide from two J-58 afterburning turbojet engines at simulated high-altitude flight conditions are reported Test conditions included flight speeds from Mach 2 to 3 at altitudes from 16 0 to 23 5 km For each flight condition exhaust measurements were made for four or five power levels, from maximum power without afterburning through maximum afterburning The data show that exhaust emissions vary with flight speed altitude, power level, and radial position across the exhaust Oxides of nitrogen emissions decreased with increasing altitude and increased with increasing flight speed Oxides of nitrogen emission indices with afterburning were less than half the value without afterburning Carbon monoxide and hydrocarbon emissions increased with increasing altitude and decreased with increasing flight speed Emissions of these species were substantially higher with afterburning than without. Author

N76-18127*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
INCIDENCE ANGLE BOUNDS FOR LIP FLOW SEPARATION OF THREE 13 97-CENTIMETER-DIAMETER INLETS
Roger W Luidens and John M Abbott Washington Feb 1976 16 p refs
(NASA-TM-X-3351, E-8523) Avail NTIS HC $3 50 CSCL 01C

Low speed wind tunnel tests were conducted to establish a procedure for determining inlet-lip flow separation and to make preliminary examination of the incidence angle bounds for lip flow separation on inlets intended for the nacelles of STOL (short takeoff and landing) aircraft Three inlets were tested Two of the inlets had short centerbodies with lower lip area contraction ratios of 1 30 and 1 44 The third inlet had a cylindrical centerbody extended forward into the inlet throat with a lower lip area contraction ratio of 1 44 The inlets were sized to fit a 13 97 centimeter-diameter fan For inlet throat Mach numbers less than about 0 43, the lip flow separation angle was increased by either increasing the ratio of throat velocity to freestream velocity (Vt/Vo) or by increasing the lower lip area contraction ratio For throat Mach numbers greater than a certain value (ranging from 0 43 to 0 52), increasing throat Mach number in some cases resulted in a decrease in the lip flow separation angle Extending a cylindrical centerbody into the inlet throat increased the flow separation angle for nearly all values of Vt/Vo Author

N76-18128*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FLIGHT VELOCITY EFFECTS ON EXHAUST NOISE OF A WEDGE NOZZLE INSTALLED ON AN UNDERWING NACELLE ON AN F-106 AIRPLANE
Richard R Burley Washington Feb 1976 31 p refs
(NASA-TM-X-3361 E-8548) Avail NTIS HC $4 00 CSCL 20A

It is important to know whether the relatively high takeoff speeds of supersonic transport aircraft will change the exhaust noise levels of nozzles from those measured at static conditions To gain some insight into this question, a modified F-106B aircraft was used to conduct flyover and static tests on a wedge nozzle Flight velocity had an adverse effect on exhaust noise when compared with static results at the same relative jet velocity but a beneficial effect when compared with static results at the same absolute jet velocity. The wedge nozzle, which has a two-dimensional wedge surface rather than an axisymmetric plug surface, had a higher peak flyover noise level than the plug nozzle Author

N76-18129*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
HEAT-TRANSFER CHARACTERISTICS OF PARTIALLY FILM COOLED PLUG NOZZLE ON A J-85 AFTERBURNING TURBOJET ENGINE
Stanley M. Nosek and David M. Straight Washington Mar 1976 31 p refs
(NASA-TM-X-3362; E-8553) Avail. NTIS HC $4.00 CSCL 21E

Plug nozzle film cooling data were obtained downstream of a slot located at 42 percent of the total plug length on a J-85 engine Film cooling reduced the aft end wall temperature as much as 150 K, reduced total pressure loss in the upstream convection cooling passages by 50 percent, and reduced estimated compressor bleed flow requirement by 14 percent compared to an all convectively cooled nozzle Shock waves along the plug surface strongly influenced temperature distributions on both convection and film cooled portions The effect was most severe at nozzle pressure ratios below 10 where adverse pressure gradients were most severe Author

N76-18130*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ACOUSTIC AND AERODYNAMIC PERFORMANCE OF A 1.83-METER (6-FT) DIAMETER 1.25-PRESSURE-RATIO FAN (QF-8)
Richard P Woodward and James G Lucas Washington Feb. 1976 106 p refs
(NASA-TN-D-8130, E-8431) Avail NTIS HC $5 50 CSCL 21E

A 1 25-pressure-ratio 1 83-meter (6-ft) tip diameter experimental fan stage with characteristics suitable for engine application on STOL aircraft was tested for acoustic and aerodynamic performance. The design incorporated proven features for low noise, including absence of inlet guide vanes, low rotor blade tip speed, low aerodynamic blade loading, and long axial spacing between the rotor and stator blade rows. The fan was operated with five exhaust nozzle areas. The stage noise levels generally increased with a decrease in nozzle area Separation of the acoustic one-third octave results into broadband and pure-tone components showed the broadband noise to be greater than the corresponding pure-tone components The sideline perceived noise was highest in the rear quadrants The acoustic results of QF-8 were compared with those of two similar STOL application fans in the test series The QF-8 had somewhat higher relative noise levels than those of the other two fans The aerodynamic results of QF-8 and the other two fans were compared with corresponding results from 50 8-cm (20-in) diam scale models of these fans and design values Although the results for the full-scale and scale models of the other two fans were in reasonable agreement for each design, the full-scale fan QF-8 results showed poor performance compared with corresponding model results and design expectations Facility effects of the full-scale fan QF-8 installation were considered in analyzing this discrepancy Author

N76-18134*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
NOISE GENERATED BY QUIET ENGINE FANS. 3: FAN C
Francis J Montegan, John W. Schaefer, and Ralph F Schmiedlin Washington Mar 1976 79 p refs
(NASA-TM-X-3360, E-8530) Avail NTIS HC $5 00 CSCL 21E

A family of fans designed with low noise features was acoustically evaluated, and noise results are documented for a 1 6-pressure-ratio, 472-m/sec (155-ft/sec) tip speed fan The fan is described and some aerodynamic operating data are given Far field noise around the fan was measured over a range of operating conditions for a variety of configurations having different arrangements of sound absorbing material in the flow ducts Complete results of 1 3 octave band analysis of the data are presented in tabular form Included also are acoustic power spectra and sideline perceived noise levels Representative 1/3 octave band data, are presented graphically, and sample graphs of continuous narrow band spectra are also provided Author

N76-20143*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
AERODYNAMIC PERFORMANCE OF FLARED FAN NOZZLES USED AS INLETS
Donald A Dietrich, Theo G Keith, and Gary G. Kelm Washington Mar. 1976 31 p refs
(NASA-TM-X-3367, E-8539) Avail NTIS HC $4 00 CSCL 21E

Tests were conducted in a low speed wind tunnel to determine the aerodynamic performance of several flared fan nozzles Each of the flared nozzles was a downstream-facing inlet to a model fan that was used to simulate a variable pitch fan during reverse thrust operation. The total pressure recovery of each of the flared nozzles as well as that of an unflared nozzle and a serrated flare nozzle was obtained for comparison. The aerodynamic performance of a selected flared nozzle was considered in further detail. The nozzle surface pressures for a flared nozzle were also determined Results indicated that the differences in aerodynamic performance among the nozzles were most apparent at the wind-tunnel-off condition A nonzero free stream velocity significantly reduced the perforamnce of all the nozzles, and crosswind flow (free stream flow perpendicular to the model axis) further reduced the performance of the nozzles The unflared nozzle and the serrated flare nozzle had reduced aerodynamic performance compared to a solid surface flared nozzle Author

N76-20145*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EFFECT OF FLAME STABILIZER DESIGN ON PERFORMANCE AND EXHAUST POLLUTANTS OF A TWO-ROW 72-MODULE SWIRL-CAN COMBUSTOR

James A Blaglow and Arthur M Trout Washington Mar 1976 23 p refs

(NASA-TM-X-3373, E-8564) Avail NTIS HC $3 50 CSCL 21E

A test program was conducted to evaluate the effects of four flame stabilizer designs on the performance and gaseous pollutant levels of an experimental full-annular swirl-can combustor Combustor operating parameters, including inlet-air temperature, reference velocity, and fuel-air ratio were set to simulate conditions in a 30 1 pressure ratio engine Combustor inlet total pressure was held constant at 6 atm due to the facility limit Combustor performance and gaseous pollutant levels were strongly affected by the geometry and resulting total pressure loss of the four flame stabilizer designs investigated The addition of shrouds to two designs produced an 18 to 22% decrease in the combustion chamber pressure loss and thus resulted in doubling the exit temperature pattern factor and up to 42% higher levels of oxides of nitrogen. A previously developed oxides of nitrogen correlating parameter agreed with each model within an emission index of plus or minus 1 but was not capable of correlating all models together Author

N76-21200*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

PRELIMINARY EVALUATION OF A TURBINE/ROTARY COMBUSTION COMPOUND ENGINE FOR A SUBSONIC TRANSPORT

Kestutis C Civinskas and Gerald A Kraft Mar 1976 59 p refs Prepared in cooperation with Army Air Mobility Res and Develop Lab , Cleveland

(NASA-TM-X-71906, E-8695) Avail NTIS HC $4 50 CSCL 21E

The fuel consumption of a modern compound engine with that of an advanced high pressure ratio turbofan was compared. The compound engine was derived from a turbofan engine by replacing the combustor with a rotary combustion (RC) engine A number of boost pressure ratios and compression ratios were examined Cooling of the RC engine was accomplished by heat exchanging to the fan duct Performance was estimated with an Otto-cycle for two levels of energy lost to cooling The effects of added complexity on cost and maintainability were not examined and the comparison was solely in terms of cruise performance and weight Assuming a 25 percent Otto-cycle cooling loss (representative of current experience), the best compound engine gave a 1 2 percent improvement in cruise. Engine weight increaseed by 23 percent For a 10 percent Otto-cycle cooling loss (representing advanced insulation/high temperature materials technology), a compound engine with a boost PR of 10 and a compression ratio of 10 gave an 8 1 percent lower cruise than the reference turbofan Author

N76-21201*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

COLD-AIR ANNULAR-CASCADE INVESTIGATION OF AERODYNAMIC PERFORMANCE OF CORE-ENGINE-COOLED TURBINE VANES 2: PRESSURE SURFACE TRAILING EDGE EJECTION AND SPLIT TRAILING EDGE EJECTION

Kerry L McLallin and Louis J Goldman Washington Apr. 1976 24 p refs

(NASA-TM-X-3369; E-8566) Avail NTIS HC $3 50 CSCL 21E

The aerodynamic performance of two trailing edge ejection cooling configurations of a core-engine stator vane were experimentally determined in an ambient inlet-air full-annular cascade where three-dimensional effects could be obtained The tests were conducted at the design mean-radius ideal aftermixed critical velocity ratio of 0 778 Overall vane aftermixed thermodynamic and primary efficiencies were obtained over a range of coolant flows to about 10 percent of the primary flow at a primary to coolant total temperature ratio of 1 0. The radial variation in efficiency and the circumferential and radial variations in vane-exit total pressure were determined Comparisons are made with the solid (uncooled) vane Author

N76-21206*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

NOISE REDUCTION FROM THE REDESIGN OF A FAN STAGE TO MINIMIZE STATOR LIFT FLUCTUATIONS

James H Dittmar and Richard P Woodward 1976 10 p refs Proposed for presentation at 3d Aero-Acoustics Conf , Palo Alto, Calif , 20-23 Jul 1976, sponsored by AIAA

(NASA-TM-X-71896, E-8682) Avail NTIS HC $3 50 CSCL 20A

An existing fan stage, redesigned to reduce stator lift fluctuations, was acoustically tested for reduced noise generation The lift fluctuations on the stator were reduced by increasing the stator chord, adjusting incidence angles, and by adjusting the rotor velocity diagrams The experiments showed significantly reduced broadband noise levels in the middle to high frequencies Blade passage tone power was not reduced, but decreases in the harmonics were observed Aerodynamic improvements in both performance and efficiency were obtained Author

N76-21207*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

MODAL STRUCTURE INFERRED FROM STATIC FAR-FIELD NOISE DIRECTIVITY

Arthur V Saule 1976 12 p refs Proposed for presentation at 3d Aero-Acoustics Conf , Palo Alto, Calif , 20-23 Jul 1976, Sponsored by AIAA

(NASA-TM-X-71909, E-8704) Avail NTIS HC $3 50 CSCL 20A

Turbofan noise directivity calculated for two directivity models was compared with experimental, blade passing frequency data from two fans at 60 and 90 percent speeds Experimental data indicated similar directivity patterns which were well represented by a single average data curve Calculated points using the equal amplitude model showed over-prediction near the fan axis and near the 90 degree position Calculated points using the equal power model showed a very good match with the average data lending support to theory of equipartition of modal power from a random source such as the interaction of the rotor with inlet flow distortion The equal modal power model also gave good agreement with individual data points Author

N76-21208*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

STIMULATION OF A TURBOFAN ENGINE FOR EVALUATION OF MULTIVARIABLE OPTIMAL CONTROL CONCEPTS

Kurt Seldner 1976 12 p refs Prepared for Presentation at Joint Autom Control Conf , Lafayette, Ind , 27-30 Jul. 1976, sponsored by the Am Autom Control Council

(NASA-TM-X-71912, E-8703) Avail NTIS HC $3 50 CSCL 21E

The development of control systems for jet engines requires a real-time computer simulation. The simulation provides an effective tool for evaluating control concepts and problem areas prior to actual engine testing. The development and use of a real-time simulation of the Pratt and Whitney F100-PW 100 turbofan engine is described The simulation was used in a multi-variable optimal controls research program using linear quadratic regulator theory The simulation is used to generate linear engine models at selected operating points and evaluate the control algorithm To reduce the complexity of the design, it is desirable to reduce the order of the linear model A technique to reduce the order of the model, is discussed Selected results between high and low order models are compared The LQR control algorithms can be programmed on digital computer This computer will control the engine simulation over the desired flight envelope. Author

N76-21212*# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio

EXHAUST EMISSIONS FROM A PREMIXING, PREVAPORIZING FLAME TUBE USING LIQUID JET A FUEL

Cecil J Marek and Leonidas C Papathakos Washington Apr 1976 15 p refs

(NASA-TM-X-3383, E-8589) Avail NTIS HC $3 50 CSCL 21E

Emissions of nitrogen oxides, carbon monoxide, and unburned hydrocarbons were measured in a burner where liquid Jet A fuel was sprayed into the heated air stream and vaporized upstream of a perforated plate flameholder The burner was tested at inlet air temperatures at 640, 800, and 833 K, an inlet pressure of 5 6 X 100,000 N/m squared, a reference velocity of 25 m/sec, and equivalence ratios from lean blowout to 0 7 Nitrogen oxide levels of below 1 0 g NO2/kg fuel were obtained at combustion efficiencies greater than 99 percent The measured emission levels for the liquid fuel agreed well with previously reported premixed gaseous propane data and agreed with well stirred reactor predictions Autoignition of the premixed fuel air mixture was a problem at inlet temperatures above 650 K with 104 msec premixing time Author

N76-21213*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

ALTITUDE PERFORMANCE OF A LOW-NOISE-TECHNOLOGY FAN IN A TURBOFAN ENGINE WITH AND WITHOUT A SOUND SUPPRESSING NACELLE

Thomas J. Biesiadny, Rudolph E Grey, and Mahmood Abdelwahab Washington Apr. 1976 31 p refs

(NASA-TM-X-3385, E-8592) Avail NTIS HC $4 00 CSCL 21E

Test variables were inlet Reynolds number index (0 2 to 0 5), flight Mach number (0 2 to 0 8), and flow distortion (tip radial and combined circumferential - tip radial patterns) Results are limited to fan bypass and overall engine performance There were no discernible effects of Reynolds number on fan performance Increasing flight Mach number shifted the fan operating line such that pressure ratio decreased and airflow increased Inlet flow distortion lowered stall margin For a Reynolds number index of 0 2 and flight Mach number of 0 54, the sound suppressing nacelle lowered fan efficiency three points and increased specific fuel consumption about 10 percent Author

N76-22198*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

SPLASH GROOVE FUEL INJECTOR Patent Application

Robert D Ingebo and Carl T Norgren, inventors (to NASA) Filed 7 Apr 1976 16 p

(NASA-Case-LEW-12417-1, US-Patent-Appl-SN-674340) Avail NTIS HC $3 50 CSCL 21E

A patent application relative to a new type of fuel injector, suitable for use on advanced high-pressure and high-temperature turbojet engines, was presented This injector distributes the fuel spray more uniformly across the complete combustor-annulus cross-section, is more reliable in performance, particularly with respect to the usage of contaminated fuels, and requires a lower pressure to maintain the desired fuel atomization It comprises an element having several grooves of successively reduced diameters, each of which provides pairs of circular lips A plurality of circularly symmetrical apertures is arranged to receive and discharge the fuel from exit orifices facing the lip from the surface in a radial plane of the second, adjacent lip of the pair Y.J A

N76-22201*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio

SPECTRAL RADIANCE MEASUREMENTS AND CALCULATED SOOT CONCENTRATIONS ALONG THE LENGTH OF AN EXPERIMENTAL COMBUSTOR

Carl T. Norgren and Robert D. Ingebo Washington Apr. 1976 26 p refs

(NASA-TM-X-3394, E-8630) Avail. NTIS HC $4 00 CSCL 21E

Radiometric data were obtained over a range of parametric test conditions at three positions along the length of an experimental combustor segment corresponding to the primary, intermediate, and dilution zones The concentration of soot entrained in the combustion gases was calculated by a technique using spectral radiance measurements Tests were conducted primarily with Jet A fuel, although limited data were taken with two fuels having higher aromatic content, diesel oil number 2 and a blend of 40 percent tetralin in Jet A fuel Radiometric observation of the combustion gases indicated that the maximum total-radiance peaked at the intermediate zone, which was located immediately upstream of the dilution holes Soot concentrations calculated from optical measurements in the dilution zone compared favorably with those obtained by in situ gas sampling at the exhaust The total radiance increased with the higher aromatic content fuels Author

N76-23265*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

NOISE COMPARISONS OF SINGLE AND TWO STAGE DEMONSTRATOR FANS FOR ADVANCED TECHNOLOGY AIRCRAFT

Marcus F Heidmann 1976 18 p refs Proposed for Presentation at the Third Aeroacoustics Conf, Palo Alto, Calif, 20-23 Jul 1976, sponsored by AIAA

(NASA-TM-X-71899, E-8688) Avail NTIS HC $3 50 CSCL 20A

A high-speed single-stage and a low-speed two-stage fan were designed, fabricated, and tested to demonstrate their predicted low noise performance for an advanced 0 85-0 90 cruise Mach number aircraft requiring a 1 8-1 9 pressure ratio fan Acoustic tests were made with both unsuppressed and suppressed configurations The two-stage fan demonstrated that quiet fan technology developed for low-speed single-stage fan is applicable to two-stage designs The unsuppressed high-speed single-stage fan demonstrated that significant reductions in inlet noise can be achieved from the sonic blockage caused by supersonic flow in the rotor blading Both fans demonstrated suppressed inlet noise levels with treated sonic inlets that met advanced technology goals. Author

N76-23266*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio

PRELIMINARY RESULTS FROM SCREENING TESTS OF COMMERCIAL CATALYSTS WITH POTENTIAL USE IN GAS TURBINE COMBUSTORS. PART 1: FURNACE STUDIES OF CATALYST ACTIVITY

David N. Anderson 1976 21 p refs Presented at Workshop on Catalytic Combust, Raleigh, N C, 25-26 May 1976 sponsored by EPA

(NASA-TM-X-73410, E-8742) Avail: NTIS HC $3.50 CSCL 21E

Thirty commercially produced monolith and pellet catalysts were tested as part of a screening process to select catalysts suitable for use in a gas turbine combustor. The catalysts were contained in a 1.8 centimeter diameter quartz tube and heated to temperatures varying between 300 and 1,200 K while a mixture of propane and air passed through the bed at space velocities of 44,000 to 70,000/hour The amount of propane oxidized was measured as a function of catalyst temperature Of the samples tested, the most effective catalysts proved to be noble metal catalysts on monolith substrates Author

N76-23267*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland Ohio.

RESULTS OF THE POLLUTION REDUCTION TECHNOLOGY PROGRAM FOR TURBOPROP ENGINES

Edward J Mularz 1976 13 p refs Proposed for Presentation at the Twelfth Propulsion Conf, Palo Alto, Calif., 26-29 Jul. 1976; Cosponsored by AIAA and SAE

(NASA-TM-X-71911, E-8713) Avail NTIS HC $3 50 CSCL 21E

A program was performed to evolve and demonstrate advanced combustor technology aimed at achieving the 1979 EPA standards for turboprop engines (Class P2). The engine selected for this program was the 501-D22A turboprop Three combustor concepts were designed and tested in a combustor

rig at the exact combustor operating conditions of the 50-D22A engine over the EPA landing-takeoff cycle. Each combustor concept exhibited pollutant emissions well below the EPA standards, achieving substantial reductions in unburned hydrocarbons, carbon monoxide, and smoke emissions compared with emissions from the production combustor of this engine Oxides of nitrogen emissions remained well below the EPA standards, also Author

N76-23268*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

NOISE REDUCTION AS AFFECTED BY THE EXTENT AND DISTRIBUTION OF ACOUSTIC TREATMENT IN A TURBOFAN ENGINE INLET

Gene L Minner and Len Homyak 1976 18 p refs Presented at 3d Aero-Acoustics Conf, Palo Alto, Calif, 20-22 Jul 1976, sponsored by AIAA

(NASA-TM-X-71904, E-8693) Avail. NTIS HC $3 50 CSCL 20A

An inlet noise suppressor for a TF-34 engine designed to have three acoustically treated rings was tested with several different ring arrangements The configurations included all three rings, two outer rings, single outer ring, single intermediate ring, and finally no rings It was expected that as rings were removed, the acoustic performance would be degraded considerably While a degradation occurred, it was not as large as predictions indicated The prediction showed good agreement with the data only for the full-ring inlet configuration The underpredictions which occurred with ring removal were believed a result of ignoring the presence of spinning modes which are known to damp more rapidly in cylindrical ducts than would be predicted by least attenuated mode or plane wave analysis Author

N76-23269*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

PRELIMINARY RESULTS FROM SCREENING TESTS OF COMMERCIAL CATALYSTS WITH POTENTIAL USE IN GAS TURBINE COMBUSTORS. PART 2 COMBUSTION TEST RIG EVALUATION

David N Anderson 1976 26 p refs Presented at Workshop on Catalytic Combustion, Raleigh, N C, 23-26 May 1976, sponsored by EPA

(NASA-TM-X-73412, E-8744) Avail NTIS HC $4.00 CSCL 21E

Several commercial monolithic catalysts were tested in a combustion test rig to determine their suitability for use in a gas turbine combuster primary zone. The catalyst test bed consisted of two to four elements of 12-centimeter diameter by 2.5-centimeter long monolith Results are presented of the measured combustion efficiency and catalyst bed temperature history for an inlet propane-air mixture temperature of 800 K, a pressure of 300,000 newtons per square meter, inlet velocities of 10 to 25 meters per second and equivalence ratios of 0 1 to 0 3 The best catalysts tested gave combustion efficiencies of virtually 100 percent for reaction temperatures ranging from 1,325 K at 10 meters per second to 1,400 K at 25 meters per second This performance was only possible with fresh catalysts The catalysts tested were not specifically developed for use at these conditions and showed some loss in activity after about 3 hours' testing Author

N76-23271*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EMISSIONS OF OXIDES OF NITROGEN FROM AN EXPERIMENTAL PREMIXED-HYDROGEN BURNER

David N Anderson Washington May 1976 20 p refs

(NASA-TM-X-3393, E-8664) Avail NTIS HC $3 50 CSCL 21E

Flame-tube experiments using premixed hydrogen and air were conducted to determine the emissions of oxides of nitrogen (NOx) resulting from ultralean combustion Measurements of NOx emissions and combustion efficiency were made for inlet mixture temperatures of 600 and 700 K, pressures of 3 8 x 10 to the 5th power and 5 2 x 10 to the 5th power N/m squared, reference velocities of 15 to 18 m/sec, and equivalence ratios of 0 2 to 0.4. At the 700 K inlet mixture temperature, NOx emissions were 0 06 ppmv, and combustion efficiency was 98 percent at an equivalence ratio of 0.24 The use of a high-blockage (92-percent blockage) flameholder made it possible to conduct tests without upstream burning in the premixing duct for mixtures with equivalence ratios less than 0 4 For richer mixtures upstream burning did occur and prevented further testing Author

N76-24241*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

THRUST PERFORMANCE OF ISOLATED, TWO-DIMENSIONAL SUPPRESSED PLUG NOZZLES WITH AND WITHOUT EJECTORS AT MACH NUMBERS FROM 0 TO 0 45

Douglas E Harrington, James J Schloemer (GE Co., Cincinnati), and Stanley A Skebe Washington May 1976 36 p refs

(NASA-TM-X-3384; E-8556) Avail NTIS HC $4 00 CSCL 21E

A series of two-dimensional plug nozzles was tested with and without ejector shrouds at free stream Mach numbers from 0 to 0.45 and over a range of nozzle pressure ratios from 2 to 4. These nozzles were also tested with and without chute noise suppressors A two-dimensional plug nozzle has an efficiency of 96.1 percent at an assumed takeoff pressure ratio of 3.0 and Mach 0 36 A 12-chute suppressed nozzle with sidewalls has an efficiency of 81 0 percent (15 1 percent below the unsuppressed nozzle) Author

N76-24242*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

SMALL, LOW-COST, EXPENDABLE TURBOJET ENGINE 1 DESIGN, FABRICATION, AND PRELIMINARY TESTING

Robert P. Dengler and Lawrence E Macioce Washington May 1976 51 p refs

(NASA-TM-X-3392; E-8590) Avail NTIS HC $4 50 CSCL 21E

A small experimental axial-flow turbojet engine in the 2,669-Newton (600-lbf) thrust class was designed, fabricated, and tested to demonstrate the feasibility of several low-cost concepts Design simplicity was stressed in order to reduce the number of components and machining operations Four engines were built and tested for a total of 157 hours. Engine testing was conducted at both sea-level static and simulated flight conditions for engine speeds as high as 38,000 rpm and turbine-inlet temperatures as high as 1,255 K (1,800 F). Author

N76-25183* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

TURBOFAN COMPRESSOR DYNAMICS DURING AFTERBURNER TRANSIENTS

Anatole P Kurkov *In* AGARD Unsteady Phenomena in Turbomachinery Apr 1976 12 p refs (For availability see N76-25169 16-07)

The effects of afterburner light-off and shut-down transients on the compressor stability are investigated The reported experimental results are based on detailed high response pressure and temperature measurements on the TF30-P-3 turbofan engine The tests were performed in an altitude test chamber simulating high altitude engine operation It is shown that during both types of transients, flow breaks down in the forward part of the fan bypass duct At a sufficiently low engine inlet pressure this resulted in a compressor stall Complete flow breakdown within the compressor was preceded by a rotating stall At some locations in the compressor rotating stall cells initially extended only through part of the blade span For the shutdown transient the time between first and last detected occurrence of rotating stall is related to the flow Reynolds number An attempt was made to deduce the number and speed of propagation of rotating stall cells Author

N76-25184* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

THE EFFECT OF CIRCUMFERENTIAL DISTORTION ON FAN PERFORMANCE AT TWO LEVELS OF BLADE LOADING

Melvin J Hartmann and Nelson L Sanger *In* AGARD Unsteady Phenomena in Turbomachinery Apr 1976 26 p refs (For availability see N76-25169 16-07)

Single stage fans designed for two levels of pressure ratio or blade loading were subjected to screen induced circumferential distortions of 90 degree extent. Both fan rotors were designed for a blade tip speed of 425 m/sec, blade solidity of 1 3 and a hub to tip radius ratio of 0 5 Circumferential measurements of total pressure, temperature static pressure, and flow angle were obtained at the hub, mean and tip radii at five axial stations Rotor loading level did not appear to have a significant influence on rotor response to distorted flow Losses in overall pressure ratio due to distortion were most severe in the stator hub region of the more highly loaded stage At the near stall operating condition tip and hub regions of (either) rotor demonstrated different response characteristics to the distorted flow. No effect of loading was apparent on interactions between rotor and upstream distorted flow fields Author

N76-26199*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

THE NASA POLLUTION-REDUCTION TECHNOLOGY PROGRAM FOR SMALL JET AIRCRAFT ENGINES Status Report

James S Fear 1976 19 p refs Presented at the 12th Propulsion Conf, Palo Alto, Calif, 26-29 Jul 1976, sponsored by AIAA and Soc of Automotive Engr

(NASA-TM-X-73419, E-8757) Avail NTIS HC $3 50 CSCL 21E

Three advanced combustor concepts, designed for the AiResearch TFE 731-2 turbofan engine, were evaluated in screening tests. Goals for carbon monoxide and unburned hydrocarbons were met or closely approached with two of the concepts with relatively modest departures from conventional combustor design practices. A more advanced premixing/prevaporizing combustor, while appearing to have the potential for meeting the oxides of nitrogen goal as well, will require extensive development to make it a practical combustion system Smoke numbers for the two combustor concepts were well within the EPA smoke standard Phase 2, Combustor-Engine Compatibility Testing, which is in its early stages, and planned Phase 3, Combustor-Engine Demonstration Testing, are also described Author

N76-27237*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

A METHOD TO ACCOUNT FOR VARIATION OF AVERAGE COMPRESSOR INLET PRESSURE DURING INSTANTANEOUS DISTORTION ANALYSES

Paul L Burstadt and Leon M Wenzel 1976 11 p refs Presented at the 12th Propulsion Conf, Palo Alto, Calif., 26-29 Jul. 1976 sponsored by AIAA and SAE

(NASA-TM-X-73438, E-8793) Avail NTIS HC $3 50 CSCL 21E

A method is presented to calculate the available surge margin as a function of time and incorporate it into an instantaneous distortion analysis Results show that inlet pressure variations which cause only a small change at the compressor exit can cause a significant variation in the available surge margin Author

N76-30216*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

ACOUSTIC, PERFORMANCE, AND WAKE SURVEY MEASUREMENTS OF A LOBED VELOCITY-DECAYER NOZZLE INSTALLED ON A QUIETED TF-34 TURBOFAN ENGINE

Nick E Samanich and Laurence J. Heidelberg Washington Aug 1976 47 p refs

(NASA-TM-X-3413, E-8676) Avail NTIS HC $4 00 CSCL 21E

Results for three velocity decayer nozzle configurations are compared with those obtained with a separate flow coannular nozzle tested on the same quieted turbofan engine Peak sideline noise, which occurred 110 degrees from the inlet; was 2 to 4 db louder than with the coannular nozzle at the same ideal effective exhaust velocity and 8 to 11 db louder at the same thrust level The decayer nozzles produced an increase in loss equivalent to about 4 percent of the engine thrust and also increased the effective exhaust velocity of the engine. The exhaust decayed to 0 35 of its peak velocity, compared with no decay for the coannular nozzle, within 3 equivalent nozzle diameters of the exit. The peak exhaust gas temperature was 400 K lower for the decayer configuration at the same location The increase in perceived noise level for the decayer nozzles as compared with the coannular nozzle was attributed to the increase in exhaust velocity and the shift in peak spectrum frequency produced by these nozzles Author

N76-30217*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

VARIABLE-CYCLE ENGINES FOR SUPERSONIC CRUISE AIRCRAFT

Edward Willis 1976 21 p refs Presented at AGARD Propulsion Conf., Paris, 6-9 Sep 1976

(NASA-TM-X-73463; E-8826) Avail NTIS HC $3 50 CSCL 21E

Progress and the current status of the Variable Cycle Engine (VCE) study are reviewed with emphasis placed on the impact of technology advancements and design specifications. A large variety of VCE concepts are also examined B B

N76-32192*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

DURABILITY OF ZIRCONIA THERMAL-BARRIER CERAMIC COATINGS ON AIR-COOLED TURBINE BLADES IN CYCLIC JET ENGINE OPERATION

Curt H. Liebert, Richard E Jacobs, Stephan Stecura, and C Robert Morse Washington Sep 1976 17 p refs

(NASA-TM-X-3410, E-8700) Avail NTIS HC $3 50 CSCL 21E

Thermal barrier ceramic coatings of stabilized zirconia over a bond coat of Ni Cr Al Y were tested for durability on air cooled turbine rotor blades in a research turbojet engine Zirconia stabilized with either yttria, magnesia, or calcia was investigated On the basis of durability and processing cost, the yttria stabilized zirconia was considered the best of the three coatings investigated Author

N76-33206*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

EFFECTS OF LONG-CHORD ACOUSTICALLY TREATED STATOR VANES ON FAN NOISE. 2: EFFECT OF ACOUSTICAL TREATMENT

James H. Dittmar, James N Scott, Bruce R Leonard, and Edward G. Stakolich Washington Oct 1976 99 p refs

(NASA-TN-D-8250; E-8736) Avail: NTIS HC $5 00 CSCL 21E

A set of long chord stator vanes was designed to replace the vanes in an existing fan stage The long chord stator vanes consisted of a turning section and axial extension pieces, all of which incorporated acoustic damping material. The long chord stator vanes were tested in two lengths, with the long version giving more noise reduction than the short, primarily because of the additional lining material. The noise reduction achieved with the acoustically treated long chord stator vanes was compared with the reduction achieved by an acoustically treated exhaust splitter. The long chord stator was at least as good as the splitter as a method for incorporating acoustic lining material. In addition, comparing an acoustic three ring inlet and an acoustic wall-only inlet discloses that the wall-only inlet could be used in an engine where the noise reduction requirements are not too stringent Author

A76-18783 * # **Measurement of model propulsion system noise in a low-speed wind tunnel.** J H Diedrich and R. W. Luidens (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 14th, Washington, D.C., Jan. 26-28, 1976, Paper 76-91.* 12 p. 14 refs

Methods are presented for making overall and directional acoustic measurements with forward velocity in the Lewis 9 x 15 V/STOL Wind Tunnel. Overall acoustic measurements are discussed first. The acoustic calibration methods, instrumentation features, and types of experiments are presented. Selected data are presented as examples of the various types of overall measurements that are possible. The method of making directional acoustic measurements is then presented The necessary alterations to the tunnel, specialized acoustic instrumentation, and calibration details are described. The results indicate that relative overall acoustic measurements can be made successfully and that directional acoustic measurements are feasible (Author)

A76-20150 * # **Effect of fuel properties on performance of a single aircraft turbojet combustor** H F Butze and R. C Ehlers (NASA, Lewis Research Center, Cleveland, Ohio) *Combustion Institute, Fall Meeting, Palo Alto, Calif., Oct 20, 21, 1975, Paper* 15 p 10 refs.

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 NOx, as well as liner temperatures and smoke At the simulated idle condition no significant differences in performance were observed. At cruise, liner temperatures and smoke increased sharply with decreasing hydrogen content of the fuel. No significant differences were observed in the performance of an oil-shale derived JP-5 and a petroleum-based Jet A fuel except for emissions of NOx which were higher with the oil-shale JP-5. The difference is attributed to the higher concentration of fuel-bound nitrogen in the oil-shale JP-5 (Author)

A76-22286 * **Experience with integrally-cast compressor and turbine components for a small, low-cost, expendable-type turbojet engine.** R. P. Dengler (NASA, Lewis Research Center, Cleveland, Ohio). *Society of Automotive Engineers, National Aerospace Engineering and Manufacturing Meeting, Culver City, Calif., Nov 17-20, 1975, Paper 751048* 22 p. 10 refs

A discussion regarding experiences with integrally-cast compressor and turbine components during fabrication and testing of four engine assemblies of a small (29 cm (11-1/2 in) maximum diameter) experimental turbojet engine design for an expendable application is presented. Various operations such as metal removal, welding, and re-shaping of these components are performed in preparation of full-scale engine tests Engines with these components have been operated for a total of 157 hours at engine speeds as high as 38,000 rpm and at turbine inlet temperatures as high as 1256 K (1800 F). (Author)

A76-22326 * # **A review of the QCSEE program.** C C. Ciepluch (NASA, Lewis Research Center, Cleveland, Ohio). *Society of Automotive Engineers, National Aerospace Engineering and Manufacturing Meeting, Culver City, Calif., Nov. 17-20, 1975, Paper.* 23 p

A description of the overall QCSEE (Quiet Clean Short-haul Experimental Engine) Program is presented. The design of the two experimental engines in the program is essentially completed. The engine designs are described and projections of their performance presented. And finally, the advanced technology elements being incorporated into the engines are discussed. (Author)

A76-25131 * # **Reduction of noise from a fan stage for a turbofan engine by use of long-chord acoustically-treated stator vanes.** J. H. Dittmar and J. N. Scott (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 90th, San Francisco, Calif., Nov. 3-7, 1975, Paper.* 27 p. 11 refs.

A set of acoustically-treated long-chord vanes was designed to replace the vanes in an existing fan stage to investigate the noise reduction possibilities of both increased stator chord length and this method of incorporating acoustic damping material The vanes were tested with both active and inactive acoustic surfaces. The inactive tests showed significant broadband noise effects with noise reductions in the middle to high frequencies and an increase at low frequencies. No reduction in blade passage tone was observed, but decreases in the overtones were observed The tests with the active acoustic treatment showed large noise reductions over a wide frequency range (Author)

A76-25765 * # **Measurement of exhaust emissions from two J-58 engines at simulated supersonic cruise flight conditions.** J. D. Holdeman (NASA, Lewis Research Center, Combustion and Pollution Research Branch, Cleveland, Ohio) *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 21-25, 1976, Paper 76-GT-8.* 13 p. 14 refs. Members, $1.50; nonmembers, $3.00.

Emissions of total oxides of nitrogen, unburned hydrocarbons, carbon monoxide, and carbon dioxide from two J-58 afterburning turbojet engines at simulated high-altitude flight conditions are reported. Test conditions included flight speeds from Mach 2 to 3 at altitudes from 16 to 23 km. For each flight condition, exhaust measurements were made for four or five power levels from maximum power without afterburning through maximum afterburning. The data show that exhaust emissions vary with flight speed, altitude, power level, and radial position across the exhaust. Oxides of nitrogen emissions decreased with increasing altitude and increased with increasing flight speed. NO(x) emission indices with afterburning were less than half the value without afterburning. Carbon monoxide and hydrocarbon emissions increased with increasing altitude and decreased with increasing flight speed. Emissions of these species were substantially higher with afterburning than without. (Author)

A76-25767 * # **Swirl-can combustor performance to near-stoichiometric fuel-air-ratio.** L A. Diehl and J A. Blaglow (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La , Mar. 21-25, 1976, Paper 76-GT-10* 10.p. 12 refs Members, $1 50, nonmembers, $3 00

Emissions and performance characteristics were determined for two full-annulus swirl-can modular combustors operated to near-stoichiometric fuel air ratios The purposes of the tests were to obtain stoichiometric data at inlet-air temperatures up to 894 K and to determine the effect of module number by investigating 120 and 72 module swirl-can combustors The maximum average exit temperature obtained with the 120-module swirl-can combustor was 2465 K with a combustion efficiency of 95 percent at an inlet-air temperature of 894 K. The 72-module swirl-can combustor reached a maximum average exit temperature of 2306 K with a combustion efficiency of 92 percent at an inlet-air temperature of 894 K At a constant inlet air temperature, maximum oxides of nitrogen emission index values occurred at a fuel-air ratio of 0.037 for the 72-module design and 0 044 for the 120-module design. The combustor average exit temperature and combustion efficiency were calculated from emissions measurements. The measured emissions included carbon monoxide, unburned hydrocarbons, oxides of nitrogen, and smoke (Author)

A76-25769 * # Advanced low NO/x/ combustors for supersonic high-altitude aircraft gas turbines P B. Roberts, J. R. Shekleton, D. J White (International Harvester Co., San Diego, Calif), and H. F Butze (NASA, Lewis Research Center, Air Breathing Engines Div., Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La , Mar. 21-25, 1976, Paper 76-GT-12.* 19 p. 9 refs. Members, $1.50, nonmembers, $3.00. NASA-supported research.

A test rig program was conducted with the objective of evaluating and minimizing the exhaust emissions, in particular NO(x), of two advanced aircraft combustor concepts at a simulated, high-altitude cruise condition. The two combustor designs, both members of the lean-reaction, pre-mixed family, are known as the Jet Induced Circulation (JIC) combustor and the Vortex Air Blast (VAB) combustor and were rig tested in the form of reverse flow can combustors in the 0.127-m size range. Various configuration modifications were applied to each of the initial JIC and VAB combustor model designs in an effort to reduce the emissions levels. The VAB combustor demonstrated a NO(x) level of 1.1 gm NO2/kg fuel with essentially 100 percent combustion efficiency at the simulated cruise combustor condition of 507 kPa, 833 K inlet pressure and temperature, respectively and 1778 K outlet temperature on Jet-A1 fuel. In addition, emissions data were obtained at low combustor inlet pressure and temperatures that indicate the potential performance at engine off-design conditions (Author)

A76-25875 * # Advanced turbine disk designs to increase reliability of aircraft engines. A Kaufman (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 21-25, 1976, Paper.* 32 p. NASA-supported research.

Results of analytical studies to improve the low cycle fatigue lives and reliability of turbine disks in high-performance gas turbine engines are presented. Advanced disk concepts were evaluated for the first-stage high pressure turbines of the CF6-50 and JT8D-17 engines. The advanced disk designs are compared to the existing disks on the bases of cycles to crack initiation and overspeed capability for initially unflawed disks, crack propagation cycles to failure for initially flawed disks, and available kinetic energy of disk burst fragments. (Author)

A76-38060 * # Noise reduction as affected by the extent and distribution of acoustic treatment in a turbofan engine inlet. G. L Minner and L Homyak (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-541* 13 p 9 refs

An inlet noise suppressor for a TF-34 engine designed to have three acoustically treated rings was tested with several different ring arrangements The configurations included all three rings, two outer rings, single outer ring, single intermediate ring, and finally no rings It was expected that as rings were removed, the acoustic performance would be degraded considerably. While a degradation occurred, it was not as large as predictions indicated In fact, the prediction showed good agreement with the data only for the full-ring inlet configuration. The under-predictions which occurred with ring removal were believed a result of ignoring the presence of spinning modes which are known to damp more rapidly in cylindrical ducts than would be predicted by least attenuated mode or plane wave analysis. (Author)

A76-38066 * # Wing shielding of high-velocity jet and shock-associated noise with cold and hot flow jets. U. von Glahn, D Groesbeck, and J. Wagner (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-547* 13 p. 6 refs

Jet exhaust noise shielding data are presented for cold and hot flows (ambient to 1100 K) and pressure ratios from 1.7 to 2.75 A nominal 9 5-cm diameter conical nozzle was used with simple shielding surfaces that were varied in length from 28 8 to 114 3 cm. The nozzle was located 8.8 cm above the surfaces The acoustic data with the various shielding lengths are compared to each other and to that for the nozzle alone In general, short shielding surfaces that provided shielding for subsonic jets did not provide as much shielding for jets with shock noise, however, long shielding surfaces did shield shock noise effectively. (Author)

A76-38085 * # Noise comparisons of single and two stage demonstrator fans for advanced technology aircraft. M. F. Heidmann (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-572* 12 p. 15 refs

A high-speed single-stage and a low-speed two-stage fan were designed, fabricated and tested to demonstrate their predicted low noise performance for an advanced 0.85 0 90 cruise Mach number aircraft requiring a 1 8-1 9 pressure ratio fan. Acoustic tests were made with both unsuppressed and suppressed configurations The two-stage fan demonstrated that quiet fan technology developed for low-speed single-stage fan is applicable to two-stage designs The unsuppressed two-stage fan was 3-5 dB quieter than the high-speed single-stage fan at the same pressure ratio The unsuppressed high-speed single-stage fan demonstrated that significant reductions in inlet noise can be achieved from the sonic blockage caused by supersonic flow in the rotor blading Both fans demonstrated suppressed inlet noise levels with treated sonic inlets that met advanced technology goals. Suppressed aft noise levels did not meet expectations for either fan The aft noise problem is attributed to both excessive source noise and ineffective treatment performance. (Author)

A76-38086 * # Acoustic and aerodynamic effects of rotor pitch angle for a variable-pitch, 6-foot diameter fan stage. R. P. Woodward and F W Glaser (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-573* 12 p 7 refs

An externally-driven, 1.2 pressure-ratio full-scale fan stage with an adjustable pitch rotor was tested in an outdoor facility at the Lewis Research Center Rotor pitch angles resulting in minimum sideline perceived noise levels are defined as a function of stage thrust. Thrust corrected fan noise variations are examined for operation at constant thrust, rotor tip speed, and stage work coefficient At constant stage thrust, reducing the rotor pitch angle below design values increased the fan noise with the greatest change occurring in the blade passing tone level At constant fan speed the minimum noise occurred at a particular rotor pitch angle, which was not the minimum thrust condition. With constant stage work coefficient, rear quadrant noise increased at above-design speed conditions. (Author)

A76-38088 * # Noise reduction from the redesign of a fan stage to minimize stator lift fluctuations J. H Dittmar and R. P Woodward (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-576* 9 p. 10 refs.

An existing fan stage, redesigned to reduce stator lift fluctuations, was acoustically tested for reduced noise generation. The lift fluctuations on the stator were reduced by increasing the stator chord, adjusting incidence angles, and by adjusting the rotor velocity diagrams The experiments showed significantly reduced broadband noise levels in the middle to high frequencies. Blade passage tone power was not reduced, but decreases in the harmonics were observed Aerodynamic improvements in both performance and efficiency were obtained (Author)

A76-38168 * # **The NASA Pollution-Reduction Technology Program for small jet aircraft engines - A status report.** J. S Fear (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-616* 13 p.

A three-phase experimental program is described which has the objective of enabling EPA Class T1 jet engines to meet the 1979 EPA emissions standards In Phase I, three advanced combustor concepts, designed for the AiResearch TFE 731-2 turbofan engine, were evaluated in screening tests. Goals for carbon monoxide and unburned hydrocarbons were met or closely approached with two of the concepts with relatively modest departures from conventional combustor design practices A more advanced premixing/ prevaporizing combustor, while appearing to have the potential for meeting the oxides of nitrogen goal as well, will require extensive development to make it a practical combustion system Smoke numbers for the two combustor concepts which will be carried forward into Phase II of the program were well within the EPA smoke standard. Phase II, Combustor-Engine Compatibility Testing, which is in its early stages, and planned Phase III, Combustor-Engine Demonstration Testing, are also described (Author)

A76-42408 * # **Investigation of upper-surface-blowing nacelle integration at cruise speeds utilizing powered engine simulators.** E. T. Meleason (NASA, Lewis Research Center, Cleveland, Ohio) and O. D. Wells (McDonnell Douglas Corp., Long Beach, Calif.). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-623* 22 p. 14 refs

Various overwing nacelle designs were investigated on a representative four-engine short-haul aircraft configuration during a combined analytical and experimental program. Design conditions were a Mach number of 0 7 and a lift coefficient of 0.4 All nacelles had D-shaped nozzle exits and included a streamline-contoured design, a low boattail angle reference configuration, and a high boattail angle powered lift design. Testing was done with the design four-engine airplane configuration as well as with only inboard nacelles installed Turbopowered engine simulators were used to provide realistic representation of nacelle flows. Performance trends are compared for the various nacelle designs In addition, comparisons are presented between analytical and experimental pressure distributions and between flow-through and powered simulator results (Author)

A76-42409 * # **Boundary layer thickness effect on boattail drag** B J Blaha, R. Chamberlin, and L. J Bober (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-676.* 22 p. 14 refs.

A combined experimental and analytical program has been conducted at the NASA Lewis Research Center, to investigate the effects of boundary layer changes on the flow over high angle boattail nozzles. The tests were run on an isolated axisymmetric sting mounted model. Various boattail geometries were investigated at high subsonic speeds over a range of boundary layer thicknesses. In general, boundary layer effects were small at speeds up to Mach 0 8. However, at higher speeds significant regions of separated flow were present on the boattail. When separation was present large reductions in boattail drag resulted with increasing boundary layer thickness The analysis predicts both of these trends. (Author)

A76-42410 * # **Variable-cycle engines for supersonic cruising aircraft.** E. A Willis (NASA, Lewis Research Center, Cleveland, Ohio) and A D. Welliver (Boeing Aerospace Co., Seattle, Wash). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-759.* 11 p. 22 refs. NASA-supported research.

The paper reviews the evolution and current status of selected recent variable-cycle engine (VCE) studies and describes how the results are influenced by airplane requirements The engine/airplane studies are intended to identify promising VCE concepts, simplify their designs and identify the potential benefits in terms of aircraft performance. This includes range, noise, emissions, and the time and effort it may require to ensure technical,readiness of sufficient depth to satisfy reasonable economic, performance, and environmental constraints A brief overview of closely-related, on-going technology programs in acoustics and exhaust emissions is presented It is shown that realistic technology advancements in critical areas combined with well matched aircraft and selected VCE concepts can lead to significantly improved economic and environmental performance relative to first-generation SST predictions. (Author)

A76-42411 * # **Flight experience with a digital integrated propulsion control system on an F-111E airplane.** F W. Burcham, Jr (NASA, Flight Research Center, Propulsion Control Branch, Edwards, Calif.) and P. G. Batterton (NASA, Lewis Research Center, Analysis Section, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-653* 15 p. 6 refs.

A digital integrated propulsion control system (IPCS) installed in the left side of an F-111 E aircraft was tested in flight. The F-111 aircraft was selected for the IPCS program because it incorporated a variable geometry inlet and an afterburning turbofan engine and had two engines, one of which could remain in the normal configuration to ensure flight safety. Flight data were compared with results of tests run in an altitude test chamber. The digital system was found to be capable of duplicating the standard engine and inlet control systems Instabilities such as inlet buzz and afterburner rumble were detected and controlled. The usefulness of an altitude chamber for developing a software and testing hardware was proven. The flexibility of IPCS was demonstrated when an autothrottle, ar in-flight thrust calculation, and a coannular noise study capability were added at the end of the flight tests S D

A76-46056 * # **Advanced combustion techniques for controlling NO/x/ emissions of high altitude cruise aircraft.** R A. Rudey and G. M. Reck (NASA, Lewis Research Center, Cleveland, Ohio). *International Astronautical Federation, International Astronautical Congress, 27th, Anaheim, Calif., Oct. 10-16, 1976, Paper 76-108.* 12 p. 12 refs

An array of experiments have been and continue to be sponsored and conducted by NASA to explore the potential of advanced combustion techniques for controlling the emissions of aircraft into the upper atmosphere. Of particular concern are the oxides of nitrogen (NO/x/) emissions into the stratosphere. The experiments utilize a wide variety of approaches varying from advanced combustor concepts to fundamental flame tube experiments Results are presented which indicate that substantial reductions in cruise NO/x/ emissions should be achievable in future aircraft engines. A major NASA program is described which focuses the many fundamental experiments into a planned evolution and demonstration of the prevaporized-premixed combustion technique in a full-scale engine. (Author)

N76-10123*# Georgia Inst of Tech , Atlanta
COMBUSTION GENERATED NOISE IN GAS TURBINE COMBUSTORS
W C Strahle and B N Shivashankara Aug 1974 41 p refs
(Contract NAS3-17861)
(NASA-CR-134843) Avail NTIS HC $3 75 CSCL 21E

Experiments were conducted to determine the noise power and spectra emitted from a gas turbine combustor can exhausting to the atmosphere Limited hot wire measurements were made of the cold flow turbulence level and spectra within the can. The fuels used were JP-4, acetone and methyl alcohol burning with air at atmospheric pressure. The experimental results show that for a fixed fuel the noise output is dominated by the airflow rate and not the fuel/air ratio The spectra are dominated by the spectra of the cold flow turbulence spectra which were invariant with airflow rate in the experiments The effect of fuel type on the noise power output was primarily through the heat of combustion and not the reactivity A theory of combustion noise based upon the flame radiating to open surroundings is able to reasonably explain the observed results A thermoacoustic efficiency for noise radiation as high as .00003 was observed in this program for JP-4 fuel Scaling rules are presented for installed configurations Author

N76-10124*# Pratt and Whitney Aircraft, East Hartford, Conn
EXPERIMENTAL CLEAN COMBUSTOR PROGRAM, PHASE 1 Final Report
R Roberts, A Peduzzi, and G E Vitti Oct 1975 214 p refs
(Contract NAS3-16829)
(NASA-CR-134736, PWA-5153) Avail, NTIS HC $7 25 CSCL 12E

A program of screening three low emission combustors for conventional takeoff and landing, by testing and analyzing thirty-two configurations is presented. Configurations were tested that met the emission goals at idle operating conditions for carbon monoxide and for unburned hydrocarbons (emission index values of 20 and 4, respectively). Configurations were also tested that met a smoke number goal of 15 at sea-level take-off conditions None of the configurations met the goal for oxides of nitrogen emissions at sea-level take-off conditions The best configurations demonstrated oxide of nitrogen emission levels that were approximately 61 percent lower than those produced by the JT9D-7 engine, but these levels were still approximately 24 percent above the goal of an emission index level of 10 Additional combustor performance characteristics, including lean blowout, exit temperature pattern factor and radial profile, pressure loss, altitude stability, and altitude relight characteristics were documented The results indicate the need for significant improvement in the altitude stability and relight characteristics In addition to the basic program for current aircraft engine combustors, seventeen combustor configurations were evaluated for advanced supersonic technology applications. The configurations were tested at cruise conditions and a conceptual design was evolved Author

N76-10127*# Advanced Technology Labs , Inc . Westbury, N Y.
STUDY OF VARIABLE CYCLE ENGINES EQUIPPED WITH SUPERSONIC FANS
Horacio Trucco Sep 1975 110 p refs
(Contract NAS3-17559)
(NASA-CR-134777, ATL-TR-201) Avail NTIS HC#5 25 CSCL 21E

Two types of variable cycle jet engines were investigated One called Variable Bypass Engine resembles a conventional bypass engine, the second is called Bleed-Burn Engine and is characterized by remote supersonic fan units These engines are characterized by the utilization of a supersonic fan to energize their bypassed flow Performance calculations show that both engines exhibit substantial reduction in fuel consumption in comparison to contemporary variable cycle engines In addition, these engines are smaller and of lighter installed weight Mission range for the case of a supersonic transport with 236 passenger cruising at Mach 2 70 were calculatd for these new engines The Variable Bypass Engine displays the best performance with relative reduction in takeoff gross weight of the order of 90,720 kg (200,000 lb) for the basic 7,408-km (4,000 N Mi) mission when compared to a conventional Duct Heating Turbofan Engine For the case of the Bleed-Burn Engine the same mission can be achieved with about 45,360 kg (100,000 lb) takeoff gross weight reduction These potentials warrant a more detailed and wider analysis of these engines which should assign first priority to the design and test of an applicable supersonic fan Author

N76-10128*# Pratt and Whitney Aircraft, East Hartford, Conn
NOISE ADDENDUM EXPERIMENTAL CLEAN COMBUSTOR PROGRAM, PHASE 1 Final Report, Dec 1973 - Jul. 1974
T. G. Sofrin and D. A Ross Oct 1975 120 p refs
(Contract NAS3-16829)
(NASA-CR-134820, PWA-5252) Avail NTIS HC $5 25 CSCL 21E

The development of advanced CTOL aircraft engines with reduced exhaust emissions is discussed Combustor noise information provided during the basic emissions program and used to advantage in securing reduced levels of combustion noise is included Results are presented of internal pressure transducer measurements made during the scheduled emissions test program on ten configurations involving variations of three basic combustor designs Author

N76-10129*# General Electric Co , Cincinnati, Ohio Aircraft Engine Group
DEMONSTRATION OF SHORT-HAUL AIRCRAFT AFT NOISE REDUCTION TECHNIQUES ON A TWENTY INCH (50.8 cm) DIAMETER FAN, VOLUME 1 An Early Domestic Dissemination Report
D L Stimpert and R A. McFalls Apr. 1975 121 p refs 3 Vol.
(Proj. FEDD; Contract NAS3-18021)
(NASA-CR-134849, R75AEG252-Vol-1) Avail NASA Regional Dissemination Centers only to U S Requesters. HC $5 25/MF $2.25 CSCL 21E

Scale models were tested in an anechoic chamber. The various techniques employed were source noise reduction features of selection of vane-blade ratio to reduce second harmonic noise, spacing effects, and lowering the Mach number through a vane row Aft suppression features were investigated which included porosity effects, variable depth treatment, and treatment regenerated flow noise Photographs of test equipment and hardware are included. Author

N76-10130*# General Electric Co , Cincinnati, Ohio Aircraft Engine Group.
DEMONSTRATION OF SHORT-HAUL AIRCRAFT AFT NOISE REDUCTION TECHNIQUES ON A TWENTY INCH (50 8 cm) DIAMETER FAN, VOLUME 2 An Early Domestic Dissemination Report
D L Stimpert Apr. 1975 307 p 3 Vol.
(Proj FEDD, Contract NAS3-18021)
(NASA-CR-134850, R75AEG252-Vol-2) Avail NASA Regional Dissemination Centers only to U S Requesters HC $9 25/MF $2 25 CSCL 21E

The 1/3 octave band sound data are plotted for various combinations of fan speeds, acoustic angles, and frequencies Author

N76-10131*# General Electric Co , Cincinnati, Ohio Aircraft Engine Group
DEMONSTRATION OF SHORT-HAUL AIRCRAFT AFT NOISE REDUCTION TECHNIQUES OF A TWENTY INCH (50 8 cm) DIAMETER FAN, VOLUME 3 An Early Domestic Dissemination Report
D L Stimpert Apr 1975 725 p 3 Vol
(Proj FEDD; Contract NAS3-18021)
(NASA-CR-134851, R75AEG252-Vol-3) Avail NASA Regional Dissemination Centers only to U S Requesters HC $17 25/MF $2 25 CSCL 21E

The 1/3 octave band sound data are presented for all the configurations tested The model data are presented on 17 foot (5 2 cm) arc and extrapolated to 200 foot (60 96 m) sideline Author

N76-10133*# Pratt and Whitney Aircraft, East Hartford, Conn
REDESIGNED ROTOR FOR A HIGHLY LOADED, 1800 FT/SEC TIP SPEED COMPRESSOR FAN STAGE 1: AERODYNAMIC AND MECHANICAL DESIGN
J E. Halle and J T Ruschak Sep 1975 68 p refs
(Contract NAS3-18020)
(NASA-CR-134835, PWA-5266) Avail NTIS HC $4.25 CSCL 21E

A highly loaded, high tip-speed fan rotor was designed with multiple-circular-arc airfoil sections as a replacement for a marginally successful rotor which had precompression airfoil sections The substitution of airfoil sections was the only aerodynamic change Structural design of the redesigned rotor blade was guided by successful experience with the original blade Calculated stress levels and stability parameters for the redesigned rotor are within limits demonstrated in tests of the original rotor Author

N76-11098*# Solar, San Diego, Calif.
ADVANCED LOW NO SUB x COMBUSTORS FOR SUPERSONIC HIGH-ALTITUDE AIRCRAFT GAS TURBINES Report for Mar. 1974 - Jun. 1975
P B Roberts, D. J. White, and J R Shekleton Nov. 1975 81 p refs
(Contract NAS3-18028)
(NASA-CR-134889, RDR-1814) Avail. NTIS HC $5 00 CSCL 21E

A test rig program was conducted with the objective of evaluating and minimizing the exhaust emissions, in particular NO sub x, of three advanced aircraft combustor concepts at a simulated, high altitude cruise condition The three combustor designs, all members of the lean reaction, premixed family, are the Jet Induced Circulation (JIC) combustor, the Vortex Air Blast (VAB) combustor, and a catalytic combustor They were rig tested in the form of reverse flow can combustors in the 0 127 m (5.0 in.) size range Various configuration modifications were applied to each of the initial JIC and VAB combustor model designs in an effort to reduce the emissions levels. The VAB combustor demonstrated a NO sub x level of 1.1 gm NO2/kg fuel with essentially 100% combustion efficiency at the simulated cruise combustor condition of 50 7 N/sq cm (5 atm), 833 K (1500 R) inlet pressure and temperature respectively and 1778 K (3200 R) outlet temperature on Jet-A1 fuel Early tests on the catalytic combustor were unsuccessful due to a catalyst deposition problem and were discontinued in favor of the JIC and VAB tests. In addition emissions data were obtained on the JIC and VAB combustors at low combustor inlet pressure and temperatures that indicate the potential performance at engine off-design conditions Author

N76-12067*# Pratt and Whitney Aircraft, East Hartford, Conn
PROGRAM FOR REFAN JT8D ENGINE DESIGN, FABRICATION AND TEST, PHASE 2 Final Report
J. A Glass, E S Zimmerman, and V. M Scaramella Nov 1975 367 p refs
(Contract NAS3-17840)
(NASA-CR-134876, PWA-5299) Avail. NTIS HC $10 50 CSCL 21E

The objective of the JT8D refan program was to design, fabricate, and test certifiable modifications of the JT8D engine which would reduce noise generated by JT8D powered aircraft. This was to be accomplished without affecting reliability and maintainability, at minimum retrofit cost, and with no performance penalty. The mechanical design, engine performance and stability characteristics at sea-level and altitude, and the engine noise characteristics of the test engines are documented. Results confirmed the structural integrity of the JT8D-109 Engine operation was stable throughout the airplane flight envelope Fuel consumption of the test engines was higher than that required to meet the goal of no airplane performance penalty, but the causes were identified and corrected during a normal pre-certification engine development program Compared to the baseline JT8D-109 engine, the acoustically treated JT8D-109 engine showed noise reductions of 6 PNdB at takeoff and 11 PNdB at a typical approach power setting Author

N76-13089*# Pratt and Whitney Aircraft, East Hartford, Conn
RESULTS OF ACOUSTIC TESTING OF THE JT8D-109 REFAN ENGINES
E. A Burdsall, F. P. Brochu, and V M Scaramella Nov 1975 369 p refs
(Contract NAS3-17840)
(NASA-CR-134875, PWA-5298) Avail NTIS HC $10.50 CSCL 20A

A JT8D engine was modified to reduce jet noise levels by 6-8 PNdB at takeoff power without increasing fan generated noise levels Designated the JT8D-109, the modified engines featured a larger single stage fan, and acoustic treatment in the fan discharge ducts Noise levels were measured on an outdoor test facility for eight engine/acoustic treatment configurations Compared to the baseline JT8D, the fully treated JT8D-109 showed reductions of 6 PNdB at takeoff, and 11 PNdB at a typical approach power setting. Author

N76-14128*# Cabot Corp., Kokomo, Ind Satellite Div
OPTIMIZATION OF AN OXIDE DISPERSION STRENGTHENED Ni-Cr-Al ALLOY FOR GAS TURBINE ENGINE VANES Final Report
D. L. Klarstrom and R Grierson Oct 1975 104 p refs
(Contract NAS3-17806)
(NASA-CR-134901) Avail NTIS HC $5 50 CSCL 21E

The investigation was carried out to determine the optimum alloy within the Ni-16Cr-Al-Y2O3 system for use as a vane material in advanced aircraft gas turbine engines Six alloys containing nominally 4%, 5% and 6% Al with Y2O3 levels of 0 8% and 1 2% were prepared by mechanical attrition Six small-scale, rectangular extrusions were produced from each powder lot for property evaluation The approximate temperatures for incipient melting were found to be 1658 K (2525 F), 1644 K (2500 F) and 1630 K (2475 F) for the 4%, 5% and 6% aluminum levels, respectively With the exception of longitudinal crystallographic texture, the eight extrusions selected for extensive evaluation either exceeded or were close to mechanical property goals. Major differences between the alloys became apparent during dynamic oxidation testing, and in particular during the 1366 K (2000 F) /500 hour Mach 1 tests carried out by NASA-Lewis An aluminum level of 4 75% was subsequently judged to be optimum based on considerations of dynamic oxidation resistance, susceptibility to thermal fatigue cracking and melting point. Author

N76-14129*# General Electric Co., Cincinnati, Ohio Aircraft Engine Group
ADVANCED SUPERSONIC PROPULSION SYSTEM TECHNOLOGY STUDY, PHASE 2 Final Report
R D Allan Dec 1975 94 p
(Contract NAS3-16950)
(NASA-CR-134913; R75AEG508) Avail. NTIS HC $5 00 CSCL 21E

Variable cycle engines were identified, based on the mixed-flow low-bypass-ratio augmented turbofan cycle, which has shown excellent range capability in the AST airplane The best mixed-flow augmented turbofan engine was selected based on range in the AST Baseline Airplane Selected variable cycle engine features were added to this best conventional baseline engine, and the Dual-Cycle VCE and Double-Bypass VCE were defined The conventional mixed-flow turbofan and the Double-Bypass VCE were on the subjects of engine preliminary design studies to determine mechanical feasibility, confirm weight and dimensional estimates, and identify the necessary technology considered not yet available Critical engine components were studied and incorporated into the variable cycle engine design Author

N76-17144*# General Electric Co., Cincinnati, Ohio.
ADDITIONAL DESIGN STUDIES OF THE NASA/NAVY LIFT/CRUISE FAN
5 Jan. 1976 34 p refs
(Contract NAS3-19411)
(NASA-CR-134928; R76AEG152) Avail. NTIS HC $4.00 CSCL 21E

Additional preliminary design studies were performed for a

turbotip lift/cruise fan propulsion system for a Navy multimission aircraft The LCF459/J97 propulsion system was previously designed for this application These studies extended the analysis in areas of (1) scroll commonality, (2) increased engine-out contingency ratings, (3) mounting systems, (4) manufacturing cost reductions, and (5) vulnerability Author

N76-17149*# General Applied Science Labs, Inc, Westbury, N.Y.
EFFECT OF PREMIXING QUALITY ON OXIDES OF NITROGEN IN GAS TURBINE COMBUSTORS FOI HC Final Report
Gerald Roffe and Antonio Ferri Feb 1976 52 p refs
(Contract NAS3-18563)
(NASA-CR-2657, TR-793) Avail NTIS HC $4 50 CSCL 21E

Experiments were conducted to determine the effectiveness of several premixing prevaporizing gas turbine combustor designs in reducing formation of oxides of nitrogen at the supersonic cruise condition An atomized spray from a single injector mounted on the axis of the mixer tube produced a high initial concentration of fuel near the axis and only moderate premixed conditions entering the combustor A fuel spray produced by 12 flush-mounted normal injection orifices in the mixer tube wall produced a good initial despersion of fuel and resulted in nearly complete premixing Oxides of nitrogen emission levels of the order of 0 2 g NO2/kg fuel were obtained at 99 percent combustion efficiency at an equivalence ratio of 0 4 Overall total pressure drop was less than 3 percent through the 1-meter combustor module Author

N76-18118*# Boeing Commercial Airplane Co, Seattle, Wash
PHASE 2 PROGRAM ON GROUND TEST OF REFANNED JT8D TURBOFAN ENGINES AND NACELLES FOR THE 727 AIRPLANE. VOLUME 1 SUMMARY Final Report
Dec 1975 58 p refs 4 Vol
(Contract NAS3-17842)
(NASA-CR-134797; BCAC-D6-42440-1-Vol-1) Avail. NTIS HC $4 50 CSCL 21E

The propulsion performance, acoustic, structural, and systems changes to a 727-200 airplane retrofitted with a refan modification of the JT8D turbofan engine are evaluated Model tests, design of certifiable airplane retrofit kit hardware, manufacture of test hardware, ground test of a current production JT8D engine, followed by test of the same engine modified to the refan configuration detailed analyses of the retrofit impact on airplane airworthiness, performance, and noise, and a preliminary analysis of retrofit costs are included Results indicate that the refan retrofit of the 727-200 would be certifiable and would result in a 6-to 8 EPNdb reduction in effective perceived noise level (EPNL) at the FAR 36 measuring points and an annoyance-weighted footprint area reduction of 68% to 83% The installed refan engine is estimated to provide 14% greater takeoff thrust at zero velocity and 10% greater thrust at 100 kn (51 4 m/s) There would be an approximate 0 6% increase in cruise specific fuel consumption (SFC) The refan engine performance in conjunction with the increase in stalled weight results in a range reduction of approximately 15% over the unmodified airplane at the same brake release gross weight (BRGW), with a block fuel increase of 1 5% to 3% With the particular model 727 that was studied, however, it is possible to operate the airplane (with minor structural modifications) at a higher BRGW and increase the range up to approximately 15% relative to the nonrefanned airplane (with equal or slightly increased noise levels) The JT8D refan engine also improves the limited-field range of the airplane Author

N76-18119*# Boeing Commercial Airplane Co, Seattle, Wash
PHASE 2 PROGRAM ON GROUND TEST OF REFANNED JT8D TURBOFAN ENGINES AND NACELLES FOR THE 727 AIRPLANE VOLUME 2 HARDWARE DESIGN AND MANUFACTURING Final Report
Dec 1975 197 p refs 4 Vol
(Contract NAS3-17842)
(NASA-CR-134798, BCAC-D6-42440-2-Vol-2) Avail NTIS HC $7 50 CSCL 21E

For abstract, see N76-18118

N76-18123*# Avco Lycoming Div, Stratford, Conn
SELF-ACTING SEALS FOR HELICOPTER ENGINES
Peter Lynwander Oct 1975 119 p refs
(Contract NAS3-18015)
(NASA-CR-134940, LYC-75-78) Avail. NTIS HC $5 50 CSCL 21E

An experimental evaluation was conducted with NASA-designed self-acting face and circumferential seals for use in the main shaft positions of advanced gas turbine engines The seals featured Rayleigh step pads (self-acting geometry) for lift augmentation The tested seals incorporated design improvements over previous self-acting configurations Self-acting face seals were tested to speeds of 214 m/s (700 ft/sec, 63700 rpm), air pressures of 216 8 N/sq cm abs (314 7 psia), and air temperatures of 688K (778 F) Self-acting circumferential seals were tested to speeds of 183 m/s (600 ft/sec, 47700 rpm), air pressures of 61 8 N/sq cm abs (89 7 psia), and air temperatures of 711 K (820 F) Self-acting face-seals are capable of operating at conditions exceeding conventional seal capability. The limit on speed capability was found to be the flatness of the seal-seat The self-acting circumferential seal design tested requires further development for use in advanced engines Author

N76-20140*# Pratt and Whitney Aircraft, East Hartford, Conn
IMPROVED TURBINE DISK DESIGN TO INCREASE RELIABILITY OF AIRCRAFT JET ENGINES
A S Alver and J K Wong Oct 1975 66 p ref
(Contract NAS3-18558)
(NASA-CR-134985, PWA-5329) Avail NTIS HC $4 50 CSCL 21E

An analytical study was conducted on a bore entry cooled turbine disk for the first stage of the JT8D-17 high pressure turbine which had the potential to improve disk life over existing design The disk analysis included the consideration of transient and steady state temperature, blade loading, creep, low cycle fatigue, fracture mechanics and manufacturing flaws The improvement in life of the bore entry cooled turbine disk was determined by comparing it with the existing disk made of both conventional and advanced (Astroloy) disk materials. The improvement in crack initiation life of the Astroloy bore entry cooled disk is 87% and 67% over the existing disk made of Waspaloy and Astroloy, respectively. Improvement in crack propagation life is 124% over the Waspaloy and 465% over the Astroloy disks The available kinetic energies of disk fragments calculated for the three disks indicate a lower fragment energy level for the bore entry cooled turbine disk Author

N76-20142*# General Electric Co, Cincinnati, Ohio. Aircraft Engine Group
QUIET, CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) TEST RESULTS FROM A 14 cm INLET FOR A VARIABLE PITCH FAN THRUST REVERSER
W F Vier Dec 1975 34 p refs
(Contract NAS3-18021)
(NASA-CR-134867; R75AEG387) Avail. NTIS HC $4 00 CSCL 21E

A 1/13th scale model of the fan discharge duct was tested with a matrix of flare exlets Exlets are flared fan nozzles configured for improved reverse flow inlet performance for reverse pitch fan applications Results showed that a flare type exlet is an acceptable design for QCSEE, as indicated by high pressure recovery and low distortion performance Author

N76-20146*# Pratt and Whitney Aircraft, East Hartford, Conn
DESIGN OF A 4 1/2 STAGE TURBINE WITH A STAGE LOADING FACTOR OF 4.66 AND HIGH SPECIFIC WORK OUTPUT Final Report
P. F. Webster Washington NASA Mar. 1976 138 p refs
(Contract NAS3-18033)
(NASA-CR-2659; PWA-5101) Avail NTIS HC $6 00 CSCL 21E

The aerodynamic design of a highly loaded multistage fan drive turbine is discussed Turbine flowpath and airfoil sections

are presented along with respective pressure and velocity distributions. Vibrational modes are identified in the expected turbine operating range. Author

N76-21205*# Pratt and Whitney Aircraft, East Hartford, Conn
MODELING AND ANALYSIS OF THE TF30-P-3 COMPRESSOR SYSTEM WITH INLET PRESSURE DISTORTION
R S Mazzawy and G A Banks Apr 1976 133 p refs
(Contract NAS3-18535)
(NASA-CR-134996, PWA-5302) Avail NTIS HC $6 00 CSCL 21E

Circumferential inlet distortion testing of a TF30-P-3 afterburning turbofan engine was conducted at NASA-Lewis Research Center. Pratt and Whitney Aircraft analyzed the data using its multiple segment parallel compressor model and classical compressor theory. Distortion attenuation analysis resulted in a detailed flow field calculation with good agreement between multiple segment model predictions and the test data Sensitivity of the engine stall line to circumferential inlet distortion was calculated on the basis of parallel compressor theory to be more severe than indicated by the data However, the calculated stall site location was in agreement with high response instrumentation measurements Author

N76-21210*# Pratt and Whitney Aircraft, East Hartford Conn
COUPLING OF HELMHOLTZ RESONATORS TO IMPROVE ACOUSTIC LINERS FOR TURBOFAN ENGINES AT LOW FREQUENCY
L W Dean Aug 1975 66 p refs
(Contract NAS3-18552)
(NASA-CR-134912; PWA-5311) Avail NTIS HC $4.50 CSCL 21E

An analytical and test program was conducted to evaluate means for increasing the effectiveness of low frequency sound absorbing liners for aircraft turbine engines Three schemes for coupling low frequency absorber elements were considered These schemes were analytically modeled and their impedance was predicted over a frequency range of 50 to 1,000 Hz An optimum and two off-optimum designs of the most promising, a parallel coupled scheme, were fabricated and tested in a flow duct facility. Impedance measurements were in good agreement with predicted values and validated the procedure used to transform modeled parameters to hardware designs Measurements of attenuation for panels of coupled resonators were consistent with predictions based on measured impedance All coupled resonator panels tested showed an increase in peak attenuation of about 50% and an increase in attenuation bandwidth of one one-third octave band over that measured for an uncoupled panel. These attenuation characteristics equate to about 35% greater reduction in source perceived noise level (PNL), relative to the uncoupled panel, or a reduction in treatment length of about 24% for constant PNL reduction The increased effectiveness of the coupled resonator concept for attenuation of low frequency broad spectrum noise is demonstrated Author

N76-22197*# Pratt and Whitney Aircraft East Hartford, Conn
STUDY OF TURBOFAN ENGINES DESIGNED FOR LOW ENERGY CONSUMPTION Final Report
D E Gray Apr 1976 119 p refs
(Contract NAS3-19132)
(NASA-CR-135002, PWA-5318) Avail NTIS HC $5 50 CSCL 21E

The near-term technology improvements which can reduce the fuel consumed in the JT9D, JT8D, and JT3D turbofans in commercial fleet operation through the 1980's are identified Projected technology advances are identified and evaluated for new turbofans to be developed after 1985 Programs are recommended for developing the necessary technology Author

N76-22200*# General Electric Co , Cincinnati, Ohio Aircraft Engine Group
BLADE ROW DYNAMIC DIGITAL COMPRESSOR PROGRAM VOLUME 1 J85 CLEAN INLET FLOW AND PARALLEL COMPRESSOR MODELS
W. A Tesch and W G Steenken Mar 1976 218 p refs
(Contract NAS3-18526)
(NASA-CR-134978, R75AEG406) Avail NTIS HC $7 75 CSCL 21E

The results are presented of a one-dimensional dynamic digital blade row compressor model study of a J85-13 engine operating with uniform and with circumferentially distorted inlet flow Details of the geometry and the derived blade row characteristics used to simulate the clean inlet performance are given A stability criterion based upon the self developing unsteady internal flows near surge provided an accurate determination of the clean inlet surge line The basic model was modified to include an arbitrary extent multi-sector parallel compressor configuration for investigating 180 deg 1/rev total pressure total temperature, and combined total pressure and total temperature distortions The combined distortions included opposed, coincident, and 90 deg overlapped patterns The predicted losses in surge pressure ratio matched the measured data trends at all speeds and gave accurate predictions at high corrected speeds where the slope of the speed lines approached the vertical Author

N76-23261*# Pratt and Whitney Aircraft, West Palm Beach, Fla Research and Development Center.
SINGLE-STAGE EXPERIMENTAL EVALUATION OF LOW ASPECT RATIO, HIGHLY LOADED BLADING FOR COMPRESSORS. PART 9: STAGE F AND STAGE G, VOLUME 1 Final Report
J G Cheatham, J D. Smith, and D L. Wright May 1976 261 p refs
(Contract NAS3-11158)
(NASA-CR-134993, PWA-FR-7033-Pt-9-Vol-1) Avail NTIS HC $9 00 CSCL 21E

Two single-stage, 0 77 hub/tip ratio axial-flow compressors were tested to evaluate the effectiveness of low aspect ratio blading as a means of obtaining higher stage loadings One compressor designated Stage F, was comprised of circular arc blading with an aspect ratio of 0 9 for both the rotor and stator This compressor was tested with uniform inlet flow hub radial, tip radial, and 180 deg arc circumferential inlet distortion The second compressor, designated Stage G, was comprised of multiple circular arc blading with an aspect ratio of 1.0 for both the rotor and stator This compressor was tested with uniform inlet flow only Design rotor tip speeds for Rotor F and Rotor G were 285 m/sec (934 ft/sec) and 327 m/sec (1,074 ft/sec) respectively Both stages operated at high loading levels with adequate efficiency and operating range The peak efficiencies and corresponding average stage diffusion factors for Stages F and G at design rotor speed were 86 4% and 84.1% and 0 59 and 0 55 respectively The surge margin at peak efficiency for Stage F was 12 6% and the corresponding value for Stage G was 16 5% Both stages experienced a loss in efficiency with increasing rotor speed; however, the multiple circular arc rotor delayed the characteristic loss in efficiency within increasing Mach number to higher Mach number Author

N76-23262*# Pratt and Whitney Aircraft West Palm Beach, Fla. Research and Development Center
SINGLE-STAGE EXPERIMENTAL EVALUATION OF LOW ASPECT RATIO, HIGHLY LOADED BLADING FOR COMPRESSORS. PART 9: STAGE F AND STAGE G VOLUME 2: DATA SUPPLEMENT Final Report
J G Cheatham, J D, Smith, and D L Wright May 1976 236 p
(Contract NAS3-11158)
(NASA-CR-134994, PWA-FR-7033-Pt-9-Vol-2) Avail NTIS HC $8 00 CSCL 21E

For abstract, see N76-23261

N76-24235*# Pratt and Whitney Aircraft, East Hartford, Conn.
POLLUTION TECHNOLOGY PROGRAM, CAN-ANNULAR COMBUSTOR ENGINES
R. Roberts, A J. Fiorentino, and W. Greene May 1976 131 p refs
(Contract NAS3-18548)
(NASA-CR-135027, PWA-5394) Avail NTIS HC $6 00 CSCL 21E

A Pollution Reduction Technology Program to develop and demonstrate the combustor technology necessary to reduce exhaust emissions for aircraft engines using can-annular combustors is described The program consisted of design, fabrication, experimental rig testing and assessment of results and was conducted in three program elements The combustor configurations of each program element represented increasing potential for meeting the 1979 Environmental Protection Agency (EPA) emission standards, while also representing increasing complexity and difficulty of development and adaptation to an operational engine Experimental test rig results indicate that significant reductions were made to the emission levels of the baseline JT8D-17 combustor by concepts in all three program elements One of the Element I single-stage combustors reduced carbon monoxide to a level near, and total unburned hydrocarbons (THC) and smoke to levels below the 1979 EPA standards with little or no improvement in oxides of nitrogen The Element II two-stage advanced Vorbix (vortex burning and mixing) concept met the standard for THC and achieved significant reductions in CO and NOx relative to the baseline Although the Element III prevaporized-premixed concept reduced high power NOx below the Element II results, there was no improvement to the integrated EPA parameter relative to the Vorbix combustor Author

N76-24236*# General Electric Co , Evendale, Ohio Advanced Engineering and Technology Programs Dept
SINGLE STAGE, LOW NOISE, ADVANCED TECHNOLOGY FAN VOLUME 1: AERODYNAMIC DESIGN
T J Sullivan, J L Younghans, and D R. Little Mar. 1976 145 p refs
(Contract NAS3-16813)
(NASA-CR-134801, R76AEG257-Vol-1) Avail NTIS HC $6.00 CSCL 21E

The aerodynamic design for a half-scale fan vehicle, which would have application on an advanced transport aircraft, is described The single stage advanced technology fan was designed to a pressure ratio of 1 8 at a tip speed of 503 m/sec 11,650 ft/sec) The fan and booster components are designed in a scale model flow size convenient for testing with existing facility and vehicle hardware. The design corrected flow per unit annulus area at the fan face is 215 kg/sec sq m (44.0 lb m/sec sq ft) with a hub-tip ratio of 0 38 at the leading edge of the fan rotor This results in an inlet corrected airflow of 117 9 kg/sec (259 9 lb m/sec) for the selected rotor tip diameter if 90 37 cm (35 58 in.). The variable geometry inlet is designed utilizing a combination of high throat Mach number and acoustic treatment in the inlet diffuser for noise suppression (hybrid inlet) A variable fan exhaust nozzle was assumed in conjunction with the variable inlet throat area to limit the required area change of the inlet throat at approach and hence limit the overall diffusion and inlet length The fan exit duct design was primarily influenced by acoustic requirements, including length of suppressor wall treatment, length, thickness and position on a duct splitter for additional suppressor treatment, and duct surface Mach numbers Author

N76-24237*# General Electric Co , Evendale, Ohio Advanced Engineering and Technology Programs Dept.
SINGLE STAGE, LOW NOISE, ADVANCED TECHNOLOGY FAN. VOLUME 2: STRUCTURAL DESIGN
J. L Schoener, G. R. Black, and R. H. Roth Mar. 1976 50 p refs
(Contract NAS3-16813)
(NASA-CR-134802, R76AEG258-Vol-2) Avail: NTIS HC $4.00 CSCL 21E

The structural design for a half-scale fan vehicle, which would have application on an advanced transport aircraft, is described The single stage advanced technology fan was designed to a pressure ratio of 1 8 at a tip speed of 503 m/sec (1 650 ft/sec) This mechanical design report describes the fan rotor design and the design of various structures of the vehicle, eg, stators, casings, splitters, seals, adapters, etc Author

N76-24238*# General Electric Co , Evendale, Ohio Advanced Engineering and Technology Programs Dept
SINGLE STAGE, LOW NOISE ADVANCED TECHNOLOGY FAN. VOLUME 3: ACOUSTIC DESIGN
S B Kazin and R B. Mishler Mar 1976 56 p refs
(Contract NAS3-16813)
(NASA-CR-134803, R76AEG259-Vol-3) Avail NTIS HC $4 50 CSCL 21E

The acoustic design for a half-scale fan vehicle, which would have application on an advanced transport aircraft, is described The single stage advanced technology fan was designed to a pressure ratio of 1 8 at a tip speed of 503 m/sec (1,650 ft/sec) The two basic approaches taken in the acoustic design were (1) minimization of noise at the source, and (2) suppression of the generated noise in the inlet and bypass exhaust duct Suppression of the generated noise is accomplished in the inlet through use of the hybrid concept (wall acoustic treatment plus airflow acceleration suppression) and in the exhaust duct with extensive acoustic treatment including a splitter The goal of the design was attainment of twenty effective perceived noise decibels (20 EPNdB) below current Federal Air Regulation noise standards for a full-scale fan at the takeoff, cutback, and approach conditions Predicted unsuppressed and suppressed fore and aft maximum perceived noise levels indicate that the cutback condition is the most critical with respect to the goal, which is probably unattainable for that condition. This is also true for aft radiated noise in the approach condition Author

N76-25167*# Pratt and Whitney Aircraft, West Palm Beach Fla Government Products Div
EFFECT OF SWIRLING FLOW ON AUGMENTOR PERFORMANCE, PHASE 2 Final Report, Dec. 1974 - Dec. 1975
T R Clements Jun 1976 80 p refs
(Contract NAS3-19413)
(NASA-CR-135024 FR-7436) Avail NTIS HC S5 00 CSCL 21E

A test program has been conducted with an augmentor that employed swirling flow as a means of promoting rapid flame propagation The program measured the trajectory and dispersion of JP-5-type kerosene sprayed into a strongly swirling flowfield Using the data obtained, a set of sprayrings was designed and evaluated in the augmentor at conditions simulating those typical of augmented turbojet engines At the inlet test temperature of 649 C the swirling flowfield had no effect on the radial position of the fuel spray The augmentor demonstrated combustion efficiencies greater than 95% over most of the operating range, which extended from an equivalence ratio of 0 2 to over 1 0 Author

N76-26195*# Pratt and Whitney Aircraft, East Hartford, Conn
TWO-STAGE, LOW NOISE ADVANCED TECHNOLOGY FAN. VOLUME 2: AERODYNAMIC DATA
K G Harley and P A Odegard Sep 1975 366 p refs
(Contract NAS3-16811)
(NASA-CR-134828, PWA-5258-Vol-2) Avail NTIS HC $10 50 CSCL 21E

Aerodynamic data from static tests of a two-stage advanced technology fan designed to minimize noise are presented Fan design conditions include delivery of 209.1kg/sec/sq m (42 85 lbm/sec/sq ft) specific corrected flow at an overall pressure ratio of 1 9 and an adiabatic efficiency of 85 3 percent The 0 836m (2.74ft) diameter first stage rotor has a hub/tip ratio of 0 4 and 365 8m/sec (1200ft/sec) design tip speed In addition to the moderate tip speed and pressure rise per stage, other noise control design features involve widely spaced blade rows and proper selection of blade-vane ratios Aerodynamic data are presented for tests with uniform and with hub and tip radially distorted inlet flow Aerodynamic data are also presented for tests of this fan with acoustic treatments, including acoustic-

ally treated casing walls, a flowpath exit acoustic ring, and a translating centerbody sonic inlet device A complete tabulation of the overall performance data, the blade element data, and the power spectral density information relating to turbulence levels generated by the sonic inlet obtained during these tests is included For vol 1, see N74-33789 Author

N76-26196*# Pratt and Whitney Aircraft, East Hartford, Conn
TWO-STAGE, LOW NOISE ADVANCED TECHNOLOGY FAN VOLUME 3 ACOUSTIC DATA
T G Sofrin and N Riloff, Jr Sep 1975 316 p refs
(Contract NAS3-16811)
(NASA-CR-134829, PWA-5303-Vol-3) Avail NTIS HC $9 75 CSCL 21E

Tabulations and plots of the principal farfield noise characteristics of the fan installed in a special outdoor static noise test facility are presented Author

N76-26197*# Pratt and Whitney Aircraft, East Hartford, Conn.
TWO-STAGE, LOW NOISE ADVANCED TECHNOLOGY FAN. 4. AERODYNAMIC FINAL REPORT
K G Harley and M J Keenan Sep 1975 177 p refs
(Contract NAS3-16811)
(NASA-CR-134830, PWA-5304) Avail NTIS HC $7 50 CSCL 21E

A two-stage research fan was tested to provide technology for designing a turbofan engine for an advanced, long range commercial transport having a cruise Mach number of 0 85 -0 9 and a noise level 20 EPNdB below current requirements The fan design tip speed was 365 8m/sec (1200ft/sec).the hub/tip ratio was 0.4, the design pressure ratio was 1 9, and the design specific flow was 209 2 kg/sec/sq m(42 85lbm/sec/sq ft) Two fan-versions were tested a baseline configuration, and an acoustically treated configuration with a sonic inlet device The baseline version was tested with uniform inlet flow and with tip-radial and hub-radial inlet flow distortions The baseline fan with uniform inlet flow attained an efficiency of 86 4% at design speed, but the stall margin was low. Tip-radial distortion increased stall margin 4 percentage points at design speed and reduced peak efficiency one percentage point Hub-radial distortion decreased stall margin 4 percentage points at all speeds and reduced peak efficiency at design speed 8 percentage points At design speed, the sonic inlet in the cruise position reduced stall margin one percentage point and efficiency 1 5 to 4 5 percentage points The sonic inlet in the approach position reduced stall margin 2 percentage points Author

N76-26198*# Pratt and Whitney Aircraft East Hartford, Conn
TWO-STAGE, LOW NOISE ADVANCED TECHNOLOGY FAN 5: ACOUSTIC FINAL REPORT
T G Sofrin and N Riloff, Jr Sep 1975 115 p refs
(Contract NAS3-16811)
(NASA-CR-134831 PWA-5305) Avail NTIS HC $5 50 CSCL 21E

The NASA Q2S(quiet two-stage) fan is a 0.836m (32 9 in) diameter model of the STF 433 engine fan, selected in a 1972 study for an Advanced Technology Transport (ATT) airplane Noise-control features include low tip speed, moderate stage pressure rise, large blade-vane spacings, no inlet guide vanes, and optimum blade and vane numbers Tests were run on the baseline Q2S fan with standard inlet and discharge ducts Further tests were made of a translating centerbody sonic inlet device and treated discharge ducts Results were scaled to JT8D and JT3D engine fan size for comparison with current two-stage fans, and were also scaled to STF 433 fan size to compare calculated ATT flyover noise with FAR 36 limits Baseline Q2S results scaled to JT8D and JT3D engine fan sizes showed substantial noise reductions Calculated unsuppressed baseline ATT flyovers averaged about 2 5 EPNdB below FAR 36 limits Using measured sonic inlet results, scaled baseline Q2S fan results, and calculated attenuations for a 1975 technology duct liner, projected flyover noise calculations for the ATT averaged about FAR 36 limits minus 10 EPNdB. Advances in suppression technology required to meet the 1985 goal of FAR 36 limits minus 20 EPNdB are discussed Author

N76-26201*# General Electric Co , Cincinnati, Ohio Aircraft Engine Group
AN IMPROVED TURBINE DISK DESIGN TO INCREASE RELIABILITY OF AIRCRAFT JET ENGINES
W N. Barack and P A Domas Jul. 1976 142 p refs
(Contract NAS3-18564)
(NASA-CR-135033: R76AEG324) Avail NTIS HC $6.00 CSCL 21E

An analytical study was performed on a novel disk design to replace the existing high-pressure turbine, stage 1 disk on the CF6-50 turbofan engine Preliminary studies were conducted on seven candidate disk design concepts. An integral multidisk design with bore entry of the turbine blade cooling air was selected as the improved disk design This disk has the unique feature of being redundant such that if one portion of the disk would fail, the remaining portion would prevent the release of large disk fragments from the turbine system Low cycle fatigue lives, initial defect propagation lives, burst speed, and the kinetic energies of probable disk fragment configurations were calculated, and comparisons were made with the existing disk, both in its current material, IN 718, and with the substitution of an advanced alloy, Rene 95. The design for redundancy approach which necessitated the addition of approximately 44 5 kg (98 lb) to the design disk substantially improved the life of the disk The life to crack initiation was increased from 30,000 cycles to more than 100,000 cycles The cycles to failure from initial defect propagation were increased from 380 cycles to 1564 cycles Burst speed was increased from 126 percent overspeed to 149 percent overspeed Additionally, the maximum fragment energies associated with a failure were decreased by an order of magnitude Author

N76-27240*# General Electric Co , Cincinnati, Ohio Dept of Advanced Engineering and Technology Programs
QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE) AERODYNAMIC CHARACTERISTICS OF 30.5 CENTIMETER DIAMETER INLETS
D L Paul Aug 1975 102 p refs
(Contract NAS3-18021)
(NASA-CR-134866, R75AEG494) Avail: NTIS HC $5 50 CSCL 21E

A low speed test program was conducted in a 9- by 15-foot V/STOL wind tunnel to investigate internal performance characteristics and determine key design features required for an inlet to meet the demanding operational conditions of the QCSEE application Four models each having a design average throat Mach number of 0 79 were tested over a range of incidence angle, throat Mach number, and freestream velocity Principal design variable was internal lip diameter ratio Stable, efficient inlet performance was found to be feasible at and beyond the 50 deg incidence angle required by the QCSEE application at its 41 2 m/sec (80 knot) nominal takeoff velocity, through suitably designed inlet lip and diffuser components Forebody design was found to significantly impact flow stability via nose curvature Measured inlet wall pressures were used to select a location for the inlet throat Mach number control's static pressure port that properly balanced the conflicting demands of relative insensitivity to flow incidence and sufficiently high response to changes in engine flow demand Author

N76-28237*# Detroit Diesel Allison, Indianapolis, Ind Dept of Combustion Research and Development
POLLUTION REDUCTION TECHNOLOGY PROGRAM, TURBOPROP ENGINES, PHASE 1
R D Anderson, A S Herman, J. G Tomlinson, J M Vaught, and A J Verdouw Mar 1976 134 p refs
(Contract NAS3-18561)
(NASA-CR-135040, EDR-8708) Avail. NTIS HC $6 00 CSCL 21E

Exhaust pollutant emissions were measured from a 501-D22A turboprop engine combustor and three low emission combustor types -- reverse flow, prechamber, and staged fuel, operating over a fuel-air ratio range of 0096 to .020 The EPAP LTO cycle data were obtained for a total of nineteen configurations Hydrocarbon emissions were reduced from 15 0 to 3 lb/1000 Hp-Hr/cycle, CO from 31 5 to 4 6 lb/1000 Hp-Hr/cycle with

an increase in NOx of 17 percent, which is still 25% below the program goal The smoke number was reduced from 59 to 17 Emissions given here are for the reverse flow Mod IV combustor which is the best candidate for further development into eventual use with the 501-D22A turboprop engine Even lower emissions were obtained with the advanced technology combustors Author

N76-29231*# Hamilton Standard, Windsor Locks, Conn.
HAMILTON STANDARD Q-FAN DEMONSTRATOR DYNAMIC PITCH CHANGE TEST PROGRAM, VOLUME 1 Final Report
W J Demers, D J Nelson, and H S. Wainauski Jul 1975 200 p refs 2 Vol
(Contract NAS3-18513)
(NASA-CR-134861, HSER-6700-Vol-1) Avail. NTIS HC $7 50 CSCL 21E

Tests of a full scale variable pitch fan engine to obtain data on the structural characteristics, response times, and fan/core engine compatibility during transient changes in blade angle, fan rpm, and engine power is reported Steady state reverse thrust tests with a take off nozzle configuration were also conducted The 1.4 meter diameter, 13 bladed controllable pitch fan was driven by a T55 L 11A engine with power and blade angle coordinated by a digital computer The tests demonstrated an ability to change from full forward thrust to reverse thrust in less than one (1) second Reverse thrust was effected through feather and through flat pitch, structural characteristics and engine/fan compatibility were within satisfactory limits Author

N76-29232*# Hamilton Standard, Windsor Locks, Conn
HAMILTON STANDARD Q-FAN DEMONSTRATOR DYNAMIC PITCH CHANGE TEST PROGRAM, VOLUME 2 Final Report
W J Demers, D J Nelson, and H S Wainauski Jul 1975 439 p 2 Vol
(Contract NAS3-18513)
(NASA-CR-134862, HSER-6700-Vol-2) Avail NTIS HC $11 75 CSCL 21E
For abstract, see vol 1

N76-29233*# Pratt and Whitney Aircraft, East Hartford, Conn
STUDY OF UNCONVENTIONAL AIRCRAFT ENGINES DESIGNED FOR LOW ENERGY CONSUMPTION Final Report
D E. Gray Jun 1976 142 p refs
(Contract NAS3-19465)
(NASA-CR-135065, PWA-5434) Avail. NTIS HC $6 00 CSCL 21A

Declining U S. oil reserves and escalating energy costs underline the need for reducing fuel consumption in aircraft engines. The most promising unconventional aircraft engines based on their potential for fuel savings and improved economics are identified The engines installed in both a long-range and medium-range aircraft were evaluated Projected technology advances are identified and evaluated for their state-of-readiness for application to a commercial transport Programs are recommended for developing the necessary technology Author

N76-29234*# General Electric Co. Evendale, Ohio Aircraft Engine Group
SINGLE STAGE, LOW NOISE, ADVANCED TECHNOLOGY FAN. VOLUME 5: FAN ACOUSTICS. SECTION 1: RESULTS AND ANALYSIS
R. R Jutras May 1976 232 p refs
(Contract NAS3-16813)
(NASA-CR-134894) Avail NTIS HC $8 00 CSCL 21E

The acoustic tests and data analysis for a 0.508-scale fan vehicle of a 111,300 newton (25,000 pound) thrust, full-size engine, which would have application on an advanced transport aircraft, is described The single-stage advanced technology fan was designed to a pressure ratio of 1 8 at a tip speed of 503 m/sec (1,650 ft/sec) to achieve the desired pressure ratio in a single-stage fan with low radius ratio (0 38), and to maintain adequate stall margin The fan has 44 tip-shrouded rotor blades and 90 outlet guide vanes The two basic approaches taken in the acoustic design were (1) minimization of noise at the source, and (2) suppression of the generated noise in the inlet and bypass exhaust duct Suppression of the generated noise was accomplished in the inlet through use of the hybrid concept (wall acoustic treatment plus airflow acceleration suppression) and in the exhaust duct with extensive acoustic treatment including a splitter The goal of the design was attainment of twenty effective perceived noise decibels (20 EPNdB) below current Federal Air Regulation noise standards for a full-scale fan at the takeoff, cutback, and approach conditions The suppression goal of FAR 36-20 was not reached, but improvements in the technology of both front and aft fan-noise suppression were realized. The suppressed fan noise was shown to be consistent with the proposed federal regulation on aircraft noise Author

N76-30218*# General Electric Co, Cincinnati, Ohio Aircraft Engine Group.
STUDY OF TURBOFAN ENGINES DESIGNED FOR LOW ENERY CONSUMPTION
R E Neitzel, R. Hirschkron, and R P. Johnston Aug. 1976 144 p refs
(Contract NAS3-19201)
(NASA-CR-135053; R76AEG432) Avail NTIS HC $6.00 CSCL 21E

Subsonic transport turbofan engine design and technology features which have promise of improving aircraft energy consumption are described Task I addressed the selection and evaluation of features for the CF6 family of engines in current aircraft, and growth models of these aircraft Task II involved cycle studies and the evaluation of technology features for advanced technology turbofans, consistent with initial service in 1985 Task III pursued the refined analysis of a specific design of an advanced technology turbofan engine selected as the result of Task II studies In all of the above, the impact upon aircraft economics, as well as energy consumption, was evaluated Task IV summarized recommendations for technology developments which would be necessary to achieve the improvements in energy consumption identified Author

N76-31231*# General Electric Co, Cincinnati, Ohio.
EXPERIMENTAL CLEAN COMBUSTOR PROGRAM, NOISE MEASUREMENT ADDENDUM, PHASE 2 Final Report
J J Emmerling and K L Bekofske Jan 1976 177 p refs
(Contract NAS3-18551)
(NASA-CR-135045 R75AEG147-13-Add) Avail NTIS HC $7 50 CSCL 21E

Combustor noise measurements were performed using wave guide probes. Test results from two full scale annular combustor configurations in a combustor test rig are presented A CF6-50 combustor represented a current design, and a double annular combustor represented the advanced clean combustor configuration The overall acoustic power levels were found to correlate with the steady state heat release rate and inlet temperature. A theoretical analysis for the attenuation of combustor noise propagating through a turbine was extended from a subsonic relative flow condition to include the case of supersonic flow at the discharge side. The predicted attenuation from this analysis was compared to both engine data and extrapolated component combustor data The attenuation of combustor noise through the CF6-50 turbine was found to be greater than 14 dB by both the analysis and the data. Author

N76-32190*# General Electric Co, Cincinnati, Ohio. Aircraft Engine Group
EXPERIMENTAL CLEAN COMBUSTOR PROGRAM, PHASE 2 Final Report
C C Gleason, D. W Rogers, and D W. Bahr Aug 1976 208 p refs
(Contract NAS3-18551)
(NASA-CR-134971, R76AEG422) Avail: NTIS HC $7 75 CSCL 21E

The primary objectives of this three-phase program are to

develop technology for the design of advanced combustors with significantly lower pollutant emission levels than those of current combustors, and to demonstrate these pollutant emission reductions in CF6-50C engine tests The purpose of the Phase 2 Program was to further develop the two most promising concepts identified in the Phase 1 Program, the double annular combustor and the radial/axial staged combustor, and to design a combustor and breadboard fuel splitter control for CF6-50 engine demonstration testing in the Phase 3 Program Noise measurement and alternate fuels addendums to the basic program were conducted to obtain additional experimental data Twenty-one full annular and fifty-two sector combustor configurations were evaluated Both combustor types demonstrated the capability for significantly reducing pollutant emission levels The most promising results were obtained with the double annular combustor Rig test results corrected to CF-50C engine conditions produced EPA emission parameters for CO, HC, and NOX of 3 4, 0.4, and 4.5 respectively These levels represent CO, HC, and NOX reductions of 69, 90, and 42 percent respectively from current combustor emission levels. The combustor also met smoke emission level requirements and development engine performance and installation requirements Author

N76-32191*# Pratt and Whitney Aircraft, East Hartford, Conn Commercial Product Div

PRELIMINARY COMPRESSOR DESIGN STUDY FOR AN ADVANCED MULTISTAGE AXIAL FLOW COMPRESSOR Final Report

H V Marman and R D Marchant Sep 1976 61 p refs (Contract NAS3-19445)

(NASA-CR-135091, PWA-5386) Avail. NTIS HC $4 50 CSCL 21E

An optimum, axial flow, high pressure ratio compressor for a turbofan engine was defined for commercial subsonic transport service starting in the late 1980's Projected 1985 technologies were used and applied to compressors with an 18 1 pressure ratio having 6 to 12 stages A matrix of 49 compressors was developed by statistical techniques The compressors were evaluated by means of computer programs in terms of various airline economic figures of merit such as return on investment and direct-operating cost The optimum configuration was determined to be a high speed, 8-stage compressor with an average blading aspect ratio of 1 15 Author

N76-32202*# Bolt, Beranek, and Newman, Inc., Canoga Park, Calif

SOFTWALL ACOUSTICAL CHARACTERISTICS AND MEASUREMENT CAPABILITIES OF THE NASA LEWIS 9x15 FOOT LOW SPEED WIND TUNNEL

Peter E Rentz Jun 1976 103 p refs (Contract NAS3-19410)

(NASA-CR-135026, BBN-3176) Avail NTIS HC $5 50 CSCL 14B

Acoustical characteristics and source directionality measurement capabilities of the wind tunnel in the softwall configuration were evaluated, using aerodynamically clean microphone supports The radius of measurement was limited by the size of the test section, instead of the 3 0 foot (1 m) limitation of the hardwall test section The wind-on noise level in the test section was reduced 10 dB. Reflections from the microphone support boom, after absorptive covering, induced measurement errors in the lower frequency bands Reflections from the diffuser back wall were shown to be significant Tunnel noise coming up the diffuser was postulated as being responsible, at least partially, for the wind-on noise in the test section and settling chamber The near field characteristics of finite-sized sources and the theoretical response of a porous strip sensor in the presence of wind are presented Author

N76-33208*# General Applied Science Labs., Inc., Westbury, N Y.

EFFECT OF INLET TEMPERATURE AND PRESSURE ON EMISSIONS FROM A PREMIXING GAS TURBINE PRIMARY ZONE COMBUSTOR Final Report

Gerald Roffe Washington NASA Sep 1976 48 p refs (Contract NAS3-18563)

(NASA-CR-2740; GASL-TR-227) Avail NTIS HC $4 00 CSCL 21E

Experiments were conducted to determine the performance of a premixing prevaporizing gas turbine primary zone combustor design over a range of combustor inlet temperatures from 700 to 1000 K and a range of inlet pressures from 40 to 240 N/sq cm The 1 meter long combustor could be operated at pressures up to and including 120 N/sq cm without autoignition in the premixing duct or flashback from the stabilized combustion zone Autoignition occurred in the mixer tube at the 240 N/sq cm pressure level with an entrance temperature of 830 K and a mixer residence time of 4 msec Measured NOx level, combustion inefficiency, and hydrocarbon emission index correlated well with adiabatic flame temperature. The NOx levels varied from approximately 0.2 to 2.0 g NO2/kg fuel at combustion inefficiencies from 4 to 0 04 percent, depending upon adiabatic flame temperature and pressure. Measured NOx levels were sensitive to pressure Tests were made at equivalence ratios ranging from 0 35 to 0.65 The overall total pressure drop for the configuration varied slightly with reference velocity and equivalence ratio, but never exceeded 3 percent Author

A76-20931 * # Jet noise characteristics of unsuppressed duct burning turbofan exhaust system. A. B. Packman, H. Kozlowski (United Technologies Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.), and O. Gutierrez (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 14th, Washington, D.C., Jan. 26-28, 1976, Paper 76-149.* 8 p 6 refs. Contract No. NAS3-17866.

Recent aero-acoustic tests of model coannular nozzles have shown that less noise is generated if the higher-velocity jet is exhausted from the outer annular passage rather than from the primary nozzle. These findings are of particular significance to a duct-burning turbofan (DBTF) engine being studied for application to an advanced supersonic transport. Unlike conventional turbofan engines that have peak velocities from the primary nozzle, it is possible to design a DBTF engine to have a fan velocity higher than that of the primary flow. Results are presented for a NASA-sponsored model test program that covers a range of fan to primary-area ratios from 0 75 to 1.2, and a range of fan to primary-velocity ratios from 0 4 to 2 8. Correlations are given that relate radiated sound power to fan velocity, fan to primary-velocity ratio, and fan to primary-area ratio. Corresponding exhaust-plume velocity-traverse data are presented which suggest that the observed noise benefits may be due to the more rapid decay of the annular flow because of shear stresses on the inner surface that result from the lower-velocity primary flow. (Author)

A76-21075 * # Aero-acoustic performance characteristics of duct burning turbofan exhaust nozzles. H. Kozlowski, A B Packman (United Technologies Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.), and O. Gutierrez (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 14th, Washington, D.C., Jan. 26-28, 1976, Paper 76-148.* 8 p. Contract No. NAS3-17866.

A recent experimental investigation has identified the aero/acoustic characteristics of exhaust nozzles for duct heating turbofan engines over a range of simulated flow conditions Jet noise and performance levels are summarized for a series of coannular nozzles representing both acoustically suppressed and unsuppressed designs operating in a static environment The basic coannular nozzles were found to provide inherent noise suppression Multi-element suppressor nozzles provided additional noise suppression, but with appreciable thrust loss. The impact of these results on the advanced supersonic transport studies is also presented, indicating potentially large reductions in take-off gross weight or community noise footprints. (Author)

A76-21901 * # Effects of casing treatment on a small, transonic axial-flow compressor. F. F Holman and J. R. Kidwell (AiResearch Manufacturing Company of Arizona, Phoenix, Ariz.) *American Society of Mechanical Engineers, Winter Annual Meeting, Houston, Tex., Nov. 30-Dec. 4, 1975, Paper 75-WA/GT-5* 14 p. 6 refs. Members, $1.50; nonmembers, $3.00. Contract No. NAS3-17846.

Improved axial compressor surge margin through effective rotor casing treatment has been identified from test results on large axial compressors. A modified scale of a large compressor was built and tested to determine if similar improvements in surge margin could be duplicated in small-size turbomachinery. In addition, the effects of rotor radial running clearance, both with and without casing treatment, were investigated and are discussed. Test results of the scale configuration are presented and compared to the parent compressor. (Author)

A76-38251 * # Results of the pollution reduction technology program for turboprop engines. E. J. Mularz (NASA, Lewis Research Center, U.S. Army, Air Mobility Research and Development Laboratory, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-760.* 9 p. 5 refs. Contract No. NAS3-18561.

A program was performed to evolve and demonstrate advanced combustor technology aimed at achieving the 1979 EPA standards for turboprop engines (Class P2). The engine selected for this program was the 501-D22A turboprop manufactured by Detroit Diesel Allison Division of General Motors Corporation. Three combustor concepts were designed and tested in a combustor rig at the exact combustor operating conditions of the 501-D22A engine over the EPA landing-takeoff cycle. Each combustor concept exhibited pollutant emissions well below the EPA standards, achieving substantial reductions in unburned hydrocarbons, carbon monoxide, and smoke emissions compared with emissions from the production combustor of this engine. Oxides of nitrogen emissions remained well below the EPA standards, also (Author)

A76-38252 * # The pollution reduction technology program for can-annular combustor engines - Description and results. R. Roberts, A. J. Fiorentino (United Technologies Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.), and L. Diehl (NASA, Lewis Research Center, Combustor Technology and Research Section, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-761.* 11 p. 10 refs. Contract No. NAS3-18548.

Pollutant reduction and performance characteristics were determined for three successively more advanced combustor concepts. Program Element I consisted of minor modifications to the current production JT8D combustor and fuel system to evaluate means of improved fuel preparation and changes to the basic airflow distribution. Element II addressed versions of the two-staged Vorbix (vortex burning and mixing) combustor and represented a moderate increase in hardware complexity and difficulty of development. The concept selected for Element III employed vaporized fuel as a means of achieving minimum emission levels and represented the greatest difficulty of development and adaptation to the JT8D engine. Test results indicate that the Element I single-stage combustors were capable of dramatic improvement in idle pollutants. The multistage combustors evaluated in Program Elements II and III simultaneously reduced CO, THC and NOx emissions, but were unable to satisfy the current 1979 EPA standards. (Author)

A76-42418 * # A report on the aerodynamic design and wind tunnel test of a Prop-Fan model. C. Rohrbach (United Technologies Corp., Hamilton Standard Div., Windsor Locks, Conn.) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-667.* 12 p. 9 refs. Contract No. NAS3-20219.

Recent transport aircraft system studies have shown that the Prop-Fan propulsion system offers the potential for significant fuel savings over high bypass turbofans employing the same core engine technology for each. This important finding has encouraged more detailed study of the Prop-Fan aerodynamics and has led to NASA sponsorship of a wind tunnel research program to explore the projected high efficiency levels of advanced propeller configurations for 0.80 Mach number, high-altitude cruise operation. The aerodynamic design philosophy for the Prop-Fan model is discussed. The geometric characteristics and predicted performance of the wind tunnel model are presented. Finally, the preliminary test results are reviewed and compared to the performance goals originally projected. (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)*

N76-13121*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

MEASUREMENT OF MODEL PROPULSION SYSTEM NOISE IN A LOW-SPEED WIND TUNNEL

James H Diedrich and Roger W Luidens 1976 19 p refs Proposed for presentation at 14th Aerospace Sci. Meeting Washington, D. C., 26-28 Jan 1976; sponsored by AIAA

(NASA-TM-X-71845; E-8572) Avail: NTIS HC $3 50 CSCL 14B

Methods are presented for making overall and directional acoustic measurements with forward velocity in the Lewis 9 x 15 V/STOL wind tunnel Overall acoustic measurements are discussed, the acoustic calibration methods, instrumentation features, and types of experiments are presented Selected data are presented as examples of the various types of overall measurements that are possible The method of making directional acoustic measurements is presented, and the necessary alterations to the tunnel, specialized acoustic instrumentation, and calibration details are described. The results indicate that relative overall acoustic measurements can be made successfully and that directional acoustic measurements are feasible Author

N76-20155*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

MODEL INVESTIGATION OF INLET PLENUM FLOW STRAIGHTENING TECHNIQUES FOR ALTITUDE TEST FACILITY

Stephen M Riddlebaugh and Heinz G Linke Washington Feb 1976 32 p

(NASA-TM-X-3348; E-8464) Avail. NTIS HC $4 00 CSCL 14B

An investigation was conducted to evaluate and improve the quality of the airflow to be supplied to the engine in altitude test chambers 3 and 4 of the Propulsion Systems Laboratory at the Lewis Research Center One-twentieth-scale models of the inlet plenum chamber of the two test chambers were used in the investigation to minimize time and cost It was possible to reduce the velocity spread in the inlet plenum from approximately 100 m/sec (330 ft/sec) to approximately 10 m/sec (30 ft/sec) through the combined use of flow diverters, multiple spaced screens, flow straighteners, and turning vanes Author

N76-30230*# Bolt, Beranek, and Newman, Inc., Canoga Park, Calif

HARDWALL ACOUSTICAL CHARACTERISTICS AND MEASUREMENT CAPABILITIES OF THE NASA LEWIS 9 X 15 FOOT LOW SPEED WIND TUNNEL

Peter E Rentz Jun 1976 96 p refs

(Contract NAS3-19410)

(NASA-CR-135025, BBN-3174) Avail NTIS HC $5 00 CSCL 14B

Experimental evaluations of the acoustical characteristics and source sound power and directionality measurement capabilities of the NASA Lewis 9 x 15 foot low speed wind tunnel in the untreated or hardwall configuration were performed The results indicate that source sound power estimates can be made using only settling chamber sound pressure measurements The accuracy of these estimates, expressed as one standard deviation, can be improved from + or - 4 db to + or - 1 db if sound pressure measurements in the preparation room and diffuser are also used and source directivity information is utilized. A simple procedure is presented. Acceptably accurate measurements of source direct field acoustic radiation were found to be limited by the test section reverberant characteristics to 3 0 feet for omni-directional and highly directional sources Wind-on noise measurements in the test section, settling chamber and preparation room were found to depend on the sixth power of tunnel velocity. The levels were compared with various analytic models Results are presented and discussed Author

12 ASTRONAUTICS (GENERAL)

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

A76-43097 * # Performance of a recoverable Tug for planetary missions including use of perigee propulsion and corrections for nodal regression. J. Borsody (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, Calif., Aug 18-20, 1976, AIAA Paper 76-809* 16 p

Mathematical equations are derived by using the Maximum Principle to obtain the maximum payload capability of a reusable Tug for planetary missions. The mathematical formulation includes correction for nodal precession of the Space Shuttle orbit. The Tug performs this nodal correction in returning to this precessed orbit. The sample case analyzed represents an inner planet mission as defined by the declination (fixed) and right ascension of the outgoing asymptote and the mission energy. Payload capability is derived for a typical cryogenic Tug and the sample case with and without perigee propulsion. Optimal trajectory profiles and some important orbital elements are also discussed (Author)

13 ASTRODYNAMICS

Includes powered and free-flight trajectories, and orbit and launching dynamics

N76-17169*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass

SOLAR ELECTRIC GEOCENTRIC TRANSFER WITH ATTITUDE CONSTRAINTS: ANALYSIS Final Technical Report

Lester L. Sackett, Harvey L. Malchow, and Theodore N. Delbaum Aug. 1975 140 p refs

(Contract NAS3-18886)

(NASA-CR-134927; CSDL-R-901) Avail: NTIS HC $6.00 CSCL 22A

A time optimal or nearly time optimal trajectory program was developed for solar electric geocentric transfer with or without attitude constraints and with an optional initial high thrust stage. The method of averaging reduces computation time. A nonsingular set of orbital elements is used. The constraints, which are those of one of the SERT-C designs, introduce complexities into the analysis and the solution yields possible discontinuous changes in thrust direction. The power degradation due to VanAllen radiation is modeled analytically. A wide range of solar cell characteristics is assumed. Effects such as oblateness and shadowing are included. The analysis and the results of many example runs are included. Author

N76-13140*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

TITAN/CENTAUR D-1T TC-2, HELIOS A FLIGHT DATA REPORT

Sep. 1975 343 p

(NASA-TM-X-71838) Avail: NTIS HC $10.00 CSCL 22C

Background data of spacecraft launching and flight are presented. A system analysis of the space vehicles is included, specifically on: (1) electronic equipment, (2) hydraulic equipment, (3) telemetry, (4) propulsion systems, (5) software (computers), and (6) guidance. Spacecraft and launch vehicle configurations are shown and described. J.R.T.

15 LAUNCH VEHICLES AND SPACE VEHICLES

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

N76-13155*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
CENTAUR ZERO GRAVITY COAST AND ENGINE RESTART DEMONSTRATION ON THE TITAN/CENTAUR (TC-2) EXTENDED MISSION
Raymond F Lacovic Oct 1975 40 p refs
(NASA-TM-X-71821, E-8520) Avail NTIS HC $4.00 CSCL 22B

The Centaur propellant management and thermal control techniques required for zero gravity coasting were successfully demonstrated during an extended mission following spacecraft separation on the TC-2 flight As part of the demonstration, two successful engine starts were accomplished The first engine start followed a one-hour zero gravity coast, and the second engine start followed a three-hour zero gravity coast All of the Centaur systems performed satisfactorily, the design parameters for zero gravity coasting were verified, and no significant problems were encountered The flight results showed that the propellant location and behavior, propellant heating, and tank pressure rise rates observed during the zero-gravity coasts were less severe than expected Consequently, the majority of the propellants remained at the tank bottom, the propellant collection times were very short, and more than 7 hours of coast could have been achieved before a tank venting was required The tank pressurization prior to the engine starts provided boost pump Net Positive Suction Head values well in excess of the values required The LO2 tank pressurization was accomplished by a new bubbler method that greatly reduced the helium usage.
Author

N76-17179*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CENTAUR STANDARD SHROUD (CCS) HEATED ALTITUDE JETTISON TESTS
Aug 1975 238 p refs
(NASA-TM-X-71814; E-8508) Avail: NTIS HC $8 00 CSCL 22D

Altitude jettison tests, at a pressure of 20 torr (0 39 psia), were performed on the Centaur Standard Shroud (CSS) in a 100-foot diameter vacuum chamber These jettison tests were part of a series of flight qualification tests which were performed on the new CSS system in preparation for the Helios and Viking missions The first two tests subjected the CSS to a thermal cycle which simulated aerodynamic heating during ascent flight and the third test was performed at altitude pressure and in ambient temperature conditions. The purpose of the ambient temperature test was to provide base line data by which the separate mechanical and thermal factors that influence jettison performance could be evaluated individually The CSS was successfully jettisoned in each of the three tests. Also, thermal, stress, and structural deflection data were obtained which verified the analytical predictions of CSS response to flight environmental conditions and performance during jettison. In addition, much important information was obtained on critical CSS-to-payload clearance losses due to shell motions prior to and during jettison. The effectiveness of the separation system was successfully demonstrated at maximum flight temperatures. Author

N76-17182*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OPTIMAL THREE-DIMENSIONAL REUSABLE TUG TRAJECTORIES FOR PLANETARY MISSIONS INCLUDING CORRECTION FOR NODAL PRECESSION
Janos Borsody Washington Feb. 1976 43 p refs
(NASA-TN-D-8168; E-8498) Avail. NTIS HC $4.00 CSCL 22A

Equations are derived by using the maximum principle to maximize the payload of a reusable tug for planetary missions The analysis includes a correction for precession of the space shuttle orbit The tug returns to this precessed orbit (within a specified time) and makes the required nodal correction A sample case is analyzed that represents an inner planet mission as specified by a fixed declination and right ascension of the outgoing asymptote and the mission energy The reusable stage performance corresponds to that of a typical cryogenic tug Effects of space shuttle orbital inclination, several trajectory parameters, and tug thrust on payload are also investigated Author

N76-22240*# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio
D-1A EQUIPMENT MODULE STRUCTURE TEST
T F Niezgoda Apr 1976 53 p
(NASA-TM-X-73401; E-8724) Avail NTIS HC $4 50 CSCL 22D

The Centaur Equipment Module (E/M) structural test program was performed in two parts due to an unscheduled hardware failure in the first test series The objectives of the initial test program were to define the flexibility characteristics of the E/M, verify the design load capability, and determine its ultimate strength capability by loading to structural failure However, during the first failure test attempt, the Intelsat IV MPA failed instead of the E/M Therefore a new adapter was fabricated to simulate the HEAO mission adapter and the second series of tests were then performed They concluded with the failure of the E/M forward interface ring resulting in about 3 5 degrees of permanent set on the high compression side Nevertheless, the linear or useable strength capability of the E/M is greater or equal to that which is required for the HEAO missions The E/M is deemed structurally qualified for the HEAO missions Author

N76-26254*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
TITAN/CENTAUR D-1TTC-5 HELIOS B FLIGHT DATA REPORT
K A Adams May 1976 177 p
(NASA-TM-X-73435, E-8784) Avail NTIS HC $7 50 CSCL 22D

The fourth operational flight of the newest NASA unmanned launch vehicle is reported The spacecraft was the Helios B, the second of two solar probes designed and built by the Federal Republic of Germany. The primary mission objective, to place the Helios spacecraft on a heliocentric orbit in the ecliptic plane with a perihelion distance of 0 29 AU, was successfully accomplished After successful injection of the Helios spacecraft, a series of experiments were performed with the Centaur stage to demonstrate its operational capabilities All objectives of the extended mission phase were successfully met This report presents the analysis of the launch vehicle flight data for the primary mission phase of the TC-5 flight Author

N76-28258*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
TITIAN/CENTAUR D-1TTC-4 VIKING A FLIGHT DATA REPORT
Jul 1976 161 p
(NASA-TM-X-73475, E-8860) Avail: NTIS HC $6 75 CSCL 22D

Titan/Centaur TC-4 was launched from the Eastern Test Range, Complex 41, at 05:22 PM EDT on Wednesday, August 20, 1975 This was the second operational flight of the newest NASA unmanned launch vehicle. The spacecraft was the Viking A, the first of two orbiting and landing missions to Mars planned for the 1975 Martian launch opportunity. The objective of the launch phase of the mission, to inject the Viking spacecraft onto the planned transfer orbit to Mars, was successfully accomplished This report presents a review of the launch vehicle system flight data Author

N76-28259*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
TITAN/CENTAUR D1TTC-3 VIKING B FLIGHT DATA REPORT
Jul 1976 153 p
(NASA-TM-X-73481; E-8863) Avail NTIS HC $6 75 CSCL 22D

Titan/Centaur TC-3 was launched from the Eastern Test Range, Complex 41, at 02 34 PM EDT on Tuesday, September 9, 1975 This was the third operational flight of the newest NASA unmanned launch vehicle The spacecraft was the Viking B, the second of two orbiting and landing missions to Mars planned for the 1975 Martian launch opportunity. The objective of the launch phase of the mission, to inject the Viking spacecraft onto the planned transfer orbit to Mars, was successfully accomplished A review of the launch vehicle system flight data is presented Author

N76-29343*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PURGING OF MULTILAYER INSULATION BY GAS DIFFUSION
Irving E Sumner and Charles M. Spuckler Washington Aug 1976 53 p refs
(NASA-TN-D-8122) Avail NTIS HC $4 50 CSCL 21I

An experimental investigation was conducted to determine the time required to purge a multilayer insulation (MLI) panel with gaseous helium by means of gas diffusion to obtain a condensable (nitrogen) gas concentration of less than 1 percent within the panel Two flat, rectangular MLI panel configurations, one incorporating a butt joint, were tested The insulation panels consisted of 15 double-aluminized Mylar radiation shields separated by double silk net spacers The test results indicated that the rate which the condensable gas concentration at the edge or at the butt joint of an MLI panel was reduced was a significant factor in the total time required to reduce the condensable gas concentration within the panel to less than 1 percent The experimental data agreed well with analytical predictions made by using a simple, one-dimensional gas diffusion model in which the boundary conditions at the edge of the MLI panel were time dependent Author

N76-30255*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
INVESTIGATION OF TC-1 FLIGHT FAILURE USING POWER SPECTRAL ANALYSIS
Carl F Lorenzo Jul 1976 34 p ref
(NASA-TM-X-71914, E-8717) Avail NTIS HC $4 00 CSCL 22D

During the Titan Centaur 1 test flight a failure involving at least one of the Centaur propellant boost pumps occurred Also, neither of the boost pump speed instruments indicated pump rotation Accelerometer data from the Titan Centaur 1 flight failure were analyzed using power spectral density methods to determine boost pump speed during attempted starts of the Centaur. The technique was demonstrated on a reference flight The hydrogen boost pump speed transient was determined for the TC-1 flight Other trends are seen in the data However, these are not believed to be the oxygen boost pump. Discussion of data enhancement techniques is also presented Author

N76-33250*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
DEGRADATION OF A MULTILAYER INSULATION DUE TO A SEAM AND A PENETRATION
Irving E Sumner Washington Oct 1976 35 p refs
(NASA-TN-D-8229, E-8622) Avail: NTIS HC $4.00 CSCL 11D

The degradation of the thermal performance of a multilayer insulation due to the presence of a seam and a penetration was studied The multilayer insulation had 30 aluminized Mylar radiation shields with silk net spacers. The seam, an offset butt joint, caused a heat input of 0.169 watt per meter in addition to the basic insulation thermal performance of 0 388 watt per square meter obtained before the installation of the butt joint The penetration, a fiberglass tank support strut, provided a heat input (including the degradation of the insulation) of 0 543 watt in addition to the basic insulation thermal performance of 0.452 watt per square meter obtained before the penetration Author

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.*

N76-21256*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
UNITED STATES SOCIETAL EXPERIMENTS VIA THE COMMUNICATIONS TECHNOLOGY SATELLITE
Patrick L Donoughe 1976 11 p refs To be presented at the Intern Conf on Commun., Philadelphia, 14-16 Jun 1976; Sponsored by IEEE
(NASA-TM-X-73403, E-8716) Avail NTIS HC $3.50 CSCL 17B

The Communications Technology Satellite (CTS) is a cooperative experimental program of the United States and Canadian governments. The CTS uses a high-power transponder at the frequencies of 14/12 GHz for two-way television and voice communication. The United States and Canada have agreed to share equally in the use of CTS. The U.S program includes a variety of societal experiments. The ground stations for these experiments are located from the Atlantic to the Pacific. The satellite communications capabilities and the antenna coverage for the U.S. are summarized Emphasis is placed on the U S societal experiments in the areas of education, health care, and community and special services; nine separate experiments are discussed Author

N76-27320*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
DISASTER WARNING SATELLITE STUDY UPDATE
E H. Davison, ed., E F Miller, G Anzic, R C Braley, and Culp May 1976 37 p refs Revised
(NASA-TM-X-73407; E-8732) Avail: NTIS HC $4.00 CSCL 17B

Project planning and research and development by NASA's Lewis Research Center, on a NOAA satellite network system for surveillance of natural dareasters is reported Topics discussed are (1) number and type of warning channels for the satellite system, (2) number of antenna beams in the satellite system, (3) number of satellites needed for adequate coverage by the satellite system, (4) power requirements for the satellite system, (5) downlink and uplink frequencies, power requirements for the satellite system, and (6) costs and service life of the satellite system J R T

N76-27319*# National Scientific Labs., Inc., McLean, Va.
FORTY AND 80 GHz TECHNOLOGY ASSESSMENT AND FORECAST INCLUDING EXECUTIVE SUMMARY
D G Mazur, R J. Mackey, Jr., S G Tanner, F J Altman, J. J Nicholas, Jr., and K A Duchaine May 1976 404 p refs
(Contract NAS3-19724)
(NASA-CR-135028, Rept-21-030) Avail NTIS HC $11.00 CSCL 17B

The results of a survey to determine current demand and to forecast growth in demand for use of the 40 and 80 GHz bands during the 1980-2000 time period are given. The current state-of-the-art is presented, as well as the technology requirements of current and projected services Potential developments were identified, and a forecast is made The impacts of atmospheric attenuation in the 40 and 80 GHz bands were estimated for both with and without diversity Three services for the 1980-2000 time period -- interactive television, high quality three stereo pair audio, and 30 MB data -- are given with system requirements and up and down-link calculations Author

N76-28268*# Computer Sciences Corp., Falls Church, Va Aerospace Systems Operation
DISASTER WARNING SYSTEM. SATELLITE FEASIBILITY AND COMPARISON WITH TERRESTRIAL SYSTEMS. VOLUME 1: EXECUTIVE SUMMARY
John H Spoor, W H Hodge, M J Fluk, and T F Bamford Sep 1974 33 p refs 3 Vol.
(Contract NAS3-17795)
(NASA-CR-134622-Vol-1; R-3015-3-1-Vol-1) Avail NTIS HC $4.00 CSCL 17B

The Disaster Warning System (DWS) is a conceptual system which will provide the National Weather Service (NWS) with communication services in the 1980s to help minimize losses caused by natural disasters The object of this study is a comparative analysis between a terrestrial DWS and a satellite DWS Baseline systems satisfying the NOAA requirements were synthesized in sufficient detail so that a comparison could be made in terms of performance and cost. The cost of both baseline systems is dominated by the disaster warning and spotter reporting functions. An effort was undertaken to reduce system cost through lower-capacity alternative systems generated by modifying the baseline systems By reducing the number of required channels and modifying the spotter reporting techniques, alternative satellite systems were synthesized A terrestrial alternative with the coverage reduced to an estimated 95 percent of the population was considered Author

N76-28269*# Computer Sciences Corp., Falls Church, Va Aerospace Systems Operation
DISASTER WARNING SYSTEM: SATELLITE FEASIBILITY AND COMPARISON WITH TERRESTRIAL SYSTEMS VOLUME 2: FINAL REPORT
John H Spoor, W. H. Hodge, M J Fluk, and T. F. Bamford Sep. 1974 196 p refs 3 Vol.
(Contract NAS3-17795)
(NASA-CR-134622-Vol-2; R-3015-3-1-Vol-2) Avail NTIS HC $7.50 CSCL 17B
For abstract, see Vol 1

N76-28270*# Computer Sciences Corp., Falls Church, Va Aerospace Systems Operation
DISASTER WARNING SYSTEM: SATELLITE FEASIBILITY AND COMPARISON WITH TERRESTRIAL SYSTEMS. VOLUME 3. APPENDICES
John H Spoor, W H. Hodge, M J Fluk, and T F. Bamford Sep 1974 123 p refs 3 Vol
(Contract NAS3-17795)
(NASA-CR-134622-Vol-3, R-3015-3-1-Vol-3) Avail NTIS HC $5.50 CSCL 17B
For abstract, see Vol 1

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.*

N76-12114*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
CENTAUR STANDARD SHROUD (CSS) STATIC ULTIMATE LOAD STRUCTURAL TESTS
Jul 1975 142 p refs
(NASA-TM-X-71823; E-8514) Avail NTIS HC $6.00 CSCL 22B

A series of tests were conducted on the jettisonable metallic shroud used on the Titan/Centaur launch vehicle to verify its structural capabilities and to evaluate its structural interaction with the Centaur stage. A flight configured shroud and the interfacing Titan/Centaur structural assemblies were subjected to tests consisting of combinations of applied axial and shear loads to design ultimate values, including a set of tests on thermal conditions and two dynamic response tests to verify the analytical stiffness model The strength capabilities were demonstrated at ultimate (125 percent of design limit) loads It was also verified that the spring rate of the flight configured shroud-to-Centaur forward structural deflections of the specimen became nonlinear, as expected, above limit load values This test series qualification program verified that the Titan/Centaur shroud and the Centaur and Titan interface components are qualified structurally at design ultimate loads Author

N76-26261*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ENVIRONMENTAL CHARGING OF SPACECRAFT-TESTS OF THERMAL CONTROL MATERIALS FOR USE ON THE GLOBAL POSITIONING SYSTEM FLIGHT SPACE VEHICLE. PART 2: SPECIMEN 6 TO 9
N. John Stevens, Frank D Berkopec, and Richard A. Blech Jun. 1976 44 p
(NASA-TM-X-73436, E-8789) Avail NTIS HC $4 00 CSCL 22B

The NASA/USAF program on the Environmental Charging of Spacecraft Surfaces consists, in part, of experimental efforts directed toward evaluating the response of materials to the environmental charged particle flux Samples of thermal blankets of the type to be used on the Global Positioning System Flight Space Vehicles were tested to determine their response to electron flux. The primary result observed was that no discharges were obtained with the quartz-fiber-fabric-covered multilayer insulation specimen. The taped aluminized polyester grounding system used on all specimens did not appear to grossly deteriorate with time, however, the specimens require specific external pressure to maintain constant grounding system resistance. Author

N76-27337*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PERFORMANCE OF A RECOVERABLE TUG FOR PLANETARY MISSIONS INCLUDING USE OF PERIGEE PROPULSION AND CORRECTIONS FOR NODAL REGRESSION
Janos Borsody 1976 22 p refs Proposed for presentation at the Astrodynamics Conf, San Diego, Calif, 18 - 20 Aug 1976, sponsored by AIAA and the Am Astron Soc
(NASA-TM-X-73433; E-8782) Avail NTIS HC $4 00 CSCL 22B

Mathematical equations are derived by using the Maximum Principle to obtain the maximum payload capability of a reusable tug for planetary missions The mathematical formulation includes correction for nodal precession of the space shuttle orbit The tug performs this nodal correction in returning to this precessed orbit The sample case analyzed represents an inner planet mission as defined by the declination (fixed) and right ascension of the outgoing asymptote and the mission energy Payload capability is derived for a typical cryogenic tug and the sample case with and without perigee propulsion Optimal trajectory profiles and some important orbital elements are also discussed Author

N76-27339*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CENTAUR D-1A NOSE FAIRING JETTISON TEST
W M Prati Jun 1976 112 p refs
(NASA-TM-X-73450, E-8808) Avail NTIS HC $5 50 CSCL 22B

An experimental investigation was conducted to verify the functional and structural capability of the Centaur D-1A nose fairing A full-scale flight-type nose fairing was jettisoned at the Lewis Research Center Space Power Chamber at simulated altitude Two complete jettisons of the nose fairing were performed, one without aft helper springs and one with aft helper springs A "static' rotation test was also performed to verify capability of the helper springs and to allow clearance measurements between the nose fairing and spacecraft envelope mock-up at certain discrete nose fairing rotation angles Nose fairing trajectories structural deflections, clearances, and hinge forces during jettison are presented Data from subsequent Centaur D-1A flights, relative to nose fairing jettisons, are compared with the experimental results Author

N76-28290* National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio
SOLAR ARRAY DRIVE SYSTEM c37
Frank D Berkopec, John C Sturman, and R. W. Stanhouse (GE, Philadelphia) *In* JPL 10th Aerospace Mech Symp 1 Jul 1976 p 185-197 refs (For availability see N76-28272 19-18) CSCL 22B

A solar array drive system consisting of a solar array drive mechanism and the corresponding solar array drive electronics is being developed The principal feature of the solar array drive mechanism is its bidirectional capability which enables its use in mechanical redundancy The solar array drive system is of a widely applicable design This configuration will be tested to determine its acceptability for generic mission sets Foremost of the testing to be performed is the testing for extended duration Author

A76-37702 * # Thermal testing of a high powered communications satellite. R. D Caswell (Department of Communications, Communications Research Centre, Ottawa, Canada) and E. A Edelman (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Thermophysics Conference, 11th, San Diego, Calif, July 14-16, 1976, Paper 76-459.* 8 p.

Thermal Vacuum and Thermal Balance tests were successfully conducted on the high power Communications Technology Satellite (CTS) The mission required testing for two distinct thermal environments; spin stabilized at 60 rpm with a minimum of 55 watts of dissipated power, and three-axis stabilized with as much as a tenfold increase of dissipation The test program verified the adequacy of the spacecraft thermal design and demonstrated functional operation over a wide temperature range for all of the components Special test hardware incorporating water-cooling systems was required to accomodate the heatpipes and high RF output power. Objectives, test facilities, special hardware, spacecraft configurations, and results of the tests are discussed Preliminary flight results and conclusions drawn from the test experience are reported. (Author)

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.*

N76-10223*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
INVESTIGATION OF THE CENTAUR BOOST PUMP OVERSPEED CONDITION AT MAIN ENGINE SHUTDOWN ON THE TITAN CENTAUR TC-2 FLIGHT
Kenneth W Baud Oct. 1975 33 p
(NASA-TM-X-71822, E-8521) Avail NTIS HC $3 75 CSCL 21H

An investigation was conducted to evaluate a potential boost pump overspeed condition which could exist on the Titan/Centaur launch vehicle after main engine shut-off. Preliminary analyses indicated that the acceleration imparted to the unloaded boost pump-turbine assembly, caused by purging residual hydrogen peroxide from the turbine supply lines, could result in a pump-turbine overspeed Previous test experience indicated that turbine damage occurs at speeds in excess of 75,000 rpm Detailed theoretical analyses, in conjunction with pump tests, were conducted to establish the maximum pump-turbine speed at main engine shut-off The analyses predicted a maximum speed of 68,000 rpm Testing showed the pump-turbine speed to be 66,700 rpm in the overspeed condition Inasmuch as both the analysis and tests showed the overspeed to be sufficiently less than the speed at which damage could occur, it was concluded that no corrective action would be required for the launch vehicle Author

N76-14190* National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio
CONTROLLED SEPARATION COMBUSTOR Patent
Albert J Juhasz and Richard W Niedzwiecki, inventors (to NASA) Issued 7 Oct 1975 5 p Filed 24 May 1973 Supersedes N73-25816 (11 - 16, p 1955)
(NASA-Case-LEW-11593-1, US-Patent-3,910,035, US-Patent-Appl-SN-363691, US-Patent-Class-60-39 23; US-Patent-Class-60-39 29, US-Patent-Class-60-39 74R) Avail: US Patent Office CSCL 21H

A short annular combustor utilizing diffuser bleed to control the airflow distribution in a gas turbine engine at various operating conditions is described Official Gazette of the U.S. Patent Office

N76-14191* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ROCKET CHAMBER AND METHOD OF MAKING Patent
Anthony Fortini, inventor (to NASA) Issued 7 Oct 1975 4 p Filed 24 Jan 1974 Supersedes N74-28232 (12 - 17, p 2084)
(NASA-Case-LEW-11118-2; US-Patent-3,910,039, US-Patent-Appl-SN-436316; US-Patent-Class-60-265; US-Patent-Class-60-267; US-Patent-Class-239-127.3) Avail US Patent Office CSCL 21H

A transpiration cooled rocket chamber is made by forming a porous metal wall on a suitably shaped mandrel. The porous wall may be made of sintered powdered metal, metal fibers sintered on the mandrel, or wires woven onto the mandrel and then sintered to bond the interfaces of the wires. Intersecting annular and longitudinal ribs are then electroformed on the porous wall An interchamber wall having orifices is then electroformed over the annular and longitudinal ribs Parallel longitudinal ribs are then formed on the outside surface of the interchamber wall after which an annular jacket is electroformed over the parallel ribs to form distribution passages. A feed manifold communicating with the distribution passages may be fabricated and welded to the rocket chamber or the feed manifold may be electroformed in place Official Gazette of the U.S Patent Office

N76-16176*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EFFECT OF TIP CLEARANCE ON PERFORMANCE OF SMALL AXIAL HYDRAULIC TURBINE
James L. Boynton and Harold E. Rohlik Jan 1976 29 p refs
(NASA-TM-X-3339, E-8370) Avail: NTIS HC $4 00 CSCL 21E

The first two stages of a six stage liquid oxygen turbine were tested in water. One and two stage performance was determined for one shrouded and two unshrouded blade end configurations over ranges of clearance and blade-jet speed ratio First stage, two stage, and second stage efficiencies are included as well as the effect of clearance on mass flow for two stage operation. Author

N76-17192*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THE 0.040-SCALE SPACE SHUTTLE ORBITER BASE HEATING MODEL TESTS IN THE LEWIS RESEARCH CENTER SPACE POWER FACILITY
Robert A. Dezelick Jan 1976 44 p refs
(NASA-TM-X-71843, E-8568) Avail NTIS HC $4.00 CSCL 21H

Space shuttle base heating tests were conducted using a 0.040-scale model in the Plum Brook Space Power Facility of The NASA Lewis Research Center The tests measured heat transfer rates, pressure distributions, and gas recovery temperatures on the orbiter vehicle 2A base configuration resulting from engine plume impingement One hundred and sixty-eight hydrogen-oxygen engine firings were made at simulated flight altitudes ranging from 120,000 to 360,000 feet. Author

N76-17194*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
SOLID ROCKET THRUST VECTOR CONTROL NASA space vehicle design criteria (chemical propulsion)
Dec 1974 200 p refs
(NASA-SP-8114) Avail NTIS HC $7 50 CSCL 21H

Thrust vector control systems that superimpose a side force on the motor thrust, steering being achieved by the side force causing a moment about the vehicle center of gravity are described A brief review of thrust vector control systems is presented, and two systems, flexible joint and liquid injection, are treated in detail Treatment of the flexible-joint thrust vector control system is limited to the design of the flexible joint and its insulation against hot motor gases. Treatment of the liquid injection thrust vector control system is limited to discussion of the injectant, valves, piping, storage tanks, and pressurization system, no evaluation is presented of the nozzle except for (1) the effect of the injectant and erosion at the injection port and (2) the effect of injection on pressure distribution within the nozzle Author

N76-19227*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
ANODE FOR ION THRUSTER Patent Application
Bruce A Banks, inventor (to NASA) Filed 8 Mar. 1976 12 p
(NASA-Case-LEW-12048-1, US-Patent-Appl-SN-665033) Avail NTIS HC $3 50 CSCL 21C

A screen anode for an ion thruster is described. The anode is constructed of a woven mesh screen, preferably of a stainless steel wire cloth with a mesh size less than the intergrid gap or openings of the screen grid or accelerator grid systems of the thruster The screen anode is sputter coated with tantalum as a result of thruster operation Because of the fineness of the screen anode any spalled material from the tantalum coated anode is in such small dimensions that the spalled pieces cannot interfere with the accelerator screen grid systems, and the focusing NASA

N76-20214*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
SOLID ROCKET MOTOR NOZZLES Space vehicle design criteria (chemical propulsion)

Russell A. Ellis (Thiokol Chemical Corp., Wasatch Div.) and Russell B. Keller, Jr., ed. Jun 1975 140 p refs
(NASA-SP-8115) Avail: NTIS HC $6.00 CSCL 21H

The steps in the nozzle design process are examined. The nozzle designer's role in defining design requirements and constraints is included along with discussions of each of the three basic phases of the nozzle design process itself: (1) aerodynamic design, in which the gas-contacting surfaces are configured to produce the required performance within the envelope limits; (2) thermal design, in which termal liners and thermal insulators are selected and configured to maintain the surfaces as closely as practical against effects of erosion and to limit the structure temperature to acceptable levels; and (3) structural design, in which materials are selected and configured to support the thermal components and to sustain the predicted loads. Analytical techniques that are used to establish thermal and structural design integrity and to predict nozzle performance are discussed along with methods for nozzle quality assurance. Emphasis is placed on nozzle design and materials for modern high-temperature aluminized propellants. Recurring nozzle design problems of graphite cracking and ejection, differential erosion at material interfaces, lack of sufficient proven nondestructive testing (NDT) techniques, the uncertainty of adhesive bonding, and inadequate definition of material properties, particularly at high temperatures are considered. Author

N76-20215*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
FUEL COMBUSTOR Patent Application
Cecil J. Marek, inventor (to NASA) Filed 31 Mar 1976 11 p
(NASA-Case-LEW-12137-1; US-Patent-Appl-SN-672210) Avail: *NTIS HC $3.50 CSCL 21H*

A fuel combustor comprised of a chamber with air and fuel inlets and a combination gas outlet is described. 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. Combustion products are exhausted, for example, into a turbine inlet. By use of the heat pipe means some of the heat of combustion is 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. Fewer pollutants are formed and complete combustion is assisted because of the improved fuel vaporization and better mixing.
NASA

N76-21276* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
METHOD OF CONSTRUCTING DISHED ION THRUSTER GRIDS TO PROVIDE HOLE ARRAY SPACING COMPENSATION Patent
Bruce A. Banks, inventor (to NASA) Issued 6 Apr 1976 4 p Filed 20 Jan 1975 Supersedes N75-16624 (13 - 08, p 0863)
(NASA-Case-LEW-11876-1; US-Patent-3,947,933; US-Patent-Appl-SN-542157; US-Patent-Class-29-25.18) Avail: US Patent Office CSCL 21C

The center-to-center spacings of a photoresist pattern for an array of holes applied to a thin metal sheet are increased by uniformly stretching the thin metal sheet in all directions along the plane of the sheet. The uniform stretching is provided by securely clamping the periphery of the sheet and applying an annular force against the face of the sheet, within the periphery of the sheet and around the photoresist pattern. The technique is used in the construction of ion thruster grid units where the outer or downstream grid is subjected to uniform stretching prior to convex molding. The technique provides alignment of the holes of grid pairs so as to direct the ion beamlets in a direction parallel to the axis of the grid unit and thereby provide optimization of the available thrust. Official Gazette of the U.S. Patent Office

N76-21288*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
TIME TEMPERATURE-STRESS DEPENDENCE OF BORON FIBER DEFORMATION
James A. DiCarlo Washington 1976 35 p refs Presented at 4th Conf. on Composite Materials Testing and Design, Valley Forge, Pa., 3-4 May 1976, sponsored by Am. Soc. for Testing and Materials
(NASA-TM-X-71907; E-8698) Avail: NTIS HC $4.00 CSCL 11D

Flexural stress relaxation (FSR) and flexural internal friction (FIF) techniques were employed to measure the time-dependent deformation of boron fibers from -190 to 800 C. The principal specimens were 203 micrometers diameter fibers commercially produced by chemical vapor deposition (CVD) on a 13 micrometer tungsten substrate. The observation of complete creep strain recovery with time and temperature indicated that CVD boron fibers deform flexurally as anelastic solids with no plastic component. Author

N76-21289*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
PROGRESS IN ADVANCED HIGH TEMPERATURE MATERIALS TECHNOLOGY
John C. Freche and G. Mervin Ault 1976 33 p refs Proposed for presentation at 3d Intern. Symp. on Superalloys, Seven Springs, Pa., 12-15 Sep. 1976, sponsored by Am. Inst. of Mining, Metallurgical and Petroleum Engr.
(NASA-TM-X-71901) Avail: NTIS HC $4.00 CSCL 11D

Significant progress has recently been made in many high temperature material categories pertinent to such applications by the industrial community. These include metal matrix composites, superalloys, directionally solidified eutectics, coatings, and ceramics. Each of these material categories is reviewed and the current state-of-the-art identified, including some assessment, when appropriate, of progress, problems, and future directions. Author

N76-21293*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
LONGITUDINAL RESIDUAL STRESSES IN BORON FIBERS
D. R. Behrendt 1976 16 p refs Presented at the Symp. on Composite Mater. Testing and Design, Valley Forge, Pa., 3-4 May 1976, sponsored by ASTM
(NASA-TM-X-73402, E-8725) Avail: NTIS HC $3.50 CSCL 11D

A method of measuring the longitudinal residual stress distribution in boron fibers is presented. The residual stresses in commercial CVD boron on tungsten fibers of 102, 142, and 203 microns (4, 5.6, and 8 mil) diameters were determined. Results for the three sizes show a compressive stress at the surface [800 to -1400 MN/sq m (120 to -200) ksi], changing monotonically to a region of tensile stress within the boron. At approximately 25 percent of the original radius, the stress reaches a maximum tensile [600 to 1000 MN/sq m(90 to 150 ksi)] and then decreases to compressive near the tungsten boride core. The core itself is under a compressive stress of approximately -1300 MN/sq m (-190 ksi). The effects of surface removal on core residual stress and core-initiated fracture are discussed. Author

N76-22297*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
SYSTEM TESTS WITH ELECTRIC THRUSTER BEAM AND ACCELERATOR DIRECTLY POWERED FROM LABORATORY SOLAR ARRAYS
John B. Stover Washington Apr 1976 28 p refs
(NASA-TM-X-3353 E-8546) Avail: NTIS HC $4.00 CSCL 21C

Laboratory high voltage solar arrays were operated directly connected to power the beam and accelerator loads of an 8-centimeter ion thruster. The beam array comprised conventional 2 by 2 centimeter solar cells, the accelerator array comprised multiple junction edge-illuminated solar cells. Conventional laboratory power supplies powered the thruster's other loads. Tests were made to evaluate thruster performance and to investigate possible electrical interactions between the solar

arrays and the thruster. Thruster performance was the same as with conventional laboratory beam and accelerator power supplies. Most of the thruster beam short circuits that occurred during solar array operation were cleared spontaneously without automatic or manual intervention No spontaneous clearing occurred during conventional-power supply operation Author

N76-26270*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EXPERIMENTAL AND THEORETICAL INVESTIGATION OF FATIGUE LIFE IN REUSABLE ROCKET THRUST CHAMBERS
Ned P. Hannum, Harold J Kasper, and Albert J. Pavli 1976 33 p refs Presented at the 12th Propulsion Conf., Palo Alto, Calif., 26-28 Jul. 1976. Sponsored by the Am. Inst. of Aeronautics and Astronautics and the Soc. of Automotive Engineers
(NASA-TM-X-73413, E-8745) Avail: NTIS HC $4.00 CSCL 21H

During a test program to investigate low-cycle thermal fatigue, 13 rocket combustion chambers were fabricated and cyclically test fired to failure Six oxygen-free, high-conductivity (OFHC) copper and seven Amzirc chambers were tested The failures in the OFHC copper chambers were not typical fatigue failures but are described as creep rupture enhanced by ratcheting The coolant channels bulged toward the chamber centerline, resulting in progressive thinning of the wall during each cycle The failures in the Amzirc alloy chambers were caused by low-cycle thermal fatigue The zirconium in this alloy was not evenly distributed in the chamber materials. The life that was achieved was nominally the same as would have been predicted from OFHC copper isothermal test data Author

N76-30284*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
LIQUID ROCKET ENGINE INJECTORS
G S Gill (Rockwell Intern Corp.) and W H Nurick (Rockwell Intern Corp.) Mar 1976 130 p refs
(NASA-SP-8089) Avail NTIS HC $6.00 CSCL 21H

The injector in a liquid rocket engine atomizes and mixes the fuel with the oxidizer to produce efficient and stable combustion that will provide the required thrust without endangering hardware durability Injectors usually take the form of a perforated disk at the head of the rocket engine combustion chamber, and have varied from a few inches to more than a yard in diameter This monograph treats specifically bipropellant injectors, emphasis being placed on the liquid/liquid and liquid/gas injectors that have been developed for and used in flight-proven engines The information provided has limited application to monopropellant injectors and gas/gas propellant systems. Critical problems that may arise during injector development and the approaches that lead to successful design are discussed Author

N76-30286*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CENTAUR BOOST PUMP TURBINE ICING INVESTIGATION
R J Rollbuhler May 1976 29 p refs
(NASA-TM-X-73421, E-8759) Avail NTIS HC $4.00 CSCL 21H

An investigation was conducted to determine if ice formation in the Centaur vehicle liquid oxygen boost pump turbine could prevent rotation of the pump and whether or not this phenomenon could have been the failure mechanism for the Titan/Centaur vehicle TC-1 The investigation consisted of a series of tests done in the LeRC Space Power Chamber Facility to evaluate evaporative cooling behavior patterns in a turbine as a function of the quantity of water trapped in the turbine and as a function of the vehicle ascent pressure profile It was found that evaporative freezing of water in the turbine housing, due to rapid depressurization within the turbine during vehicle ascent, could result in the formation of ice that would block the turbine and prevent rotation of the boost pump But for such icing conditions to exist it would be necessary to have significant quantities of water in the turbine and/or its components, and the turbine housing temperature would have to be colder than 40 F at vehicle liftoff Author

A76-18515 * # **Computer controlled vent and pressurization system.** E. J. Cieslewicz (NASA, Lewis Research Center, Cleveland, Ohio). *Illinois Institute of Technology, Fluid Power Society and National Fluid Power Association, National Conference on Fluid Power, Chicago, Ill., Oct. 21-23, 1975, Paper.* 27 p.

The paper illustrates how the Centaur space launch vehicle airborne computer, which was primarily used to perform guidance, navigation, and sequencing tasks, was further used to monitor and control inflight pressurization and venting of the cryogenic propellant tanks. Computer software flexibility also provided a failure detection and correction capability necessary to adopt and operate redundant hardware techniques and enhance the overall vehicle reliability. (Author)

A76-20298 * # **Optimum exhaust velocity for laser-driven rockets.** W. E. Moeckel (NASA, Lewis Research Center, Physical Sciences Div., Cleveland, Ohio) *Journal of Spacecraft and Rockets*, vol 12, Nov. 1975, p 700, 701 6 refs

The laser-driven rocket in which remotely generated laser power is used to heat propellant belongs basically to the class of specific-impulse limited propulsion systems if difficult missions are considered It was previously established that trip time reaches a minimum as specific impulse is varied for payload transfers from low earth orbit to synchronous orbit and return via laser-driven rocket propulsion, the computations being based on the perigee-propulsion laser drive described by Minovitch (1972). The present study shows that such minimum occur for all missions and that optimum specific impulse is primarily determined by the mission difficulty. More generally, this optimum specific impulse maximizes payload kinetic energy achievable with a fixed jet power and propulsion time. A formula relating propulsion time parameter to payload ratio is obtained for estimating mission capabilities of laser-driven rockets. S.D.

A76-38210 * # **Experimental and theoretical investigation of fatigue life in reusable rocket thrust chambers.** N. P. Hannum, H. J. Kasper, and A. J. Pavli (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-685.* 24 p. 11 refs

During a test program to investigate low-cycle thermal fatigue, 13 rocket combustion chambers were fabricated and cyclically test fired to failure. Six oxygen-free, high-conductivity (OFHC) copper and seven Amzirc chambers were tested The chamber liners were fabricated of copper or copper alloy and contained milled coolant channels The chambers were completed by means of an electroformed nickel closeout. The oxidant/fuel ratio for the liquid oxygen and gaseous hydrogen propellants was 6.0. The failures in the OFHC copper chambers were not typical fatigue failures but are described as creep rupture enhanced by ratcheting The coolant channels bulged toward the chamber centerline, resulting in progressive thinning of the wall during each cycle The failures in the Amzirc alloy chambers were caused by low-cycle thermal fatigue The lives were much shorter than were predicted by an analytical structural analysis computer program used in conjunction with fatigue life data from isothermal test specimens, due to the uneven distribution of Zr in the chamber material (Author)

A76-40693 * **Power processing for electric propulsion** R. C. Finke (NASA, Lewis Research Center, Cleveland, Ohio), B. G. Herron (Hughes Research Laboratories, Malibu, Calif.), and G. D. Gant (Xerox Corp., Pasadena, Calif.). In EASCON '75; Electronics and Aerospace Systems Convention, Washington, D.C., September 29-October 1, 1975, Record. (A76-40642 20-32) New York, Insti-

tute of Electrical and Electronics Engineers, Inc , 1975, p. 201-A to 201-M.

The potential of achieving up to 30 per cent more spacecraft payload or 50 per cent more useful operating life by the use of electric propulsion in place of conventional cold gas or hydrazine systems in science, communications, and earth applications spacecraft is a compelling reason to consider the inclusion of electric thruster systems in new spacecraft design The propulsion requirements of such spacecraft dictate a wide range of thruster power levels and operational lifetimes, which must be matched by lightweight, efficient, and reliable thruster power processing systems This paper will present electron bombardment ion thruster requirements, review the performance characteristics of present power processing systems, discuss design philosophies and alternatives in areas such as inverter type, arc protection, and control methods, and project future performance potentials for meeting goals in the areas of power processor weight (10 kg/kW), efficiency (approaching 92 per cent), reliability (0.96 for 15,000 hr), and thermal control capability (0.3 to 5 AU). (Author)

N76-13202*# McDonnell-Douglas Astronautics Co , Huntington Beach, Calif.
VALUE CONTAMINATION AVOIDANCE DEVICES Final Report, May 1974 - July 1975
D L. Endicott Nov 1975 122 p refs
(Contract NAS3-17812)
(NASA-CR-134877, MDC-G6029) Avail NTIS HC $5 50 CSCL 21H

Mechanical redesign methods were used to minimize contamination damage of conventional fluid components and a contamination separator device was developed for long term reusable space vehicles These were incorporated into an existing 50 8 mm poppet valve and tested for damage tolerance in a full size open-loop flow system with gaseous and liquid nitrogen Cyclic and steady flow conditions were tested with particles of 125 to 420 micrometers aluminum oxide dispersed in the test fluids Nonflow life tests (100,000 cycles) were made with two valve configurations in gaseous hydrogen The redesigned valve had an acceptable cycle life and improved tolerance to contamination damage when the primary sealing surfaces were coated with thin coatings of hard plastic (Teflon S and Kynar) Analytical studies and flow testing were completed of four different versions of the separator. overall separation efficiencies in the 55-90% range were measured with these non-optimum configurations Author

N76-19229*# Boeing Aerospace Co , Seattle, Wash
THREE DIMENSIONAL THRUST CHAMBER LIFE PREDICTION Final Contractor Report
William H Armstrong and E W Brogren Mar 1976 119 p refs
(Contract NAS3-19717)
(NASA-CR-134979, D180-19309-1) Avail. NTIS HC $5 50 CSCL 21H

A study was performed to analytically determine the cyclic thermomechanical behavior and fatigue life of three configurations of a Plug Nozzle Thrust Chamber This thrust chamber is a test model which represents the current trend in nozzle design calling for high performance coupled with weight and volume limitations as well as extended life for reusability The study involved the use of different materials and material combinations to evaluate their application to the problem of low-cycle fatigue in the thrust chamber. The thermal and structural analyses were carried out on a three-dimensional basis Results are presented which show plots of continuous temperature histories and temperature distributions at selected times during the operating cycle of the thrust chamber Computed structural data show critical regions for low-cycle fatigue and the histories of strain within the regions for each operation cycle Author

N76-21291*# Fiber Science, Inc , Gardena, Calif
FILAMENT-WOUND SPAR SHELL GRAPHITE/EPOXY FAN BLADES
Sam Yao Feb 1976 25 p
(Contract NAS3-17822)
(NASA-CR-134899, FSI-551-201) Avail NTIS HC $3 50 CSCL 11D

The methodology for fabrication of wet filament wound spar shell fan blades is presented All principal structural elements were filament wound, assembled, formed, bonded and co-cured in a female mold A pair of blades were fabricated as one integral unit and parted into two after curing Author

N76-21292*# General Electric Co , Philadelphia, Pa Space Sciences Lab
FURTHER DEVELOPMENT OF HIGH TEMPERATURE-RESISTANT GRAPHITE FIBER COUPLING AGENTS
R N. Griffin Mar. 1976 57 p refs
(Contract NAS3-18931)
(NASA-CR-134987) Avail NTIS HC $4 50 CSCL 11D

Potential coupling agents for graphite fibers were screened by their effect on the weight losses of Thornel 300, HMS, and HTS fibers at 588K for 200 and 400 hours Unidirectional laminates were made from HMS and HTS fibers, untreated, and treated with each of the seven coupling agents The matrix of all laminates was PMR polyimide (PMR-PR) On the basis of the best overall retention of elevated temperature interlaminar shear strength after 200 hours at 588K, composite weight after 200 hours at 588K, and fiber weight after 400 hours at 588K, ventromer T-1 applied from aqueous solution and pyrolyzed PPQ were selected for further evaluation as coupling agents for HTS fiber while ventromer T-2 and pyrolyzed PPQ were selected as coupling agents for HMS fiber It was shown that pyrolyzed PPQ as a coupling agent improves the oxidative stability of HTS/PMR-PI composites Author

N76-23355*# Hughes Research Labs , Malibu Calif
THRUSTER ENDURANCE TEST Final Report
C Collett May 1976 276 p refs
(Contracts NAS3-15523 NAS3-17803)
(NASA-CR-135011) Avail NTIS HC $9 25 CSCL 21C

A test system was built and several short term tests were completed The test system included, in addition to the 30-cm ion thruster, a console for powering the thruster and monitoring performance, a vacuum facility for simulating a space environment and a storage and feed system for the thruster propellant This system was used to perform three short term tests (one 100-hour and two 500-hour tests), an 1108-hour endurance test which was aborted by a vacuum facility failure, and finally the 10,000-hour endurance test In addition to the two 400 series thrusters which were used in the short term and 1100-hour tests, four more 400 series thrusters were fabricated, checked out, and delivered to NASA. Three consoles similar to the one used in the test program were also fabricated and delivered. Author

N76-25343*# TRW, Inc , Redondo Beach, Calif
BEAM EFFLUX MEASUREMENTS Final Report
G. K Komatsu and J M. Stellen, Jr. 1 Jun 1976 137 p refs
(Contract NAS3-19537)
(NASA-CR-135038) Avail NTIS HC $6 00 CSCL 21C

Measurements have been made of the high energy thrust ions, (Group I), high angle/high energy ions (Group II), and high angle/low energy ions (Group IV) of a mercury electron bombardment thruster in the angular divergence range from 0 deg to greater than 90 deg The measurements have been made as a function of thrust ion current, propellant utilization efficiency, bombardment discharge voltage, screen and accelerator grid potential (accel-decel ratio) and neutralizer keeper potential The shape of the Group IV (charge exchange) ion plume has remained essentially fixed within the range of variation of the engine operation parameters The magnitude of the charge exchange ion flux scales with thrust ion current, for good propellant

utilization conditions For fixed thrust ion current, charge exchange ion flux increases for diminishing propellant utilization efficiency Facility effects influence experimental accuracies within the range of propellant utilization efficiency used in the experiments. The flux of high angle/high energy Group II ions is significantly diminished by the use of minimum decel voltages on the accelerator grid A computer model of charge exchange ion production and motion has been developed. The program allows computation of charge exchange ion volume production rate, total production rate, and charge exchange ion trajectories for 'genuine' and 'facilities effects' particles In the computed flux deposition patterns, the Group I and Group IV ion plumes exhibit a counter motion Author

N76-27355*# TRW Systems, Redondo Beach, Calif
CHARGED PARTICLE MEASUREMENTS ON A 30-CM DIAMETER MERCURY ION ENGINE THRUST BEAM
J M Sellen, Jr, G K Komatsu, D. K Hoffmaster, and R F Kemp 1 Apr 1974 36 p refs
(Contract NAS3-17641)
(NASA-CR-148293; TRW-25781-6001-RU-00) Avail NTIS HC $4 00 CSCL 21C

Measurements of both thrust ions and charge exchange ions were made in the beam of a 30 centimeter diameter electron bombardment mercury ion thruster A qualitative model is presented which describes magnitudes of charge exchange ion formation and motions of these ions in the weak electric field structure of the neutralized thrust beam plasma Areas of agreement and discrepancy between observed and modeled charge exchange properties are discussed. Author

N76-33283*# Hughes Research Labs, Malibu, Calif Ion Physics Dept
THE 2 5 kW ADVANCED TECHNOLOGY ION THRUSTER Final Report, 13 Jun. 1974 - 29 Feb. 1976
R L Poeschel Apr 1976 106 p refs
(Contract NAS3-17831)
(NASA-CR-135076) Avail NTIS HC $5 50 CSCL 21C

A representative thruster was extensively documented with respect to performance parameters and characteristics at selected ion beam currents in the 0 5 to 2 75 A range, including measurements of thrust losses resulting from doubly-charged ions and ion beam divergence Corrected total efficiency was shown to be relatively insensitive to operating parameter selection at any given power level. Factors affecting doubly-charged ionization were studied and it was found that the fraction of doubly-charged ions is directly proportional to the discharge chamber propellant utilization The parameter that most affects this proportionality is the accel aperture diameter (which controls neutral atom loss). Thruster-power conditioner interactions were studied with the result that previous power supply specifications remain satisfactory Options for reducing the number of power supplies required were demonstrated to be feasible. Gimbal actuator designs were studied with the goal of selecting a particular approach for design and development The conclusion drawn was that optimum gimbal actuator design depends heavily on the thruster application and consequently the effort was concluded by developing a computer program to aid in specifying the gimbal requirements for the thrust vectoring required in a specific application Author

A76-10269 * # Advanced regenerative-cooling techniques for future space transportation systems W R Wagner and J M. Shoji (Rockwell International Corp., Rocketdyne Div., Canoga Park, Calif.). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 11th, Anaheim, Calif , Sept. 29-Oct. 1, 1975, AIAA Paper 75-1247.* 29 p. 8 refs. Contracts No. NAS3-17825, No. NAS8-27980

A review of regenerative-cooling techniques applicable to advanced planned engine designs for space booster and orbit transportation systems has developed the status of the key elements of this cooling mode. This work is presented in terms of gas side, coolant side, wall conduction heat transfer, and chamber life fatigue margin considerations Described are preliminary heat transfer and trade analyses performed using developed techniques combining channel wall construction with advanced, high-strength, high-thermal-conductivity materials (NARloy-Z or Zr-Cu alloys) in high heat flux regions, combined with lightweight steel tubular nozzle wall construction Advanced cooling techniques such as oxygen cooling and dual-mode hydrocarbon/hydrogen fuel operation and their limitations are indicated for the regenerative cooling approach. (Author)

A76-11171 * # Advanced space engine component developments. M. Yost and A. Csomor (Rockwell International Corp., Rocketdyne Div , Canoga Park, Calif.) *JANNAF Propulsion Meeting, Anaheim, Calif., Sept 30-Oct 2, 1975, Paper.* 26 p. Contract No. NAS3-16751

The principal components of a high-performance advanced space engine are being fabricated and tested at Rocketdyne under NASA contracts. Effort is in progress on the main liquid hydrogen and liquid oxygen turbopumps, thrust chamber, and injector. A description of the primary design and performance parameters, and the mechanical arrangement of each component is presented. Fabrication techniques used in producing test hardware are related and test results and plans are outlined (Author)

A76-11172 * # Integrated auxiliary propulsion for the Space Tug. J F. Nichols (Rockwell International Corp, Space Div., Seal Beach, Calif.) and J. D. Sims (Aerojet Liquid Rocket Co , Sacramento, Calif.). *JANNAF Propulsion Meeting, Anaheim, Calif., Sept. 30-Oct. 2, 1975, Paper.* 25 p. 7 refs. Contract No NAS3-18913.

This paper summarizes the results of a design study which considered several possible methods for applying the liquid-liquid cryogenic oxygen/hydrogen auxiliary propulsion concept to the Space Tug This concept, which is based on maintaining the propellant in the liquid phase from storage to thruster inlet, is much simpler than previous oxygen/hydrogen systems which converted the propellant to vapor for distribution to the thrusters The paper describes the selected liquid-liquid concept which is an integrated design that uses the Tug main propulsion tanks as a propellant source The characteristics of this integrated system are compared with dedicated storable propellant systems. The integrated concept is found to have only slightly superior mission payload performance, but provides inherent vehicle versatility through the interchangeable availability of main and auxiliary propellant Propellant interchange also was found to permit the auxiliary system to provide abort backup capability in the event of most main engine failures. This capability implies Tug program cost savings which more than offset the higher development costs of the integrated auxiliary propulsion system. (Author)

A76-12789 * # Lightweight fuel cell powerplant for Tug. L. M. Handley (United Technologies Corp , South Windsor, Conn.). *AAS, AIAA, IEEE, ORSA, and IMS, Meeting on Space Shuttle Missions of the 80's, Denver, Colo., Aug 26-28, 1975, AAS Paper 75-143* 14 p. 8 refs. Contracts No. NAS3-15339, No. NAS8-30637; No. NAS9-11034; No. F33615-72-C-1371

The design and characteristics of a lightweight powerplant based on advanced cell technology to meet the requirements of the Space Tug are described. The powerplant can be operated off low-pressure hydrogen and oxygen rocket propellant tanks and avoid the need for a dedicated reactant supply. Product water can be condensed or not, depending on vehicle or payload requirements. The heart of the unit, the fuel cell power section, consist of lightweight, series-connected, alkaline cells, while the power section contains accessory components for reactant conditioning, distribution, and venting, coolant circulation, passive product water removal and electric control The proposed design offers at least a 50 per cent saving in powerplant weight, so that the total estimated powerplant dry weight including structure, tubing, wiring, interface connectors, and interface heat exchanger is 48 lb S.D.

A76-12862 * # **Advanced space engine component technology status.** A T Zachary (Rockwell International Corp , Rocketdyne Div., Canoga Park, Calif.). *AAS, AIAA, IEEE, ORSA, and IMS, Meeting on Space Shuttle Missions of the 80's, Denver, Colo., Aug. 26-28, 1975, AAS Paper 75-156.* 16 p Contracts No. NAS3-17794; No NAS3-17800, No. NAS3-17825.

Key to the achievement of maximum benefit from the Space Tug transportation system is the availability of a low-cost, high-performance engine system To define this engine system, studies have been conducted under Arr Force and NASA direction, and pertinent hardware technology programs have been initiated. From among the several candidate systems studied, the cryogenic, staged-combustion cycle, high chamber pressure system in conjunction with a large-area-ratio nozzle was selected for component and subsystem demonstration Main turbopump, high-area-ratio thrust chamber, preburner, and igniter components are being evaluated. A brief description of the engine capabilities, the main liquid hydrogen and liquid oxygen turbopump/preburner, and the main thrust chamber programs are presented, designs and progress in fabrication are shown and test results discussed. (Author)

A76-42428 * # **Future higher performance O2/H2 engine combustion cycle alternatives.** W R Wagner (Rockwell International Corp , Rocketdyne Div., Canoga Park, Calif) *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif , July 26-29, 1976, AIAA Paper 76-709.* 44 p 8 refs. Contracts No NAS3-17825, No NAS8-27980

The status of current and projected advanced O2/H2 rocket engine configurations for high-efficiency engine designs is examined. Particular attention is given to engine cycle configurations, operating pressures, and performance characteristics which can be foreseen for the engine configurations past the 1980 era for single-stage-to-orbit boosters and advanced space engines. The discussion covers potential O2/H2 performance gains achievable, engine cycle improvements, and projected O2/H2 engine component efficiency, weight, and other improvements foreseen through future development S D

A76-42431 * # **Small, high-performance engine component technology status.** M C Yost and A. Csomor (Rockwell International Corp., Rocketdyne Div , Canoga Park, Calif.). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-738.* 32 p Contracts No NAS3-19713, No. NAS3-17825, No. NAS3-17794; No NAS3-17800

Rocketdyne, under contract to NASA-Lewis Research Center, is engaged in developing the technology for major subsystems of a small, high-performance, liquid rocket engine with the capabilities required for high-energy, upper-stage applications Included in these efforts are the high-pressure turbopumps, preburner, igniter components, and high-area-ratio thrust chamber. A brief description of the engine system and its subsystems is given The status of the programs is reviewed and the results of the testing conducted are presented (Author)

23 CHEMISTRY AND MATERIALS (GENERAL)

Includes biochemistry and organic chemistry.

A76-22288 * Trends in high temperature materials technology for advanced aircraft turbine engines. C P. Blankenship (NASA, Lewis Research Center, Cleveland, Ohio). *Society of Automotive Engineers, National Aerospace Engineering and Manufacturing Meeting, Culver City, Calif., Nov. 17-20, 1975, Paper 751050* 14 p. 32 refs

The utilization of high temperature materials for turbine blades, disks, vanes, and combustors is reviewed. The use of directionally solidified eutectic alloys and of metal fiber reinforced superalloys as turbine blade materials is discussed. The application of powder metallurgy to the production of turbine disks is considered It is shown that oxide-dispersion strengthened alloys (including NiCr and NiCr-Al) and ceramics are the best refractory turbine vane materials. The use of heat resistant sheet alloys as combustor materials is examined. The cost benefits to be derived from the application of high temperature technology to advanced CTOL and STOL engines are described. B J.

A76-33396 * # Preliminary results from screening tests of commercial catalysts with potential use in gas turbine combustors. II - Combustion test rig evaluation D. N. Anderson (NASA, Lewis Research Center, Cleveland, Ohio). *U.S. Environmental Protection Agency, Workshop on Catalytic Combustion, Raleigh, N.C., May 24-26, 1976, Paper.* 25 p. 9 refs.

Several commercial monolithic catalysts were tested in a combustion test rig to determine their suitability for use in a gas-turbine combustor primary zone. The catalyst test bed consisted of two to four elements of 12-centimeter diameter by 2.5-centimeter long monolith. Results are presented of the measured combustion efficiency and catalyst bed temperature history for an inlet propane-air mixture temperature of 800 K, a pressure of 300,000 newtons per square meter, inlet velocities of 10 to 25 meters per second and equivalence ratios of 0.1 to 0.3. The best catalysts tested gave combustion efficiencies of virtually 100% for reaction temperatures ranging from 1325 K at 10 meters per second to 1400 K at 25 meters per second. This performance was only possible with fresh catalysts. The catalysts tested were not specifically developed for use at these conditions and showed some loss in activity after about 3 hours' testing (Author)

24 COMPOSITE MATERIALS

Includes laminates.

N76-12142*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
COMBINED-LOAD STRESS-STRAIN RELATIONSHIP FOR ADVANCED FIBER COMPOSITES
C C. Chamis and T. L. Sullivan 1975 44 p refs Proposed for Presentation at 31st Ann Reinforced Plastics Composites Conf. Washington, D. C., 3-6 Feb 1976; sponsored by Soc. of the Plastics Ind
(NASA-TM-X-71825, E-8526) Avail NTIS HC $4.00 CSCL 11D

It was demonstrated experimentally that only one test specimen is required to determine the combined-load stress-strain relationships of a given fiber composite system These relationships were determined using a thin angle-plied laminate tube and subjecting it to a number of combined-loading conditions The measured data obtained are compared with theoretical predictions Some important considerations associated with such a test are identified, and the significance of combined-load stress-strain relationships in certain practical designs are discussed Author

N76-13220*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
SUPER-HYBRID COMPOSITES: AN EMERGING STRUCTURAL MATERIAL
C. C. Chamis, R F Lark, and T L. Sullivan 1975 24 p refs Presented at 3d Conf on Fibrous Composites in Flight Vehicle Design, Williamsburg, Va., 4-6 Nov 1975; sponsored by NASA and AFFDL
(NASA-TM-X-71836; E-8545) Avail NTIS HC $3.50 CSCL 11D

Specimens of super-hybrids and advanced fiber composites were tested for smooth and center notch tensile strength, flexural strength, and Izod impact strength along the fiber direction and in the transverse direction Specimens were also subjected to thermal fatigue and tested for possible degradation at room temperature. The smooth tensile specimens were instrumented to obtain data for stress-strain curves Laminate analysis was used to analyze the super-hybrid specimens with respect to elastic and thermal properties, residual stresses, and ply stresses at the specimen fracture stress condition The results show that the super-hybrid composites exhibit superior resistance to Izod impact compared with other hybrid and advanced fiber composites, are only slightly degraded by thermal fatigue, and have transverse flexural strengths about three times that of diffusion bonded boron/aluminum Author

N76-16181*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland Ohio.
IMPROVED METHOD OF MAKING REINFORCED COMPOSITE STRUCTURES Patent Application
Lee C McCandless (General Technologies Corp., Reston, Va.) and Glen E Weber, inventors (to NASA) (General Technologies Corp., Reston, Va.) Filed 19 Apr 1974 16 p
(Contract NAS3-15828)
(NASA-Case-LEW-12619-1, US-Patent-Appl-SN-462424) Avail NTIS HC $3.50 CSCL 11D

A process is reported for making reinforced matrix composite structures of the type where reinforcing filament is wound on a body and metallic matrix material is electroformed on and between the windings to form each new layer of composite structure The matrix material is then machined until a new smooth surface is attained on which to precision-wind the next filament convolutions with their flat sides in close contact and with the spacings between convolutions very closely controlled NASA

N76-18233*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
BONDING AND COMPATIBILITY OF ALUMINUM OXIDE FIBERS IN NICKEL ALLOY COMPOSITES
Leonard J Westfall Washington Jan 1976 35 p refs
(NASA-TM-X-3333, E-8489) Avail NTIS HC $4.00 CSCL 11D

Bond strength and chemical compatibility of nickel and a range of nickel alloy compositions with single-crystal Al_2O_3 filaments were investigated The matrix materials studied were nickel, Ni-20Cr, Hastelloy-X, and NASA Nifeco-5 A pullout specimen was developed and used to determine the fiber matrix bond strength at room and elevated temperatures Fiber matrix reaction data were obtained and are discussed along with the effects of a thermal anneal on the elevated-temperature bond strength of the composite systems Good compatibility and adequate high temperature bond strength were shown for Hastelloy-X and NASA Nifeco-5, with the latter being superior Nickel and Ni-20Cr were shown to be unacceptable matrices because of severe chemical reactions Author

N76-18236*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
IMPROVED IMPACT-RESISTANT BORON-ALUMINUM COMPOSITES FOR USE AS TURBINE ENGINE FAN BLADES
David L McDaniels and Robert A. Signorelli [1976] 29 p refs Presented at Symp on Failure Modes in Composites, Las Vegas, Nev 23-24 Feb., 1976 sponsored by Am Inst. of Mining, Metallurgical, and Petrol Engrs
(NASA-TM-X-71875) Avail NTIS HC $4.00 CSCL 11D

Efforts to improve the impact resistance of B/Al are reviewed and analyzed. Thin sheet Charpy and Izod impact tests and standard full size Charpy impact tests were conducted on unidirectional and angleply composites containing 4 5 6 and 8 mil boron in 1100, 2024, 5052 and 6061 Al matrices Impact failure modes of B/Al are proposed in an attempt to describe the mechanisms involved and to provide insight for maximizing impact resistance The impact strength of B/Al was significantly increased by proper selection of materials and processing The use of more ductile matrices (1100 Al) and larger diameter (8 mil) boron fibers gave the highest impact strengths by allowing matrix shear deformation and multiple fiber breakage Author

N76-21287*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
AN OXIDE DISPERSION STRENGTHENED Ni-W-Al ALLOY WITH SUPERIOR HIGH TEMPERATURE STRENGTH
Thomas K Glasgow 1976 13 p refs Proposed for presentation at Third Intern Symp., Seven Springs, Pa., 12-15 Sep 1976; sponsored by Am. Inst of Mining, Met and Petrol. Engrs.
(NASA-TM-X-71888; E-8669) Avail NTIS HC $3.50 CSCL 11D

An experimental oxide dispersion strengthened (ODS) alloy, WAZ-D, derived from the WAZ-20 composition was produced by the mechanical alloying process Cast WAZ-20 is strengthened by both a high refractory metal content, and 70 volume percent of gamma prime The ODS alloy WAZ-D was responsive to variables of alloy content, of attritor processing, of consolidation by extrusion, and of heat treatment The best material produced had large highly elongated grains It exhibited tensile strengths generally superior to a comparable cast alloy. The ODS alloy exhibited high temperature stress rupture life considerably superior to any known cast superalloy Tensile and rupture ductility were low, as was intermediate temperature rupture life Very low creep rates were noted and some specimens failed with essentially no third stage creep Also the benefit derived from the oxide dispersion, far out-weighed that from the elongated microstructure alone Author

N76-22309* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
BEARING MATERIAL Patent
Harold E. Sliney, inventor (to NASA) Issued 27 Apr 1976 7 p Filed 10 Oct 1974 Supersedes N75-15746 (13 - 07,

p 0747)
(NASA-Case-LEW-11930-1, US-Patent-3,953,343; US-Patent-Appl-SN-513611, US-Patent-Class-252-12) Avail US Patent Office CSCL 11D

A composite material is described which will provide low friction surfaces for materials in rolling or sliding contact and is self-lubricating and oxidation resistant up to and in excess of about 930 C The composite is comprised of a metal component which lends strength and elasticity to the structure, a fluoride salt component which provides lubrication and, lastly, a glass component which not only provides oxidation protection to the metal but may also enhance the lubrication qualities of the composite. Official Gazette of the U.S Patent Office

N76-22313*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CHANGES IN BORON FIBER STRENGTH DUE TO SURFACE REMOVAL BY CHEMICAL ETCHING
Robert J. Smith Washington Apr. 1976 21 p refs
(NASA-TN-D-8219, E-8635) Avail: NTIS HC $3 50 CSCL 11D

The effects of chemical etching on the tensile strength of commercial boron/tungsten fibers were investigated. Fibers with as-received diameters of 203, 143, and 100 micrometers were etched to diameters as small as 43 micrometers The etching generally resulted in increasing fiber tensile strength with decreasing fiber diameter. And for the 203 micrometer fibers there was an accompanying significant decrease in the coefficient of variation of the tensile strength for diameters down to 89 micrometers Heat treating these fibers above 1,173 K in a vacuum caused a marked decrease in the average tensile strength of at least 80 percent. But after the fibers were etched, their strengths exceeded the as-received strengths The tensile strength behavior is explained in terms of etching effects on surface flaws and the residual stress pattern of the as-received fibers. Author

N76-22314*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
TEN DEG OFF-AXIS TENSILE TEST FOR INTRALAMINAR SHEAR CHARACTERIZATION OF FIBER COMPOSITES
Christos C Chamis and John H. Sinclair Washington Apr 1976 34 p refs
(NASA-TN-D-8215; E-8577) Avail NTIS HC $4 00 CSCL 11D

A combined theoretical and experimental investigation was conducted to assess the suitability of the 10 deg off-axis tensile test specimen for the intralaminar shear characterization of unidirectional composites. Composite mechanics, a combined-stress failure criterion, and a finite element analysis were used to determine theoretically the stress-strain variation across the specimen width and the relative stress and strain magnitudes at the 10 deg plane Strain gages were used to measure the strain variation across the specimen width at specimen midlength and near the end tabs Specimens from Mod-I/epoxy, T-300/epoxy, and S-glass/epoxy were used in the experimental program. It was found that the 10 deg off-axis tensile test specimen is suitable for intralaminar shear characterization and it is recommended that it should be considered as a possible standard test specimen for such a characterization Author

N76-23359*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THERMAL BARRIER COATING SYSTEM Patent Application
Stephan Stecura and Curt H Liebert, inventors (to NASA) Filed 14 May 1976 10 p
(NASA-Case-LEW-12554-1, US-Patent-Appl-SN-686449) Avail NTIS HC $3 50 CSCL 11C

A coating system is described which contains a bond coating and a thermal barrier coating It 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 NASA

N76-26282*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
BEARING MATERIAL Patent Application
Harold E Sliney, inventor (to NASA) Filed 25 Sep 1975 28 p
(NASA-Case-LEW-11930-2, US-Patent-Appl-SN-616528) Avail NTIS HC $4.00 CSCL 11D

A composite material is described which will provide low friction surfaces for materials in rolling or sliding contact and is self-lubricating and oxidation resistant up to and in excess of about 930 C The composite is comprised of a metal component which lends strength and elasticity to the structure, a fluoride salt component which provides lubrication, and a glass component which not only provides oxidation protection to the metal but may also enhance the lubrication qualities of the composite. NASA

N76-26283*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF ESTER IMPURITIES IN PMR-POLYIMIDE RESIN
Richard W Lauver 1976 14 p refs Presented at A Critical Rev of Techniques for the Characterization of Polymeric Mater., Watertown, Mass., 6-8 Jul. 1976
(NASA-TM-X-73444, E-8798) Avail NTIS HC $3 50 CSCL 11D

Spectral and chomatographic studies were conducted which established the presence of tri- and tetraester impurities in aged monomer solutions employed in fabrication of PMR-polyimide resin composites The equilibrium constant and apparent rate of the esterification were determined. It was demonstrated, using differential scanning calorimetry, that the ortho-ester moiety of these impurities does not completely react at typical cure conditions It is concluded that voids formed in composites fabricated with aged monomer solution are due to gaseous decomposition products evolved by ester impurities and/or unreacted amine during elevated temperature post-cure treatment. Author

N76-26287*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
TENSILE BEHAVIOR OF UNNOTCHED AND NOTCHED TUNGSTEN-COPPER LAMINAR COMPOSITES
Charles A. Hoffman Washington Jun 1976 34 p refs
(NASA-TN-D-8254; E-8069) Avail: NTIS HC $4 00 CSCL 11D

Relations were studied between the tensile strengths of unnotched and of notched, and elastic moduli of unnotched laminar sheet or foil composites and the amounts of reinforcement. Tungsten was used as the reinforcement and copper as the matrix, and the tests were run at room temperature Three thicknesses of tungsten (i e., 0 00254, 0.0127, and 0 0254 cm (0.001, 0.005, and 0 010 in) were used and the nominal volume fraction of tungsten was varied from about 0.05 to 0 95. It was found that the tensile strength of the unnotched specimens could be related to the amount of reinforcement, as could the elastic moduli, and that these values could be predicted by use of the rule of mixtures The tensile strengths of the notched laminar composites could be predicted by use of the rule of mixtures using strengths for notched constituents, provided notch effects did not predominate. Author

N76-30295*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FAILURE MECHANICS OF FIBER COMPOSITE NOTCHED CHARPY SPECIMENS
C C Chamis 1976 24 p ref Presented at the Army Symp on Solid Mechanics, Composite Materials, and the Influence of

Mechanics of Failure on Design, Cape Cod, Mass 14-16 Sep 1976
(NASA-TM-X-73462, E-8773) Avail NTIS HC $3 50 CSCL 11D

A finite element stress analysis was performed to determine the stress variation in the vicinity of the notch and far field of fiber composites Charpy specimens (ASTM Standard). NASTRAN was used for the finite element analysis assuming linear behavior and equivalent static load The unidirectional composites investigated ranged from Thornel 75 Epoxy to S-Glass/Epoxy with the fiber direction parallel to the long dimension of the specimen The results indicate a biaxial stress state exists in (1) the notch vicinity which is dominated by transverse tensile and interlaminar shear and (2) near the load application point which is dominated by transverse compression and interlaminar shear The results also lead to the postulation of hypotheses for the predominant failure modes, the fracture initiation, and the fracture process Finally, the results indicate that the notched Charpy test specimen is not suitable for assessing the impact resistance of nonmetallic fiber composites directly. Author

N76-33287*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
MICROSTRUCTURE OF HOT-PRESSED Al2O3-Si3N4 MIXTURES AS A FUNCTION OF HOLDING TEMPERATURE
Hun C Yeh 1976 12 p refs Presented at the 6th Intern. Materials Symp , Berkeley, Calif 24-27 Aug 1976
(NASA-TM-X-73482) Avail NTIS HC $3 50 CSCL 11D

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 Electron Microscopy and Transmission Electro 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. Photomicrographs of microstructures are shown.
Author

N76-33293*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EFFECT OF ANGLEPLYING AND MATRIX ENHANCEMENT ON IMPACT-RESISTANT BORON/ALUMINUM COMPOSITES
David L McDanels and Robert A Signorelli Washington Oct 1976 31 p refs
(NASA-TN-D-8205, E-8673) Avail NTIS HC $4 00 CSCL 11D

Efforts to improve the impact resistance of B/Al are reviewed and analyzed Tensile and dynamic modulus tests, thin sheet Charpy and Izod impact tests, and standard full size Charpy impact tests were conducted on 0 20 mm (8 mil) diameter-B/1100 Al matrix composites Anglephes ranged from unidirectional to + or - 30 deg The best compromise between reduced longitudinal properties and increased transverse properties was obtained with + or - 15 deg angleply The pendulum impact strengths of improved B/Al were higher than that of notched titanium and appear to be enough to warrant consideration of B/Cl for application to fan blades in aircraft gas turbine engines Author

A76-11168 * # Structure and thermal cycling stability of a hafnium monocarbide reinforced directionally solidified cobalt-base eutectic alloy. Y. G. Kim (NASA, Lewis Research Center, Cleveland, Ohio) *AIME, NASA, U.S. Army, and U.S Navy, Conference on In-Situ Composites II, Lake George, N.Y., Sept 2-5, 1975, Paper.* 11 p. 18 refs.

A nominal composition of Co-15Cr-20Ni-10.5Hf-0 7C was directionally solidified at 0.8 cm/hr growth rate to produce aligned HfC in a cobalt matrix alloy. The aligned HfC fibers were present as rod and plate types. The diameter of the aligned fibers was about 1 micron, with volume fraction in the range of 11 to 15 per cent. The growth direction of the fibers was parallel to the 100 direction. The alloy was subjected to thermal cycling between 425 and 1100 C, using a 2.5 minute cycle No microstructural degradation of the HfC fibers in the alloy was observed after 2500 cycles. (Author)

A76-16572 * Measurement of residual strains in boron-epoxy and glass-epoxy laminates. I M. Daniel, T. Liber (IIT Research Institute, Chicago, Ill.), and C. C. Chamis (NASA, Lewis Research Center, Cleveland, Ohio). In: Composite reliability, Proceedings of the Symposium, Las Vegas, Nev., April 15, 16, 1974. (A76-16551 05-24) Philadelphia, Pa , American Society for Testing and Materials, 1975, p. 340-351. 5 refs NASA-sponsored research.

Embedded-strain-gage techniques were developed and used for measuring strains in composite angle-ply laminates during curing and thermal cycling. The specimens were 2.54 by 22.9 cm eight-ply boron-epoxy and S-glass-epoxy laminates Unidirectional specimens were used for control purposes. Strain readings were corrected for the purely thermal output of the gages obtained from an instrument quartz reference specimen. The strains measured during the cooling part of the curing cycle were in agreement with those recorded during subsequent thermal cycling, indicating that residual stresses induced during curing are primarily caused by differential thermal expansions of the various plies. Restraint strains were computed for the 0-deg and 45-deg plies of the angle-ply laminates tested, and the residual stresses obtained using the anisotropic constitutive relations and taking into account the temperature dependence of stiffnesses and strains (Author)

A76-18513 * # Super-hybrid composites - An emerging structural material. C C Chamis, R F Lark, and T. L. Sullivan (NASA, Lewis Research Center, Cleveland, Ohio). *NASA Langley Research Center and U.S. Air Force, Conference on Fibrous Composites in Flight Vehicle Design, 3rd, Williamsburg, Va., Nov. 4-6, 1975, Paper.* 23 p.

Specimens of super-hybrids and advanced fiber composites were subjected to extensive tests to determine their mechanical properties, including impact and thermal fatigue. The super-hybrids were fabricated by a procedure similar to that reported by Chamis et al., (1975) Super-hybrids subjected to 1000 cycles of thermal fatigue from -100 to 300 F retained over 90% of their longitudinal flexural strength and over 75% of their transverse flexural strength, their transverse flexural strength may be as high as 8 times that of a commercially supplied boron/1100-Al composite The thin specimen Izod longitudinal impact resistance of the super-hybrids was twice that of the boron/110-Al material. Super-hybrids subjected to transverse tensile loads exhibited nonlinear stress-strain relationships The experimentally determined initial membrane (in-plane) and bending elastic properties of super-hybrids were predicted adequately by linear laminate analysis C K.D.

A76-25841 * # Heat treating of a lamellar eutectic alloy /gamma/gamma prime + delta/. S N. Tewari (NASA, Lewis Research Center, Cleveland, Ohio) and R. L. Dreshfield (National Research Council, Washington, D.C.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La , Mar. 21-25, 1976, Paper 76-GT-103.* 8 p. 5 refs. Members, $1.50, nonmembers, $3.00.

Eutectic superalloys are being developed at several laboratories for application as aircraft gas turbine airfoils. One such alloy gamma/gamma prime + delta was subjected to several heat treatments to determine if its mechanical properties could be improved. It was found that by partially dissolving the gamma prime at 1210 C and then aging at 900 C, the tensile strength can be increased about 12 per cent at temperatures up to 900 C. At 1040 C, no change in tensile strength was observed. Times to rupture were measured between 760 and 1040 C and were essentially the same or greater than for as-grown material. Tensile and rupture ductility of the alloy were reduced by heat treatment. (Author)

A76-31507 * # Longitudinal residual stresses in boron fibers. D. R Behrendt (NASA, Lewis Research Center, Cleveland, Ohio) *American Society for Testing and Materials, Conference on Composite Materials Testing and Design, 4th, Valley Forge, Pa , May 3, 4, 1976, Paper.* 15 p 8 refs.

A technique is proposed for measuring the longitudinal residual stress distribution in commercial CVD (Chemical Vapor Deposition) boron on tungsten fibers of 102, 142, and 203 microns in diameter. The experimental apparatus is so designed that continuous measurements are made of the length changes of a boron fiber specimen as the surface of the fiber is removed by electropolishing The effects of surface removal on core residual stress and core-initiated fracture are discussed. The three sizes of boron fibers investigated show similar residual stress distributions, i.e., compressive at the surface, tensile near the core, and for the 102-micron fiber compressive again in the core. It is shown that an increase in UTS is due to the increase in the compressive stress at the core produced by fiber contraction during surface removal. An expression is derived for calculating the longitudinal residual stress at a given radius for an as-received fiber of a certain radius from measurements of the axial strain produced by removal of the surface by electropolishing S.D

A76-31509 * # Time-temperature-stress dependence of boron fiber deformation. J A DiCarlo (NASA, Lewis Research Center, Material Science Branch, Cleveland, Ohio) *American Society for Testing and Materials, Conference on Composite Materials Testing and Design, 4th, Valley Forge, Pa., May 3, 4, 1976, Paper.* 34 p. 22 refs.

The time-dependent deformation of boron fibers over the temperature range from -190 to 800 C is studied by flexural stress relaxation and flexural internal friction techniques on 203-micron diam specimen fibers commercially produced by chemical vapor deposition (CVD) on a 13-micron tungsten substrate It is shown that up to at least 800 C all nonelastic behavior observed during axial deformation of CVD boron fibers can be explained solely by anelastic mechanisms and that although creep strains are small, boron fiber anelasticity can produce significant mechanical effects which would otherwise be neglected under the elastic approximation. Relations are obtained to demonstrate the considerable effects of anelasticity on such fiber/composite properties as modulus, creep, creep recovery, stress relaxation, and damping capacity. For an elastic-core/anelastic-sheath model, boron fibers on tungsten substrates are shown to have predictable fracture stresses for time-temperature conditions ranging from impact to long-time stress rupture. Possible techniques for altering these stresses are discussed. S D

N76-11252*# Aluminum Co of America, Pittsburgh, Pa
FEASIBILITY AND PROCESS SCALE-UP LOW COST ALUMINA FIBERS FOR ADVANCED RE-USABLE SURFACE INSULATION (RSI) Final Report
Alan Pearson 1 Oct 1975 121 p refs
(Contract NAS3-16779)
(NASA-CR-134884) Avail: NTIS HC $5.50 CSCL 11D

The objective of this program was to establish feasibility of a process to produce low cost aluminum oxide fibers having sufficient strength, flexibility, and thermal stability for multiple re-use at temperatures to 1480 C in advanced RSI type heat shields for reentry vehicles Using bench-scale processing apparatus, the Alcoa 'Saphiber' process was successfully modified to produce nominally 8 microns diameter polycrystalline alpha-alumina fiber. Thermal stability was demonstrated in vacuum reheating tests to 1371 C and in atmospheric reheating to 1483 C. Individual fiber properties of strength, modulus, and flexibility were not determined because of friability, and short length of the fiber. Rigidized tile produced from fiber of nominally 8, 20 and 40 micron diameter had thermal conductivities significantly higher than those of RSI SiO2 or mullite at relatively low temperature but became comparable above about 1000 C Tile densities were high due to short fiber length, especially in the coarser diameter fiber No significant effect of fiber diameter on thermal properties could be determined form the data Mechanical properties of tiles deteriorated as fiber diameter increased Author

N76-11253*# Martin Marietta Aerospace, Denver, Colo
EVALUATION OF LOW COST/HIGH TEMPERATURE INSULATION, JULY 1974 - JUNE 1975
E. L. Strauss Nov. 1975 133 p refs
(Contract NAS3-18900)
(NASA-CR-134902; MCR-75-262) Avail: NTIS HC $6 00 CSCL 11D

Six fiber products and six insulation blankets comprising silica, alumina, zirconia, mullite, and mixed ceramic systems were subjected to furnace exposures up to 500 hours at temperatures of 1000 to 1600 C and evaluated for chemical and dimensional stability and for changes in thermal conductivity Alumina, zirconia, and mullite fibers were fabricated into reusable surface insulation (RSI) tile by water-felting and reimpregnation with ethyl silicate Specimens were exposed to 25 thermal cycles at 1200 C and 1400 C and a pressure of 10 and 32 torr, respectively. Production costs for 930 sq m (10,000 sq ft) of blanket insulation and of alumina RSI tile were developed Author

N76-13221*# TRW Equipment Labs , Cleveland, Ohio
COMPOSITE IMPACT STRENGTH IMPROVEMENT THROUGH A FIBER/MATRIX INTERPHASE Final Report
P. J. Cavano and W. E. Winters Oct 1975 98 p refs
(Contract NAS3-18902)
(NASA-CR-134887; TRW-ER-7747F) Avail NTIS HC $5.00 CSCL 11D

Research was conducted to improve the impact strength and toughness of fiber/resin composites by means of a fiber coating interphase Graphite fiber/epoxy resin composites were fabricated with four different fiber coating systems introduced in a matrix-fiber interphase Two graphite fibers, a high strength and a high modulus type, were studied with the following coating systems chemical vapor deposited boron, electroless nickel, a polyamide-imide resin and a thermoplastic polysulfone resin Evaluation methods included the following tests: Izod, flexure, shear fracture toughness, longitudinal and transverse tensile, and transverse and longitudinal compression. No desirable changes could be effected with the high strength fiber, but significant improvements in impact performance were observed with the polyamide-imide resin coated high modulus fiber with no loss in composite modulus Author

N76-17202*# Westinghouse Electric Corp . Pittsburgh, Pa. Research and Development Center.
FABRICATION PROCESS DEVELOPMENT OF SiC/SUPERALLOY COMPOSITE SHEET FOR EXHAUST SYSTEM COMPONENTS Technical Report, 15 Jul. 1974 - 31 Oct. 1975
J A. Cornie, C. S Cook, and C A Anderson Jan 1976 47 p refs
(Contract NAS3-18921)
(NASA-CR-134958) Avail: NTIS HC $4 00 CSCL 11D

A chemical compatibility study was conducted between SiC filament and the following P/M matrix alloys: Waspaloy, Hastelloy-X, NiCrAlY, Ha-188, S-57, FeCrAlY, and Incoloy 800 None of the couples demonstrated sufficient chemical compatibility to withstand the minimum HIP consolidation temperatures (996 C) or intended application temperature of the composite (982 C) However, Waspaloy, Haynes 188, and Hastelloy-X were the least reactive with SiC of the candidate alloys. Chemical vapor deposited tungsten was shown to be an effective diffusion barrier between the superalloy matrix and SiC filament providing a defect-free coating of sufficient thickness However, the coating breaks down when the tungsten is converted into intermetallic compounds by interdiffusion with matrix constituents Waspaloy was demonstrated to be the most effective matrix alloy candidate in contact with the CVD tungsten barrier because of its relatively low growth rate constant of the intermediate compound and the lack of formation of Kirkendall voids at the matrix-barrier interface Fabrication methods were developed for producing panels of uniaxial and angle ply composites utilizing CVD tungsten coated filament. Author

N76-19233*# Stanford Research Inst., Menlo Park, Calif Electromagnetic Sciences Lab
PHOTOCONDUCTIVITY OF HIGH-VOLTAGE SPACE INSULATING MATERIALS Final Report, 1 Jul 1974 - 1 Oct. 1975
H T Coffey, J E. Nanevicz, and R C. Adamo Oct 1975 67 p refs
(Contract NAS3-18912 SRI Proj 3545)
(NASA-CR-134995) Avail NTIS HC $4 50 CSCL 11D

The dark and photoconductivities of four high voltage spacecraft insulators, Kapton-H, FEP Teflon, Parylene, and fused quartz, were studied under a variety of conditions intended to simulate a space environment All measurements were made in a vacuum of less than .00001 torr while the temperature was varied from 22 C to 100 C Some of the samples used employed conventional deposited metal electrodes--others employed electrodes composed either of an electron beam or a plasma formed by ionization of the residual gas in the test chamber Test results show. (1) Kapton had unusual conduction properties: it conductivity decreased by more than an order of magnitude when heated at 100 C in a vacuum, but ultimately attained a stable and reproducible value (2) Both Teflon and fused quartz had high dark resistivities but low photoresistivities when exposed to UV Optical-density measurements revealed that both materials transmitted UV with little attenuation (3) Parylene was found to have a low but relatively stable resistivity--comparatively minor changes occurred upon heating or illuminating the sample Optical-density measurements showed that Parylene was absorbent in the UV and would prevent photoemission from the metal electrode on the back surface Author

N76-20230*# Avco Corp., Lowell, Mass Systems Div
IMPROVING THE TOUGHNESS OF REFRACTORY COMPOUNDS Final Report
Thomas Vasilos and Rowland M. Cannon, Jr Nov 1975 62 p refs
(Contract NAS3-17768)
(NASA-CR-134813, AVSD-0108-76-RR) Avail NTIS HC $4 50 CSCL 11D

Composition and processing studies were conducted on silicon nitride and silicon carbide materials Charpy mode impact testing to 2415 F established the effectiveness of higher purity silicon nitride powder sources in reducing the scatter of measurements and in improving short time bend strengths as well as bend stress rupture properties Stabilized zirconia additions in particular were observed to dramatically enhance low and high temperature bend strengths and stress rupture properties for all grades of silicon nitride powder Silicon carbide samples showed relatively poor impact resistance, although the maxima in stress rupture behavior was exhibited by this material Author

N76-25353*# TRW, Inc., Cleveland, Ohio
TUNGSTEN WIRE-NICKEL BASE ALLOY COMPOSITE DEVELOPMENT Contractor Report, 1 Jun 1974 - 29 Feb. 1976
W. D Brentnall and D J Moracz Mar 1976 61 p refs
(Contract NAS3-17816)
(NASA-CR-135021, ER-7849) Avail NTIS HC $4 50 CSCL 11D

Further development and evaluation of refractory wire reinforced nickel-base alloy composites is described Emphasis was placed on evaluating thermal fatigue resistance as a function of matrix alloy composition, fabrication variables and reinforcement level and distribution Tests for up to 1,000 cycles were performed and the best system identified in this current work was 50v/o W/NiCrAlY Improved resistance to thermal fatigue damage would be anticipated for specimens fabricated via optimized processing schedules Other properties investigated included 1,093 C (2,000 F) stress rupture strength, impact resistance and static air oxidation. A composite consisting of 30v/o W-Hf-C alloy fibers in a NiCrAlY alloy matrix was shown to have a 100-hour stress rupture strength at 1,093 C (2,000 F) of 365 MN/square meters (53 ksi), or a specific strength advantage of about 3.1 over typical D S eutectics Author

N76-27365*# Boeing Aerospace Co., Seattle, Wash
DEVELOPMENT OF POLYPHENYLQUINOXALINE GRAPHITE COMPOSITES Final Report
Jose D Shdo Jun 1976 54 p refs
(Contract NAS3-18927)
(NASA-CR-135041) Avail NTIS HC $4 50 CSCL 11D

Six polyphenylquinoxalines (PPQ) containing pendant cyano (CN) groups were synthesized The polymers were characterized in terms of inherent viscosity, glass transition temperature, softening temperature and weight loss due to aging in air at 316 C (600 F) The potential for crosslinking PPQs by trimerization of pendant CN groups was investigated A polymer derived from 1 mole 3,3,4 4 -tetraaminobenzophenone, 2 mole p-bis(p -cyanophenoxyphenylglyoxalyl)benzene and 8 mole p-bis (phenylglyoxalyl)benzene was selected for more extensive characterization in HM-S graphite fiber-reinforced composites Mechanical properties were determined using composites made from HM-S fiber and polymer and composites made from HM-S fiber, polymer and a potential CN group trimerization catalyst. Composite mechanical properties, inter-laminar shear strength and flexure properties, were determined over the temperature range of +21 C to 316 C Author

N76-29370*# General Electric Co., Schenectady, N Y Metallurgy Lab
COATINGS FOR DIRECTIONAL EUTECTICS Final Report
J. R Rairden and M R Jackson 25 Jul 1976 82 p refs
(Contract NAS3-17815)
(NASA-CR-135050, SRD-76-076) Avail: NTIS HC $5.00 CSCL 11D

Significant advances have been made in the development of an environmentally stable coating for a very high strength, directionally solidified eutectic alloy designated NiTaC-13 Three duplex (two-layer) coatings survived 3 000 hours on a cyclic oxidation test (1,100 C to 90 C). These coatings were fabricated by first depositing a layer of NiCrAl(Y) by vacuum evaporation from an electron beam heated source, followed by depositing an aluminizing overlayer The alloy after exposure with these coatings was denuded of carbide fibers at the substrate/coating interface It was demonstrated that TaC fiber denudation can be greatly retarded by applying a carbon-bearing coating The coating was applied by thermal spraying followed by aluminization Specimens coated with NiCrAlCY+Al survived over 2,000 hours in the cyclic oxidation test with essentially no TaC denudation Coating ductility was studied for coated and heat-treated bars, and stress rupture life at 871 C and 1,100 C was determined for coated and cycled bars Author

N76-30296*# Hamilton Standard Div United Aircraft Corp., Windsor Locks Conn
FIBER COMPOSITE FAN BLADE IMPACT IMPROVEMENT Final Report
J Graff, L Stoltze, and E M Varholak Feb 1976 77 p refs
(Contract NAS3-17837)
(NASA-CR-135001, HSER-6968) Avail NTIS HC $5 00 CSCL 11D

The improved foreign object damage resistance of a metal matrix advanced composite fan blade was demonstrated The fabrication, whirl impact test and subsequent evaluation of nine advanced composite fan blades of the QCSEE' type design were performed The blades were designed to operate at a tip speed of 282 m/sec The blade design was the spar/shell type, consisting of a titanium spar and boron/aluminum composite airfoils The blade retention was designed to rock on impact with large birds, thereby reducing the blade bending stresses The program demonstrated the ability of the blades to sustain impacts with up to 681 g slices of birds at 0 38 rad with little damage (only 1 4 percent max weight loss) and 788 g slices of birds at 0 56 rad with only 3 2 percent max weight loss Unbonding did not exceed 1 1 percent of the post-test blade area during any of the tests All blades in the post-test condition were judged capable of operation in accordance with the FAA guidelines for medium and large bird impacts Author

N76-31298*# United Technologies Research Center, East Hartford, Conn

MULTI-FIBER COMPOSITES Final Report

R C Novak Apr 1976 107 p refs

(Contract NAS3-18941)

(NASA-CR-135062, R76-912098-11) Avail NTIS HC $5 50 CSCL 11D

Resin matrix composites having improved resistance to foreign object damage in gas turbine engine fan blade applications were developed Materials evaluated include epoxy matrix graphite/glass and boron/glass hybrids, thermoplastic matrix boron/glass hybrids, and superhybrids consisting of graphite/epoxy, boron/aluminum, and titanium alloy sheets Static, pendulum impact, and ballistic impact test results are reported for all materials Superhybrid blade like specimens are shown to be capable of withstanding relatively severe ballistic impacts from gelatin spheres without fracture The effects of ply configuration and projectile angle of incidence on impact behavior are described Predictions of surface strains during ballistic impact are presented and shown to be in reasonable agreement with experimental measurements Author

A76-43307 * Quaternary and quinary modifications of the eutectic superalloy gamma/gamma prime-delta. F. D Lemkey and G P. McCarthy (United Technologies Research Center, East Hartford, Conn.). In: Conference on In Situ Composites, 2nd, Bolton Landing, N.Y., September 2-5, 1975, Proceedings (A76-43301 22-24) Lexington, Mass., Xerox Individualized Publishing, 1976, p. 77-87; Discussion, p. 87, 88. 17 refs Contract No. NAS3-17785.

Quaternary modifications and quinary additions from the elements Co, Ti, Mo, W, Re, B, Si, and Ta to the baseline quaternary alloy gamma/gamma prime-delta Ni-19.7 at.% Nb-6 0 at.% Cr-2 5 at.% Al are examined for various concentrations. From modification studies five alloys were chosen for detailed mechanical property characterization: Ni-19.7 Nb-6.0 Cr-2.5 Al-1.0 W; Ni-19.7 Nb-6 0 Cr-2 5 Al-1.0 Mo; Ni-18 6 Nb-6.0 Cr-2.5 Al-0 87 Ti; Ni-20 2 Nb-6.0 Cr-2.5 Al-2.0 Co; and Ni-17.9 Nb-6 0 Cr-2.5 Al-3 0 Ta. It is shown that extensive alloying of the baseline quaternary alloy is possible for elements exhibiting a wide solubility range in both phases, and that limited substitution of W, Mo, Re, Si, and B is possible for elements with restricted solid solubility especially in the delta phase. Improvement of creep rupture strength and cyclic oxidation resistance at 1100 C is discussed. S D.

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*

N76-14216*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
SAMPLE PREPARATION OF METAL ALLOYS BY ELECTRIC DISCHARGE MACHINING
Gilbert B Chapman, II and William A Gordon Washington Jan 1976 22 p refs
(NASA-TM-X-3328, E-8438) Avail NTIS HC $3 50 CSCL 07D

Electric discharge machining was investigated as a noncontaminating method of comminuting alloys for subsequent chemical analysis Particulate dispersions in water were produced from bulk alloys at a rate of about 5 mg/min by using a commercially available machining instrument The utility of this approach was demonstrated by results obtained when acidified dispersions were substituted for true acid solutions in an established spectrochemical method The analysis results were not significantly different for the two sample forms Particle size measurements and preliminary results from other spectrochemical methods which require direct aspiration of liquid into flame or plasma sources are reported Author

N76-18247*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ANALYSIS OF BENZO(A)PYRENE IN AIRBORNE PARTICULATES BY GAS CHROMATOGRAPHY
Eva Luedecke Feb 1976 11 p refs
(NASA-TM-X-71872; E-8645) Avail NTIS HC $3 50 CSCL 07D

A routine method was developed to measure benzo(a)pyrene in airborne particulates Samples were collected on a filter and the organic portion was extracted with cyclohexane The polynuclear hydrocarbon (PNHC) fraction was separated from the aliphatics by column chromatography. An internal standard was added to the extract and a portion of it was injected into a gas chromatograph Although the gas chromatographic method has often been reported in the literature, satisfactory separation of benzo(a)pyrene and benzo(e)pyrene has not been achieved With the introduction of a nematic liquid crystal as the stationary phase good separation is now possible Author

N76-27383* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
METHOD OF PRODUCING I-123 Patent
James W Blue, inventor (to NASA) Issued 29 Jun 1976 4 p Filed 13 Mar 1973 Supersedes N73-20763 (11 - 11, p 1326) Continuation-in-part of abandoned US Patent Appl SN-247434, filed 25 Apr. 1972
(NASA-Case-LEW-11390-2, US-Patent-3,966,547, US-Patent-Appl-SN-340863, US-Patent-Class-176-11, US-Patent-Class-176-16, US-Patent-Class-423-249, US-Patent-Appl-Sn-247434) Avail: US Patent Office CSCL 07D

Bombarding a cesium heat pipe with high energy particles causes a spallation reaction which produces vapors of Xe-123 and contaminants. The contaminants are removed in a dry ice cold trap while the Xe-123 condenses in a liquid nitrogen trap where it decays to I-123.
Official Gazette of the U S Patent Office

N76-29379* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
PRODUCTION OF I-123 Patent
James W. Blue, inventor (to NASA) Issued 27 Jul 1976 5 p Filed 12 Jul. 1973 Supersedes N73-28128 (11 - 19, p 2248) Continuation-in-part of US Patent Appl SN-247434, filed 25 Apr. 1972
(NASA-Case-LEW-11390-3; US-Patent-3,971,697, US-Patent-Appl-SN-247434; US-Patent-Appl-SN-380046, US-Patent-Class-176-11, US-Patent-Class-176-16, US-Patent-Class-176-14; US-Patent-Class-250-400, U S-Patent-Class-250-429; US-Patent-Class-250-492R) Avail: US Patent Office CSCL 07D

Bombarding a cesium heat pipe with high energy particles causes a spallation reaction which produces vapors of Xe-123 and contaminants. The contaminants are removed in a dry ice cold trap while the Xe-123 condenses in a liquid nitrogen trap where it decays Official Gazette of the U-S Patent Office

N76-30319*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
NO sub X DESTRUCTION BY CO IN NO sub X TO NO CONVERTERS OF CHEMILUMINESCENT NO ANALYZERS
Robert L Summers Jul 1976 23 p refs
(NASA-TM-X-73480, E-8862) Avail NTIS HC $3 50 CSCL 07D

An instrument modification for chemiluminescent NO - NOx analyzers was developed which minimizes the NOx destruction in the NOx to NO converters of NO analyzers due to high concentrations of CO This mechanism causes the NO analyzers to indicate incorrect NOx concentrations when the analyzers are operated in the NOx analysis mode The modification is applicable to analyzers in which the detection chamber is evacuated Author

A76-25389 * Effect of adsorbed chlorine and oxygen on the shear strength of iron and copper junctions. D. R. Wheeler (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Applied Physics*, vol. 47, Mar 1976, p. 1123-1130. 14 refs

Static-friction experiments were performed in ultrahigh vacuum at room temperature on copper, iron, and steel contacts selectively contaminated with oxygen and chlorine in submonolayer amounts. The concentration of the adsorbates was determined with Auger electron spectroscopy and was measured relative to the saturation concentration of oxygen on iron (concentration, 1 0) The coefficient of static friction decreased with increasing adsorbate concentration, however, it was independent of the type of metal and the adsorbate species The results compared satisfactorily with an extension of the junction growth theory to heterogeneous interfaces. The reduction in interfacial shear strength was measured by the ratio of the shear strength of the interface with an adsorbate concentration of 1 0 and the strength of the clean metal interface This ratio was about 0 835 for all the systems tested. (Author)

A76-30694 * Production of chromium base alloys by ball milling in hydrogen iodide A. Arias (NASA, Lewis Research Center, Cleveland, Ohio). *Metallurgical Transactions B - Process Metallurgy*, vol. 6B, Dec. 1975, p. 631-640. 21 refs.

The effects of processing variables on the tensile properties and ductile-to-brittle transition temperature (DBTT) of Cr + 4 vol% ThO2 alloys and of pure Cr produced by ball milling in hydrogen iodide were investigated Hot rolled Cr + ThO2 was stronger than either hot pressed Cr + ThO2 or pure Cr at temperatures up to 1540 C. Hot pressed Cr + ThO2 had a DBTT of 500 C as compared with -8 to 24 C for the hot rolled Cr + ThO2 and with 140 C for pure Cr It is postulated that the dispersoid in the hot rolled alloys lowers the DBTT by inhibiting recovery and recrystallization of the strained structure. (Author)

A76-31022 * New solid conductors of Na/+/ and K/+/ ions. J. Singer, W. L. Fielder, H E Kautz, and J. S Fordyce (NASA, Lewis Research Center, Cleveland, Ohio). *Electrochemical Society, Journal*, vol 123, May 1976, p 614-617 23 refs.

About 40 structure types for solid conductors of Na(+) and K(+) ions are surveyed Five compounds in three structure types are discovered to be good solid conductors of alkali metal ions, capable of ion transport with conductivities in the vicinity of 0.00001/ohm-cm at 25 C. These compounds are a bcc form of NaSbO3, an orthorhombic layer structure of the composition 2M2O 3Nb2O5 with M equal to Na or K, and the Na pyrochlores NaTa2O5F and NaTaWO6. Ion exchange is required to produce each of these Na compounds. Only the 2K2O.3Nb2O5 can so far be synthesized directly from the oxides and thus is the only one which can be sintered readily. The niobate is about as good a conductor of K(+) ion as is K-beta alumina The NaSbO3 compares well with Na beta at 280 C A number of phase diagrams are developed. S.D.

A76-33395 * # Preliminary results from screening tests of commercial catalysts with potential use in gas turbine combustors. I - Furnace studies of catalyst activity. D N Anderson (NASA, Lewis Research Center, Cleveland, Ohio). *U S Environmental Protection Agency, Workshop on Catalytic Combustion, Raleigh, N.C., May 24-26, 1976, Paper.* 18 p. 13 refs.

Thirty commercially produced monolith and pellet catalysts were tested as part of a screening process to select catalysts suitable for use in a gas turbine combustor The catalysts were contained in a 1 8 centimeter diameter quartz tube and heated to temperatures varying between 300 and 1200 K while a mixture of propane and air passed through the bed at space velocities of 44,000 to 70,000 per hour. The amount of propane oxidized was measured as a function of catalyst temperature Of the samples tested, the most effective catalysts proved to be noble metal catalysts on monolith substrates (Author)

A76-33397 * # Experimental evaluation of two premixing-prevaporizing fuel injection concepts for a gas turbine catalytic combustor. R Tacina (NASA, Lewis Research Center, Cleveland, Ohio) *U S Environmental Protection Agency, Workshop on Catalytic Combustion, Raleigh, N C., May 24-26, 1976, Paper.* 14 p 5 refs

A premixing-prevaporizing fuel system for a gas turbine catalytic combustor has been developed and evaluated Spatial fuel distribution and degree of vaporization were measured at inlet temperatures up to 800 K and fuel-air ratios of 0.01 and 0 025 The test pressure was 0 5 MPa, velocity was 20 m/sec Both a multiple-jet cross-stream injector and a splash-groove injector with a 30 deg air swirler exhibited a uniform fuel distribution and a high degree of vaporization with little total pressure drop. Fuel oxidation reactions were observed at the 800 K inlet air temperature, indicating that a different design concept is necessary for application with an automotive gas turbine. C K D.

A76-34535 * Mass spectrometric determination of hydrogen thermally extracted from titanium D. A Otterson and R J Smith (NASA, Lewis Research Center, Cleveland, Ohio). *Analytical Chemistry*, vol 48, no 4, Apr. 1976, p 783, 784 9 refs

A76-38614 * Combustion modeling in internal combustion engines F. J. Zeleznik (NASA, Lewis Research Center, Cleveland, Ohio). *Combustion Science and Technology*, vol. 12, no. 4-6, 1976, p 159-164.

The fundamental assumptions of the Blizard and Keck combustion model for internal combustion engines are examined and a generalization of that model is derived The most significant feature of the model is that it permits the occurrence of unburned hydrocarbons in the thermodynamic-kinetic modeling of exhaust gases. The general formulas are evaluated in two specific cases that are likely to be significant in the applications of the model. (Author)

A76-41670 * Alloy softening in binary iron solid solutions J R Stephens and W. R Witzke (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of the Less-Common Metals*, vol. 48, Aug. 1976, p. 285-308. 20 refs.

An experimental study was conducted to determine whether alloy softening in Fe alloys is dependent on electron concentration and to provide a direct comparison of alloy softening and hardening in several binary Fe alloy systems having the same processing history. Alloy additions to Fe included the elements in the Periods 4-6 and the Groups IV-VIII with the exception of technetium A total of 19 alloy systems was investigated, and hardness testing was the primary means of evaluation. Testing was carried out at four temperatures over a homologous temperature range of 0 043-0 227 times the absolute melting temperature of unalloyed Fe. Major conclusions are that the atomic radius ratio of solute-to-Fe is the key factor in controlling low-temperature hardness of the binary Fe alloys and that alloy softening rates at 77 K and alloy hardening rates at 411 K are correlated with this atomic radius ratio for 15 of the binary alloy systems. Mechanisms of alloy softening and hardening are proposed. S.D.

A76-42675 * Emission spectrometric arcing procedure with minimal effect of chemical form of sample. W. A. Gordon (NASA, Lewis Research Center, Cleveland, Ohio). *Applied Spectroscopy*, vol. 30, May-June 1976, p 329-335. 14 refs.

This paper describes a study of matrix effects related to the chemical form of materials analyzed. The study was made using an arc in argon buffered with silver chloride. The effect of chemical form was minimal for a variety of metals, oxides, and carbides representing the most refractory compounds and thermally stable metal-containing molecules. Among these, only four of the most refractory materials known showed significant emission depressions due to incomplete volatilization in the arc system. These results are discussed in terms of vapor pressure of the solid materials placed on the anodes and dissociation reactions of the molecules in the gaseous environment. (Author)

A76-47624 * # Exoelectron emission from a clean, annealed magnesium single crystal during oxygen adsorption J. Ferrante (NASA, Lewis Research Center, Cleveland, Ohio) *American Society of Lubrication Engineers, Annual Meeting, 31st, Philadelphia, Pa , May 10-13, 1976, Paper.* 19 p 17 refs

Exoelectron emission has been observed from a clean, annealed Mg (0001) surface during oxygen and chlorine adsorption at pressures of 0.000065 N/sq m and lower The studies were performed in an ultrahigh vacuum system The crystals were cleaned by argon-ion bombardment and annealed at 300 C Auger electron spectroscopy was used to verify surface cleanliness, and low-energy electron diffraction was used to verify that the surface was annealed The emission was found to be dependent on oxygen arrival rate Two peaks were observed in the electron emission with exposure Evidence is presented that the formation of the second peak corresponds to oxidation of the Mg surface. The results verify that electron emission occurs from a strain-free surface simply upon adsorption of oxygen A qualitative explanation for the mechanisms of emission in terms of chemical effects is presented. (Author)

A76-47706 * Production of Ne Auger electrons by Ne/+/ bombardment of Mg and Al surfaces. J. Ferrante and S V Pepper (NASA, Lewis Research Center, Cleveland, Ohio) *Surface Science*, vol. 57, no. 1, July 1976, p 420 424 16 refs.

A description is given of experiments which provide evidence for the production of an inner shell vacancy in the Ne by the asymmetric Ne-Mg and Ne-Al collision. In addition, autoionization states of neutral Ne have been observed These states are to be distinguished from the more usual case in Auger electron spectroscopy of de-excitation of an ion with a core vacancy. The experiments involved the bombardment of Mg and Al surfaces with Ne(+) ions A LEED-Auger system equipped with an ion gun and a four-grid retarding potential analyzer operated in the usual dN(E)/dE mode was used. G R.

26 METALLIC MATERIALS

Includes physical, chemical, and mechanical properties of metals, e.g., corrosion; and metallurgy.

N76-10301*# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio
PRELIMINARY STUDY OF OXIDE-DISPERSION-STRENGTHENED B-1900 PREPARED BY MECHANICAL ALLOYS
Thomas K Glasgow and Max Quatinetz Washington Oct 1975 27 p refs
(NASA-TM-X-3303; E-8373) Avail NTIS HC $3.75 CSCL 11F

An experimental oxide dispersion strengthened (ODS) alloy based on the B-1900 composition was produced by the mechanical alloying process. Without optimization of the processing for the alloy or the alloy for the processing, recrystallization of the extruded product to large elongated grains was achieved Materials having grain length-width ratios of 3 and 5 5 were tested in tension and stress-rupture The ODS B-1900 exhibited tensile strength similar to that of cast B-1900 Its stress-rupture life was lower than that of cast B-1900 at 760 C At 1095 C the ODS B-1900 with the higher grain length-width ratio (5 5) had stress-rupture life superior to that of cast B-1900. It was concluded that, with optimization, oxide dispersion strengthening of B-1900 and other complex cast nickel-base alloys has potential for improving high temperature properties over those of the cast alloy counterparts Author

N76-11278*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
EFFECTS OF LONG-TERM AGING ON DUCTILITY OF THE COLUMBIUM ALLOYS C-103, Cb-1Zr, AND Cb-752 AND THE MOLYBDENUM ALLOY Mo-TZM
Joseph R Stephens Washington Oct. 1975 27 p refs
(NASA-TN-D-8095, E-8374) Avail. NTIS HC $3 75 CSCL 11F

A program was conducted to determine if aging embrittlement occurs in the columbium alloys C-103, CB-1Zr, and Cb-752 or in the molybdenum alloy Mo-TZM. Results showed that aging embrittlement does not occur in C-103, Cb-1Zr, or Mo-TZM during long-term (1000 hr) aging at temperatures in the range 700 to 1025 C In contrast, aging embrittlement did occur in the Cb-752 alloy after similar aging at 900 C A critical combination of the solute additions W and Zr in Cb-752 led to Zr segregation at grain boundaries during long-term aging This segregation subsequently resulted in embrittlement as indicated by an increase in the ductile-brittle transition temperature from below -1960 C to about -150 C. Author

N76-11279*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CRITICAL ASPECT RATIO FOR TUNGSTEN FIBERS IN COPPER-NICKEL MATRIX COMPOSITES
Robert W Jech Washington Oct 1975 23 p refs
(NASA-TM-X-3311, E-8442) Avail. NTIS HC $3 50 CSCL 11F

Stress-rupture and tensile tests were conducted at 816 C (1500 F) to determine the effect of matrix composition on the minimum fiber length to diameter ratio (critical aspect ratio) below which fibers in a tungsten fiber/copper-nickel alloy matrix composite could not be stressed to their ultimate load carrying capability This study was intended to simulate some of the conditions that might be encountered with materials combinations used in high-temperature composites The critical aspect ratio for stress-rupture was found to be greater than for short-time tension, and it increased as the time to rupture increased The increase was relatively slight, and calculated fiber lengths for long service appear to be well within practical size limits for effective reinforcement and ease of fabrication of potential gas turbine components Author

N76-13267*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
IMPROVED BIMETALLIC JUNCTIONS Patent Application
F G. Arcella (Westinghouse Electric Corp., Pittsburgh, Pa.), G G. Lessmann (Westinghouse Electric Corp., Pittsburgh, Pa.), and R A Lindberg, inventors (to NASA) Filed 24 Oct 1975 11 p
(NASA-Case-LEW-11573-1 US-Patent-Appl-SN-625733) Avail. NTIS HC $3 50 CSCL 11D

A procedure is reported for reducing the coalescence and void growth in bimetallic welded structures exposed to high operating temperatures The procedure involves the utilization of an alloy of the parent material in the junction of the parent material, or preannealing the junction at an ultrahigh temperature These methods are also used to reduce the concentration gradient of a hardening agent NASA

N76-13268*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
HYDROGEN ENVIRONMENT EMBRITTLEMENT OF ASTROLOY AND UDIMET 700 (NICKEL-BASE) AND V-57 (IRON-BASE) SUPERALLOYS
Hugh R Gray and Joseph P. Joyce Washington Dec 1975 46 p refs
(NASA-TN-D-8046; E-8407) Avail NTIS HC $4 00 CSCL 11F

The sensitivity to hydrogen environment embrittlement of three superalloys was determined Astroloy forgings were resistant to embrittlement during smooth tensile, notched tensile, and creep testing in 3 5-MN/sq m hydrogen over the range 23 to 760 C The notched tensile strength of Udimet 700 bar stock in hydrogen at 23 C was only 50 percent of the baseline value in helium Forgings of V-57 were not significantly embrittled by hydrogen during smooth tensile testing over the range 23 to 675 C, creep and rupture lives of V-57 were degraded by hydrogen Postcreep tensile ductility of V-57 was reduced by 40 percent after creep exposure in hydrogen Author

N76-13269*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FRICTION DIFFERENCES BETWEEN ALIPHATIC AND AROMATIC STRUCTURES IN LUBRICATION OF TITANIUM
Donald H Buckley Washington Dec 1975 19 p refs
(NASA-TN-D-8088; E-8405) Avail· NTIS HC $3 50 CSCL 11F

Sliding friction experiments were conducted with a titanium (0001) single crystal surface with various adsorbed aliphatic and aromatic compounds containing the same number of carbon atoms. An Auger emission spectroscopy analysis was used to monitor the presence of the organic lubricating compounds Results of the investigation indicate that hexane and benzene give the same friction coefficients over a range of loads. At light loads the friction decreased with an increase in the halogen atom size where the halogens chlorine, bromine, and iodine are incorporated into the benzene molecular structure The aliphatic compounds chlorohexane and bromohexane exhibited lower friction coefficients than the aromatic structures chlorobenzene and bromobenzene Author

N76-13270*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
RESISTANCE OF A GAMMA/GAMMA PRIME - DELTA DIRECTIONALLY SOLIDIFIED EUTECTIC ALLOY TO RECRYSTALLIZATION
Surendra N. Tewari, Coulson M. Scheuermann, and Charles W. Andrews Washington Dec 1975 21 p refs
(NASA-TM-X-3272; E-8388) Avail NTIS HC $3 50 CSCL 11F

The lamellar directionally solidified nickel-base eutectic alloy gamma/gamma prime-delta has potential as an advanced turbine blade material The microstructural stability of this alloy was investigated. Specimens were plastically deformed by uniform compression or Brinell indentation, then annealed between 705 and 1120 C. Microstructural changes observed after annealing

included gamma prime coarsening, pinch-off and spheroidization of delta lamellae, and the appearance of an unidentified blocky phase in surface layers. All but the first of these was localized in severely deformed regions, suggesting that microstructural instability is not a serious problem in the use of this alloy.
Author

N76-14240*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
HIGH GAS VELOCITY OXIDATION AND HOT CORROSION TESTING OF OXIDE DISPERSION-STRENGTHENED NICKEL-BASE ALLOYS
Daniel L. Deadmore and Carl E. Lowell Nov 1975 29 p refs
(NASA-TM-X-71835, E-8544) Avail: NTIS HC $4.00 CSCL 11F

Several oxide dispersion strengthened (ODS) nickel-base alloys were tested in high velocity gases for cyclic oxidation resistance at temperatures to 1200 C and times to 500 hours and for hot corrosion resistance at 900 C for 200 hours. Nickel-chromium-aluminum ODS alloys were found to have superior resistance to oxidation and hot corrosion when compared to bare and coated nickel-chromium ODS alloys. The best of the alloys tested had compositions of nickel - 15.5 to 16 weight percent chromium with aluminum weight percents between 4.5 and 5.0. All of the nickel-chromium-aluminum ODS materials experienced small weight losses (less than 16 mg/sq cm).
Author

N76-14243*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio
ANALYSIS OF RADIALLY CRACKED RING SEGMENTS SUBJECT TO FORCES AND COUPLES
Bernard Gross and John E. Strawley [1975] 26 p refs Proposed for presentation at Comm. E-24 Symp. on Develop. in Fracture Mech. Tests, St. Louis, 2-7 May 1976, sponsored by the Am. Soc. for Testing and Mater.
(NASA-TM-X-71842) Avail: NTIS HC $4.00 CSCL 11F

Results of planar boundary collocation analysis are given for ring segment (C shaped) specimens with radial cracks, subjected to combined forces and couples. Mode I stress intensity factors and crack mouth opening displacements were determined for ratios of outer to inner radius in the range 1.1 to 2.5, and ratios of crack length to segment width in the range 0.1 to 0.8.
Author

N76-14245*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EFFECT OF NATURE OF OXYGEN INTERACTIONS ON FRICTION OF TITANIUM, ALUMINUM, AND MOLYBDENUM
Donald H. Buckley Washington Jan. 1976 17 p refs
(NASA-TN-D-8123, E-8386) Avail: NTIS HC $3.50 CSCL 11F

Friction studies were conducted with a gold pin contacting titanium, aluminum, and molybdenum surfaces after exposure to oxygen with various methods. Oxygen was adsorbed on the surface, it reacted with the surface, and the surface was ion bombarded with oxygen. The presence of oxygen was monitored with Auger spectroscopy. Titanium friction varied with the mode of the metal-oxygen interaction. It was highest with the adsorbed oxygen and least with ion bombardment using oxygen. Aluminum exhibited lower friction values for the reacted and the ion bombarded surfaces than for the surface having the adsorbed layer. With molybdenum the friction coefficients were generally the same despite the nature of the surface treatment with oxygen.
Author

N76-14246*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EFFECTS OF CARBON AND HAFNIUM CONCENTRATIONS IN WROUGHT POWDER-METALLURGY SUPERALLOYS BASED ON NASA 2B-11 ALLOY
Robert V. Miner, Jr. Washington Jan. 1976 36 p refs
(NASA-TN-D-8113; E-8468) Avail: NTIS HC $4.00 CSCL 11F

A candidate alloy for advanced-temperature turbine engine disks, and four modifications of that alloy with various C and Hf concentrations were produced as cross-rolled disks from prealloyed powder that was hot isostatically compacted. The mechanical properties, microstructures, and phase relations of the alloys are discussed in terms of their C and Hf concentrations. A low-C and high-Hf modification of IIB-11 had the best balance of mechanical properties for service below about 750 C. Because of their finer grain sizes, none of the powder-metallurgy alloys produced had the high-temperature rupture strength of conventionally cast and wrought IIB-11.
Author

N76-14247*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
NICKEL BASE ALLOY Patent Application
John C. Freche and William J. Waters, inventors (to NASA) Filed 30 Dec. 1975 9 p
(NASA-Case-LEW-12270-1, US-Patent-Appl-SN-645507) Avail: NTIS HC $3.50 CSCL 11F

A nickel base superalloy for use at temperatures of 2000 F (1095 C) to 2200 F (1205 C) as a stator vane material in advanced gas turbine engines is described. The alloy has a nominal composition in weight percent of 16 tungsten, 7 aluminum, 1 molybdenum, 2 columbium, 0.3 zirconium, 0.2 carbon and the balance nickel.
NASA

N76-16220*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
OXIDE DISPERSION STRENGTHENED NICKEL PRODUCED BY NONREACTIVE MILLING
Alan Arias Washington Jan. 1976 25 p refs
(NASA-TM-X-3331, E-8465) Avail: NTIS HC $3.50 CSCL 11F

It is shown that oxide dispersion strengthened alloys can be produced by a postulated nonreactive milling mechanism whereby the dispersoid is trapped at the interface between welding metal powder particles. This interparticle welding is possible because, without a suitable and sufficiently vigorous chemical reaction between the metal powder particles and the milling fluid, no protective, weld-preventing reaction coating is formed on these particles. Using water as the nonreactive milling fluid, Ni - 1.8-vol % thoria and Ni - 1.8-vol % yttria alloys with 1093 C tensile strengths ranging from 122.3 to 141.5 MN/sq m (17,900 to 20,500 psi) were produced by nonreactive milling.
Author

N76-17224*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
COREST. A FORTRAN COMPUTER PROGRAM TO ANALYZE PARALINEAR OXIDATION BEHAVIOR AND ITS APPLICATION TO CHROMIC OXIDE FORMING ALLOYS
Charles E. Barrett and Alden F. Presler Washington Feb. 1976 81 p refs
(NASA-TN-D-8132; E-8432) Avail: NTIS HC $5.00 CSCL 11F

A FORTRAN computer program (COREST) was developed to analyze the high-temperature paralinear oxidation behavior of metals. It is based on a mass-balance approach and uses typical gravimetric input data. COREST was applied to predominantly Cr_2O_3-forming alloys tested isothermally for long times. These alloys behaved paralinearly above 1100 C as a result of simultaneous scale formation and scale vaporization. Output includes the pertinent formation and vaporization constants and kinetic values of interest. COREST also estimates specific sample weight and specific scale weight as a function of time. Most importantly, from a corrosion standpoint, it estimates specific metal loss.
Author

N76-17225*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

THERMOGRAVIMETRIC STUDY OF REDUCTION OF OXIDES PRESENT IN OXIDIZED NICKEL-BASE ALLOY POWDERS

Thomas P. Herbell Washington Jan. 1976 18 p refs (NASA-TM-X-3340; E-8492) Avail: NTIS HC $3.50 CSCL 11F

Carbon, hydrogen, and hydrogen plus carbon reduction of three oxidized nickel-base alloy powders (a solid solution strengthened alloy both with and without the gamma prime formers aluminum and titanium and the solid solution strengthened alloy NiCrAlY) were evaluated by thermogravimetry Hydrogen and hydrogen plus carbon were completely effective in reducing an alloy containing chromium, columbium, tantalum, molybdenum, and tungsten However, with aluminum and titanium present the reduction was limited to a weight loss of about 81 percent. Carbon alone was not effective in reducing any of the alloys, and none of the reducing conditions were effective for use with NiCrAlY Author

N76-17231*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HEAT TREATING OF A LAMELLAR EUTECTIC ALLOY (GAMMA/GAMMA PRIME + DELTA)

S. N Tewari and R L Dreshfield 1976 22 p refs Proposed for presentation at Intern. Gas Turbine Conf., New Orleans, 21-25 Mar 1976, sponsored by ASME

(NASA-TM-X-71833; E-8531) Avail NTIS HC $3.50 CSCL 11F

Eutectic superalloys are being developed at several laboratories for application as aircraft gas turbine airfoils One such alloy was subjected to several heat treatments to determine if its mechanical properties could be improved It was found that by partially dissolving the alloy at 1210 C and then aging at 900 C the tensile strength can be increased about 12 percent at temperatures up to 900 C At 1040 C no change in tensile strength was observed Times to rupture were measured between 760 and 1040 C and were essentially the same or greater than for as-grown material. Tensile and rupture ductility of the alloy are reduced by heat treatment. Photographs of the microstructure are shown. Author

N76-17232*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

ALLOY SOFTENING IN BINARY IRON SOLID SOLUTIONS

Joseph R. Stephens and Walter R Witzke Washington Feb. 1976 30 p refs

(NASA-TN-D-8167, E-8479) Avail: NTIS HC $4.00 CSCL 11F

An investigation was conducted to determine softening and hardening behavior in 19 binary iron-alloy systems. Microhardness tests were conducted at four temperatures in the range 77 to 411 K Alloy softening was exhibited by 17 of the 19 alloy systems. Alloy softening observed in 15 of the alloy systems was attributed to an intrinsic mechanism, believed to be lowering of the Peierls (lattice friction) stress. Softening and hardening rates could be correlated with the atomic radius ratio of solute to iron. Softening observed in two other systems was attributed to an extrinsic mechanism, believed to be associated with scavenging of interstitial impurities. Author

N76-17233*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

TANTALUM MODIFIED FERRITIC IRON BASE ALLOYS Patent Application

Robert E Oldrieve and Charles P Blakenship, inventors (to NASA) Filed 21 Jan 1976 10 p

(NASA-Case-LEW-12095-1, US-Patent-Appl-SN-651009) Avail NTIS HC $3.50 CSCL 11F

Improved iron based alloys with ferritic body centered cubic microstructures are reported. The alloys are of the Fe-Cr-Al type and have high temperature and oxidation resistance properties in the 800 C to 1040 C range. The application of these alloys to furnace linings and flue stacks was discussed NASA

N76-18261*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

DESCRIPTION OF A COMPUTERIZED METHOD FOR PREDICTING THERMAL FATIGUE LIFE OF METALS

D. A Spera and E C Cox 1975 15 p refs Presented at Symp. on Thermal Fatigue of Mater. and Components, New Orleans, 17-18 Nov. 1975, sponsored by Am Soc for Testing and Mater.

(NASA-TM-X-71866, E-8509) Avail. NTIS HC $3.50 CSCL 11F

A computer program is described which can be used to predict the thermal fatigue life of metals and structural components from conventional metal properties A unique feature of TFLIFE is that it calculates lives according to several different failure criteria for the same input data. These criteria are surface crack initiation, interior crack initiation, and complete fracture of both unnotched and notched fatigue specimens. Sample output tables are shown, together with results for two typical problems (1) Thermal-mechanical fatigue of bar specimens of the tantalum alloy T-111, and (2) thermal-stress fatigue of wedge specimens of the nickel alloy B-1900 Author

N76-18262*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio

METHOD OF FORMING METAL HYDRIDE FILMS Patent Application

Robert Steinberg, Donald L Alger, and Dale W Cooper, inventors (to NASA) Filed 20 Feb 1976 13 p

(NASA-Case-LEW-12083-1, US-Patent-Appl-SN-659882) Avail: NTIS HC $3.50 CSCL 11F

A method of forming a continuous, thin film of stoichiometric metal hydride such as titanium dihydride, titanium dideuteride, or titanium ditritide on a substrate which may be of metal, glass or the like is disclosed The substrate is first cleaned, both chemically and by off-sputtering in a vacuum chamber In an ultrahigh vacuum system vapor deposition by a sublimator or vaporizer first 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, a 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 NASA

N76-21318*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

INTERIM ANALYSIS OF LONG TIME CREEP BEHAVIOR OF COLUMBIUM C-103 ALLOY

William D Klopp and Robert H Titran Mar 1976 21 p refs (NASA-TM-X-71895, E-8681) Avail NTIS HC $3.50 CSCL 11F

Analysis of 16 long time creep tests on columbium C-103 alloy (Cb-10Hf-1Ti-0.7Zr) indicates that the calculated stresses to give 1 percent creep strain in 100,000 hours at 1,255 K (1800 F) are 7.93 and 8.96 MPa (1,150 and 1,300 psi) for fine grained and course grained materials, respectively. The apparent activation energy and stress dependence for creep of this alloy are approximately 315 KJ/gmol (75,300 cal/gmol) and 2.51, respectively, based on Dorn-Sherby types of relations However, the 90 percent confidence limits on these values are wide because of the limited data currently available Author

N76-21319*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

CORRELATIONS AMONG ULTRASONIC PROPAGATION FACTORS AND FRACTURE TOUGHNESS PROPERTIES OF METALLIC MATERIALS

Alex Vary 1976 31 p refs Presented at Spring Conf of the Am Soc for Nondestructive Testing, Los Angeles, 8-11 Mar. 1976

(NASA-TM-X-71889, E-8671) Avail: NTIS HC $4.00 CSCL 11D

Empirical evidence was developed to show that a close relation exists among fracture toughness, yield strength, and ultrasonic attenuation properties of metallic materials. The evidence was obtained by ultrasonic probing of specimens of two maraging steels and a titanium alloy It was concluded that nondestructive ultrasonic methods can be used to indirectly evaluate fracture-related material properties The results suggest that these nondestructive ultrasonic measurements can also serve as an adjunct to destructive testing, measurement, and analysis of fracture properties Author

N76-21322*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
SELECTED FRETTING-WEAR-RESISTANT COATINGS FOR TITANIUM - 6-PERCENT-ALUMINUM - 4-PERCENT-VANADIUM ALLOY
Robert C. Bill Washington Apr. 1976 24 p refs
(NASA-TN-D-8214, E-8594) Avail: NTIS HC $3.50 CSCL 11F

A titanium - 6-percent-aluminum - 4-percent-vanadium alloy (Ti-6Al-4V) was subjected to fretting-wear exposures against uncoated Ti-6Al-4V as a baseline and against various coatings and surface treatments applied to Ti-6Al-4V. The coatings evaluated included plasma-sprayed tungsten carbide with 12 percent cobalt, aluminum oxide with 13 percent titanium oxide, chromium oxide, and aluminum bronze with 10 percent aromatic polyester, polymer-bonded polyimide, polyimide with graphite fluoride, polyimide with molybdenum disulfide (MoS2), and methyl phenyl silicone bonded MoS2, preoxidation surface treatment, a nitride surface treatment, and a sputtered MoS2 coating Results of wear measurements on both the coated and uncoated surfaces after 300,000 fretting cycles indicated that the polyimide coating was the most wear resistant and caused the least wear to the uncoated mating surface Author

N76-22352*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
APPLICATION OF STRAINRANGE PARTITIONING TO THE PREDICTION OF CREEP-FATIGUE LIVES OF AISI TYPES 304 AND 316 STAINLESS STEEL
James F Saltsman and Gary R Halford 1976 28 p refs Proposed for presentation at the Intern Joint Pressure Vessels and Piping and Petroleum Mech. Eng Conf., Mexico City, 19-23 Sep 1976; sponsored by ASME
(NASA-TM-X-71898; E-8672) Avail NTIS HC $4.00 CSCL 11F

As a demonstration of the predictive capabilities of the method of Strainrange Partitioning, published high-temperature, low cycle, creep-fatigue test results on AISI Types 304 and 316 stainless steel were analyzed and calculated, cyclic lives compared with observed lives Predicted lives agreed with observed lives within factors of two for 76 percent, factors of three for 93 percent, and factors of four for 98 percent of the laboratory tests analyzed Agreement between observed and predicted lives is judged satisfactory considering that the data are associated with a number of variables (two alloys, several heats ,and heat treatments, a range of temperatures, different testing techniques, etc) that are not directly accounted for in the calculations Author

N76-22356*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ADHESION AND FRICTION OF THIN METAL FILMS
Donald H Buckley Washington Apr 1976 19 p refs
(NASA-TN-D-8230, E-8565) Avail NTIS HC $3.50 CSCL 11F

Sliding friction experiments were conducted in vacuum with thin films of titanium, chromium, iron, and platinum sputter deposited on quartz or mica substrates A single crystal hemispherically tipped gold slider was used in contact with the films at loads of 1 0 to 30 0 and at a sliding velocity of 0 7 mm/min at 23 C Test results indicate that the friction coefficient is dependent on the adhesion of two interfaces, that between the film and its substrate and the slider and the film There exists a relationship between the percent d bond character of metals in bulk and in thin film form and the friction coefficient Oxygen can increase adhesive bonding of a metal film (platinum) to a substrate Author

N76-23415*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THE METAL TO METAL INTERFACE AND ITS EFFECT ON ADHESION AND FRICTION
Donald H Buckley 1976 39 p refs Presented at the Intern Conf. on Colloids and Surfaces, San Juan Puerto Rico, 21-25 Jun 1976; sponsored by Am. Chem Soc and the Intern Union of Pure and Appl Chem
(NASA-TM-X-73431, E-8584) Avail NTIS HC $4 00 CSCL 11F

The nature of the interface, adhesion and friction properties of noble metals, platinum metals, Group IV (B) metals and transition metals were considered. The surface chemical activity of the noble and platinum metals is shown to effect metal to metal interfaces as does a valance bonding in the transition metals With the Group IV (B) metals the degree of metallic nature of the elements is shown to effect interfacial behavior The effect of surface segregation of alloy constituents such as silicon in iron and its influence on the metal to metal interface is discussed In addition the effect of alloy constituents on changes in bulk properties such as transformations in tin are shown to effect interfacial adhesion and friction behavior Author

N76-24392*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
EFFECT OF MINOR REACTIVE METAL ADDITIONS ON FRACTURE TOUGHNESS OF IRON: 12-PERCENT NICKEL ALLOY AT-196 DEG AND 25 DEG C
Walter R. Witzke and Joseph R. Stephens Washington May 1976 38 p refs
(NASA-TN-D-8232, E-8555) Avail NTIS HC $4 00 CSCL 11F

The slow bend precracked Charpy fracture toughness and tensile behavior of arc-melted and hot-rolled Fe-12Ni alloys containing up to 4 atomic percent reactive metal additions were determined at -196 C and 25 C after water quenching from three annealing temperatures. The fracture toughness of Fe-12Ni at -196 C was improved by small amounts of Al, Ce, Hf, La, Nb, Ta, Ti, V, Y, and Zr, but not by Si Cryogenic toughness was improved up to 7 5 times that of binary Fe-12Ni and varied with the reactive metal, its concentration, and the annealing temperature Author

N76-26316*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
RESISTANCE OF NICKEL-CHROMIUM-ALUMINUM ALLOYS TO CYCLIC OXIDATION AT 1100 C AND 1200 C
Charles A Barrett and Carl E Lowell Washington Jun. 1976 40 p refs
(NASA-TN-D-8255, E-8615) Avail NTIS HC $4.00 CSCL 11F

Nickel-rich alloys in the Ni-Cr-Al system were evaluated for cyclic oxidation resistance in still air at 1,100 and 1,200 C A first approximation oxidation attack parameter Ka was derived from specific weight change data involving both a scaling growth constant and a spalling constant. An estimating equation was derived with Ka as a function of the Cr and Al content by multiple linear regression and translated into countour ternary diagrams showing regions of minimum attack. An additional factor inferred from the regression analysis was that alloys melted in zirconia crucibles had significantly greater oxidation resistance than comparable alloys melted otherwise Author

N76-26317*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EFFECT OF CASTING GEOMETRY ON MECHANICAL PROPERTIES OF TWO NICKEL-BASE SUPERALLOYS
James R Johnston, Robert L Dreshfield, and Henry E Collins (TRW, Inc., Cleveland) Washington Jun. 1976 17 p refs

(NASA-TM-X-3386, E-8661) Avail NTIS HC $3 50 CSCL 11F

An investigation was performed to determine mechanical properties of two rhenium-free modifications of alloy TRW, and to evaluate the suitability of the alloy for use in a small integrally cast turbine rotor The two alloys were initially developed using stress rupture properties of specimens machined from solid gas turbine blades Properties in this investigation were determined from cast to size bars and bars cut from 3 8 by 7 6 by 17 8 cm blocks Specimens machined from blocks had inferior tensile strength and always had markedly poorer rupture lives than cast to size bars At 1,000 C the cast to size bars had shorter rupture lives than those machined from blades Alloy R generally had better properties than alloy S in the conditions evaluated The results show the importance of casting geometry on mechanical properties of nickel base superalloys and suggest that the geometry of a component can be simulated when developing alloys for that component Author

N76-30346*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

LOW VAPOR PRESSURE BRAZE ALLOYS FOR THERMIONIC ENERGY CONVERTERS

Virginia L Bair 1976 11 p refs Presented at the Intern Conf on Plasma Science, Austin, Texas, 24-26 May 1976, sponsored by IEEE

(NASA-TM-X-73493, E-8891) Avail. NTIS HC $3 50 CSCL 11F

The evaluation of cesium diode electrode materials called for braze fillers with very low vapor pressures and a wide range of melting points Binary alloys of low vapor pressure refractory metals were chosen to fill this need These alloys of Th, Zr, Hf, Ru, Nb, Ir, Mo, Ta, Os, Re, and W have reported melting point minima or eutectics from 1 510 K to above 3,000 K Preliminary data are compiled on the use of several of these braze alloys Melting points and surface wetting on a Ta base are given Results of brazing Ir, LaB6, Nb, Re, W, and Zr-22 wt % ZrO2 materials into Ta and Nb-1% Zr bases are presented Current braze usage is summarized Author

N76-30347*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

VOLUME FRACTION DETERMINATION IN CAST SUPERALLOYS AND DS EUTECTIC ALLOYS BY A NEW PRACTICE FOR MANUAL POINT COUNTING

C W Andrews Jun 1976 25 p refs

(NASA-TM-X-73449, E-8787) Avail NTIS HC $3 50 CSCL 11F

Volume fraction of a constituent or phase was estimated in six specimens of conventional and DS-eutectic superalloys, using ASTM E562-76 a new standard recommended practice for determining volume fraction by systematic manual point count Volume fractions determined ranged from 0 086 to 0 36, and with one exception, the 95 percent relative confidence limits were approximately 10 percent of the determined volume fractions Since the confidence-limit goal of 10 percent, which had been arbitrarily chosen previously, was achieved in all but one case, this application of the new practice was considered successful Author

N76-30348*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

MICROSTRUCTURAL CHANGES CAUSED BY THERMAL TREATMENT AND THEIR EFFECTS ON MECHANICAL PROPERTIES OF A GAMMA/GAMMA PRIME - DELTA EUTECTIC ALLOY

Surendra N Tewari and Robert L Dreshfield Washington Aug. 1976 36 p refs

(NASA-TN-D-8280, E-8531) Avail NTIS HC $4 00 CSCL 11F

Microstructural changes due to thermal treatments of a directionally solidified gamma/gamma'-delta eutectic alloy were investigated Aging treatments of 8 to 48 hours and ranging from 750 to 1120 C were given to the alloy in both its as directionally solidified condition and after gamma' solutioning Aging resulted in gamma' coarsening, gamma precipitates in delta, and delta and gamma'' precipitates in gamma The tensile strength was increased about 12 percent at temperatures up to 900 C by a heat treatment Times to rupture were essentially the same or greater than for as directionally solidified material Tensile and rupture ductility in the growth direction of the alloy were reduced by the heat treatment Author

N76-31330*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

TWO-LAYER THERMAL BARRIER COATING FOR TURBINE AIRFOILS - FURNACE AND BURNER RIG TEST RESULTS

Stephan Stecura Washington Sep 1976 20 p refs

(NASA-TM-X-3425; E-8767) Avail NTIS HC $3 50 CSCL 11C

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 those coatings initially examined, the most promising system consisted of a Ni-16Cr-6Al-0 6Y (in wt%) thermal barrier 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 an air-cooled airfoil The coating withstood 3 200 cycles (80 sec at 1,280 C surface temperature) and 275 cycles (1 hr at 1,490 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

N76-33314*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

TRANSVERSE TENSILE AND STRESS RUPTURE PROPERTIES OF GAMMA/GAMMA PRIME-DELTA DIRECTIONALLY SOLIDIFIED EUTECTIC

Hugh H. Gray Aug 1976 23 p refs

(NASA-TM-X-73451 E-8810) Avail NTIS HC $3 50 CSCL 11F

Tensile and stress rupture properties were determined primarily at 760 C for specimens oriented at various angles (0 deg, 10 deg, 45 deg, and 90 deg) from the solidification direction of bars and/or slabs of the Ni-20Cb-6Cr-2 5A (gamma/gamma prime-delta) eutectic Threaded-head specimens yielded longer rupture lives with significantly less scatter than did tapered-head specimens Miniature specimens are suitable for determining traverse tensile and rupture properties of 1 2 centimeter diameter bar stock The 300 hour rupture stress at 760 C for specimens oriented at 10 deg from the solidification direction was reduced from 740 to 460 MPa, and to 230 MPa for material oriented at either 45 deg or 90 deg Author

A76-10485 * Scanning electron microscope investigation of the structural growth in thick sputtered coatings T Spalvins (NASA, Lewis Research Center, Cleveland, Ohio). In, Microstructural science.

Volume 3. New York, American Elsevier Publishing Co., Inc., 1975, p. 525-549. 8 refs.

Sputtered S-Monel, silver, and 304 stainless steel coatings and molybdenum disulfide coatings were deposited on mica and metal substrates with various surface finishes to investigate the structural growth of the coating by scanning electron microscopy. The geometry and the surface morphology of the nodules are characterized. Compositional changes within the coating were analyzed by energy dispersive X-ray analysis. Defects in the surface finish act as preferential nucleation sites and form isolated overlapping and complex nodules and various unusual surface overgrowths on the coating. The nodule boundaries are very vulnerable to chemical etching and these nodules do not disappear after full annealing Further, they have undesirable effects on mechanical properties, cracks are initiated at the nodules when the coating is stressed by mechanical forces (Author)

A76-14800 * Strain-cycling fatigue behavior of ten structural metals tested in liquid helium, liquid nitrogen, and ambient air. A. J Nachtigall (NASA, Lewis Research Center, Cleveland, Ohio). In Properties of materials for liquefied natural gas tankage. Philadelphia, Pa., American Society for Testing and Materials (ASTM Special Technical Publication, No. 579), p 378-396. 6 refs

A76-14849 * Dynamic SEM wear studies of tungsten carbide cermets. W. A. Brainard and D. H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio) In: Joint Lubrication Conference, Miami Beach, Fla., October 21-23, 1975, Technical Preprints. (A76-14843 04-27) Park Ridge, Ill., American Society of Lubrication Engineers, 1975 9 p 17 refs.

Dynamic friction and wear experiments were conducted in a scanning electron microscope. The wear behavior of pure tungsten carbide and composite with 6 and 15 weight percent cobalt binder was examined. Etching of the binder was done to selectively determine the role of the binder in the wear process. Dynamic experiments were conducted as the WC and bonded WC cermet surfaces were transversed by a 50 micron radiused diamond stylus. These studies show that the predominant wear process in WC is fracture initiated by plastic deformation. The wear of the etched cermets is similar to pure WC. The presence of the cobalt binder reduces both friction and wear. The cementing action of the cobalt reduces granular separation and promotes a dense polished layer because of its low shear strength film-forming properties. The wear debris generated from unetched surface is approximately the same composition as the bulk. (Author)

A76-18511 * # A study of the oxide dispersion and recrystallization in NiCrAl prepared from preoxidized powder. T. K Glasgow (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Mining, Metallurgical, and Petroleum Engineers, Fall Meeting, Cincinnati, Ohio, Nov. 10-13, 1975, Paper.* 32 p. 22 refs.

The SAP technique of dispersion strengthening (formation of an oxide dispersion by preoxidation of metal powders) was applied to atomized powder of the alloy Ni-17Cr-5Al-0 2 Y SAP-NiCrAl was worked by extrusion and rod rolling at 1205 C and by swaging at 760 C A variety of annealing treatments were applied after working to determine the recrystallization response NiCrAlY, similarly prepared from atomized powder, but without a preoxidation treatment, was examined for comparison. The SAP-NiCrAl of this study exhibited oxide particle size and spacing much larger than that usually observed in oxide dispersion strengthened alloys; nonetheless, it was possible to achieve abnormal (secondary) recrystallization in the SAP-NiCrAl as has been reported for other oxide dispersion strengthened alloys. In contrast, unoxidized NiCrAlY exhibited only primary recrystallization. (Author)

A76-25376 * Shear strength of metal-sapphire contacts. S. V. Pepper (NASA, Lewis Research Center, Cleveland, Ohio) *Journal of Applied Physics,* vol. 47, Mar. 1976, p. 801-808. 36 refs.

The shear strength of polycrystalline Ag, Cu, Ni, and Fe contacts on clean (0001) sapphire has been studied in ultrahigh vacuum. Both clean metal surfaces and surfaces exposed to O2, Cl2, and C2H4 were used. The results indicate that there are two sources of strength of Al2O3-metal contacts: an intrinsic one that depends on the particular clean metal in contact with Al2O3 and an additional one due to intermediate films. The shear strength of the clean metal contacts correlated directly with the free energy of oxide formation for the lowest metal oxide, in accord with the hypothesis that a chemical bond is formed between metal cations and oxygen anions in the sapphire surface. Contacts formed by metals exposed to chlorine exhibited uniformly low shear strength indicative of van der Waals bonding between chlorinated metal surfaces and sapphire. Contacts formed by metals exposed to oxygen exhibited enhanced shear strength, in accord with the hypothesis that an intermediate oxide layer increases interfacial strength. (Author)

A76-25846 * # Effects of C and Hf concentration on the mechanical properties of wrought superalloys based on NASA IIB-11 produced from prealloyed powders. R. V. Miner, Jr. (NASA, Lewis Research Center, Cleveland, Ohio) *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 21-25, 1976, Paper 76-GT-112.* 10 p. 6 refs. Members, $1.50; nonmembers, $3.00.

This work describes the effects of C and Hf concentration on the mechanical properties of NASA IIB-11, a candidate material for advanced-temperature gas turbine engine disks IIB-11 and four alloys of varied C and Hf concentrations were produced as cross-rolled disks from hot-isostatically pressed powder billets. The lower C, higher Hf modification exhibited the best mechanical properties at 760 C and below. These properties were at least equivalent to those of other candidate alloys for advanced temperature disks Because of their finer grain sizes, all of these powder metallurgy alloys had lower rupture strength, however, than that achieved previously in conventionally processed IIB-11. (Author)

A76-26421 * Composition effects on mechanical properties of HfC-strengthened molybdenum alloys. W. R. Witzke (NASA, Lewis Research Center, Cleveland, Ohio). *Metallurgical Transactions A - Physical Metallurgy and Materials Science,* vol 7A, Mar 1976, p. 443-451. 14 refs.

The mechanical properties of swaged rod thermomechanically processed from arc-melted Mo-2Re-Hf-C alloys containing as much as 0.9 mol pct HfC have been evaluated. The low temperature ductilities of these alloys were not influenced by the amount of HfC present but by the amount of Hf in excess of stoichiometry. Maximum ductility occurred at 0.2 to 0.3 at. pct excess Hf. At 0.3 to 0 5 mol pct HfC, alloy strength varied directly with the Mo content of extracted carbide particles, both decreasing as the amount of excess Hf increased. Additions of 2 at. pct Re had little effect on strength or ductility. Tensile and creep strengths of Mo-2Re-0.7Hf-0 5C alloy equaled or exceeded those of other high strength Mo alloys. (Author)

A76-28023 * # Description of a computerized method for predicting thermal fatigue life of metals. D A. Spera and E C. Cox (NASA, Lewis Research Center, Cleveland, Ohio). *American Society for Testing and Materials, Symposium on Thermal Fatigue of Materials and Components, New Orleans, La , Nov. 17, 18, 1975, Paper.* 14 p. 20 refs.

A computer program called TFLIFE is described which can be used to predict the thermal fatigue life of metals and structural components from conventional metal properties This program is used as a subroutine with a main program supplied by the user. The main program calculates input cycles of temperature and total strain for TFLIFE which then calculates a stress cycle, creep and plastic strain damage, and cyclic life. A unique feature of TFLIFE is that it calculates lives according to several different failure criteria for the same input data. These criteria are surface crack initiation, interior crack initiation, and complete fracture of both unnotched and notched fatigue specimens. Results are presented for two typical problems. thermal-mechanical fatigue of bar specimens of the tantalum alloy T-111 and thermal-stress fatigue of wedge specimens of the nickel alloy B-1900. The computer program is now ready for more extensive evaluation on structural components and additional laboratory specimens (Author)

A76-28024 * # Wide range stress intensity factor expressions for ASTM E 399 standard fracture toughness specimens. J E. Srawley (NASA, Lewis Research Center, Cleveland, Ohio) *American Society for Testing and Materials, Committee E-24 Meeting, Orlando, Fla., Mar. 22-26, 1976, Paper.* 4 p.

A76-31506 * # Correlations among ultrasonic propagation factors and fracture toughness properties of metallic materials. A Vary (NASA, Lewis Research Center, Cleveland, Ohio) *American Society for Nondestructive Testing, Spring Conference, Los Angeles, Calif., Mar. 8-11, 1976, Paper* 31 p 19 refs

Empirical evidence was developed to show that a close relation exists among fracture toughness, yield strength, and ultrasonic attenuation properties of metallic materials The evidence was obtained by ultrasonic probing of specimens of two maraging steels and a titanium alloy. It was concluded that nondestructive ultrasonic methods can be used to indirectly evaluate fracture-related material properties. The results suggest that these nondestructive ultrasonic measurements can also serve as an adjunct to destructive testing, measurement, and analysis of fracture properties (Author)

A76-33108 * Observations on the relationship of structure to the mechanical properties of thin TD-NiCr sheet. J. D. Whittenberger (NASA, Lewis Research Center, Cleveland, Ohio). *Metallurgical Transactions A - Physical Metallurgy and Materials Science*, vol 7A, May 1976, p. 611-619. 23 refs

A study of the relationship between structure and mechanical properties of thin TD-NiCr sheet indicated that the elevated temperature tensile, stress-rupture, and creep strength properties are dependent on grain aspect ratio and sheet thickness In general, the strength properties increase with increasing grain aspect ratio and sheet thickness Tensile testing revealed an absence of ductility at elevated temperatures (not less than 1144 K). Significant creep damage as determined by subsequent tensile testing at room temperature occurs after very small amounts (less than 0 1%) of prior creep deformation over the temperature range 1144-1477 K A threshold stress for creep appears to exist Creep exposure below the threshold stress at T not less than 1366 K results in almost full retention of room temperature tensile properties. (Author)

A76-33110 * Thermal expansion in the Ni-Cr-Al and Co-Cr-Al systems to 1200 C determined by high-temperature X-ray diffraction. C. E Lowell, R G Garlick, and B. Henry (NASA, Lewis Research Center, Engineering Applications Development Section, Cleveland, Ohio). *Metallurgical Transactions A - Physical Metallurgy and Materials Science*, vol. 7A, May 1976, p. 655 660 15 refs

A76-33712 * Effect of adsorbed films on friction of Al2O3-metal systems. S. V. Pepper (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Applied Physics*, vol 47, June 1976, p. 2579-2588 18 refs

The kinetic friction of polycrystalline Al2O3 sliding on Cu, Ni, and Fe in ultrahigh vacuum was studied as a function of the surface chemistry of the metal. Clean metal surfaces were exposed to O2, Cl2, C2H4, and C2H3Cl, and the change in friction due to the adsorbed species was observed. Auger electron spectroscopy assessed the elemental composition of the metal surface. It was found that the systems exposed to Cl2 exhibited low friction, interpreted as the van der Waals force between the Al2O3 and metal chloride. The generation of metal oxide by oxygen exposures resulted in an increase in friction, interpreted as due to strong interfacial bonds established by reaction of metal oxide with Al2O3 to form the complex oxide (spinel). The only effect of C2H4 was to increase the friction of the Fe system, but C2H3Cl exposures decreases friction in both Ni and Fe systems, indicating the dominance of the chlorine over the ethylene complex on the surface (Author)

A76-38234 * # Ceramic thermal-barrier coatings for cooled turbines C. H. Liebert and F. S Stepka (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA Paper 76-729.* 10 p 11 refs.

Ceramic thermal-barrier coatings on hot engine parts have the potential to reduce metal temperatures, coolant requirements, cost and complexity of the cooling configuration, and to increase life turbine efficiency and gas temperature Coating systems consisting o a plasma-sprayed layer of zirconia stabilized with either yttria magnesia or calcia over a thin alloy bond coat have been developed their potential analyzed and their durability and benefits evaluated in a turbojet engine. The coatings on air-cooled rotating blades were in good condition after completing as many as 500 two-minute cycles of engine operation between full power at a gas temperature of 1644 K and flameout, or as much as 150 hours of steady-state operation on cooled vanes and blades at gas temperatures as high as 1644 K with 35 start and stop cycles. On the basis of durability and processing cost, the yttria-stabilized zirconia was considered the best of the three coatings investigated. (Author)

A76-47650 * Corrosion of oxygen-doped tantalum by lithium S Stecura (NASA, Lewis Research Center, Cleveland, Ohio) *Corrosion Science*, vol 16, 1976, p 233-241 24 refs

The increase in the penetration of tantalum by liquid lithium with increasing oxygen content of tantalum results from the ability of lithium to extract oxygen from tantalum oxides and/or from regions of high oxygen concentrations, accompanied by the creation of minute channels At low oxygen concentration, oxides are present primarily at the grain boundaries and the lithium penetration is primarily intergranular At high oxygen concentration, oxides and/or regions of high oxygen concentration are present both at the grain boundaries and within the grains, lithium penetration is both intergranular and transgranular For a specific oxygen concentration, the severity of corrosion decreases with increasing temperature because (1) the oxygen solubility increases with temperature decreasing the number of oxide particles and/or regions of high oxygen concentration, and (2) the diffusivity of oxygen in tantalum increases, allowing more rapid oxygen removal at the tantalum lithium interface (Author)

N76-10303*# Bell Aerospace Co., Buffalo, N.Y.
INVESTIGATION OF ELECTROFORMING TECHNIQUES, LITERATURE ANALYSIS REPORT Contractor Report, Jun. - Oct. 1974
G. A Malone Apr. 1975 118 p refs
(Contract NAS3-17823)
(NASA-CR-134776, BAC-8756-953002) Avail NTIS HC $5 25 CSCL 11F

A literature analysis is presented of reports, specifications, and documented experiences with the use of electroforming to produce copper and nickel structures for aerospace and other engineering applications The literature period covered is from 1948 to 1974 Specific effort was made to correlate mechanical property data for the electrodeposited material with known electroforming solution compositions and operating conditions From this survey, electrolytes are suggested for selection to electroform copper and nickel outer shells on regeneratively cooled thrust chamber liners, and other devices subject to thermal and pressure exposure, based on mechanical properties obtainable, performance under various thermal environments, and ease of process control for product reproducibility Processes of potential value in obtaining sound bonds between electrodeposited copper and nickel and copper alloy substrates are also discussed
Author

N76-11273*# Mar-Test, Inc., Cincinnati, Ohio.
HIGH-TEMPERATURE, LOW-CYCLE FATIGUE OF COPPER-BASE ALLOYS FOR ROCKET NOZZLES. PART 1: DATA SUMMARY FOR MATERIALS TESTED IN PRIOR PROGRAMS Technical Report, Jul. - Oct. 1975
J. B. Conway, R H Stentz, and J T. Berling Nov. 1975 310 p refs
(Contract NAS3-19720)
(NASA-CR-134908; MTI-003-3-1-Pt-1) Avail NTIS HC $9 75 CSCL 11F

A more detailed analysis of the results obtained in 188 previously reported low-cycle fatigue tests of various candidate

materials for regeneratively-cooled, reusable rocket nozzle liners was reported Plots of load range versus cycles were reported for each test along with a stress-strain hysteresis loop near half-life In addition, a summary table was provided to compare N5 (cycles to a five percent load range drop) and Nf (cycles to complete specimen separation) values for each test. Author

N76-11275*# Pratt and Whitney Aircraft, East Hartford, Conn
CONTINUED DEVELOPMENT OF ABRADABLE GAS PATH SEALS Final Report, 25 Sep. 1974 - 29 Aug. 1975
L. T. Shiembob 1 Nov. 1975 100 p refs
(Contract NAS3-18565)
(NASA-CR-134879, PWA-5314) Avail NTIS HC $4 75 CSCL 11F

Major program objectives were the continued development of NiCrAlY feltmetal and honeycomb systems for knife edge seal applications in the 1144 to 1366 K temperature range, and to initiate abradable seal material evaluation for blade tip seal applications in the 1366 to 1589 K temperature range Larger fiber size, higher density feltmetal showed greatly improved erosion resistance with a slight reduction in abradability compared to the baseline feltmetal Pack aluminide coating of the honeycomb extended the oxidation resistance and slightly improved the abradability of this material Evaluation through selected abradability, erosion and oxidation testing, and pertinent metallography led to selection of a plasma sprayed yttria stabilized zirconia (ZrO2)/CoCrAlY layered system as the system with the most potential to meet the 1589 K requirement for blade tip seals This system demonstrated structural integrity, erosion resistance, and some degree of abradability. Author

N76-22355*# Pratt and Whitney Aircraft, East Hartford, Conn
ALLOY AND STRUCTURAL OPTIMIZATION OF A DIRECTIONALLY SOLIDIFIED LAMELLAR EUTECTIC ALLOY
K D. Sheffler May 1976 320 p refs
(Contract NAS3-17811)
(NASA-CR-135000, PWA-5300) Avail NTIS HC $9 75 CSCL 11F

Mechanical property characterization tests of a directionally solidified Ni-20 percent Cb-2 5 percent Al-6 percent Cr cellular eutectic turbine blade alloy demonstrated excellent long time creep stability and indicated intermediate temperature transverse tensile ductility and shear strength to be somewhat low for turbine blade applications Alloy and structural optimization significantly improves these off-axis properties with no loss of longitudinal creep strength or stability. The optimized alloy-structure combination is a carbon modified Ni-20 1 percent Cb-2 5 percent Al-6 0 percent Cr-0 06 percent C composition processed under conditions producing plane front solidification and a fully-lamellar microstructure With current processing technology, this alloy exhibits a creep-rupture advantage of 39 C over the best available nickel base superalloy, directionally solidified MAR M200+ Hf While improved by about 20 percent, shear strength of the optimized alloy remains well below typical superalloy values Author

N76-23416*# Battelle Columbus Labs., Ohio
LOW-CYCLE FATIGUE OF TYPE 347 STAINLESS STEEL AND HASTELLOY ALLOY X IN HYDROGEN GAS AND IN AIR AT ELEVATED TEMPERATURES Final Report
Carl E. Jaske Richard C Rice, Richard D Buchheit Donald B Roach, and Theodore L Porfilio May 1976 110 p refs
(Contract NAS3-20078)
(NASA-CR-135022) Avail NTIS HC $5 50 CSCL 11F

An investigation was conducted to assess the low-cycle fatigue resistance of two alloys, Type 347 stainless steel and Hastelloy Alloy X, that were under consideration for use in nuclear-powered rocket vehicles Constant-amplitude, strain-controlled fatigue tests were conducted under compressive strain cycling at a constant strain rate of 0.001/sec and at total axial strain ranges of 1 5, 3 0, and 5 0 %, in both laboratory-air and low-pressure hydrogen-gas environments at temperatures from 538 to 871 C Specimens were obtained from three heats of Type 347 stainless steel bar and two heats of Hastelloy Alloy X The tensile properties of each heat were determined at 21, 538, 649, and 760 C The continuous cycling fatigue resistance was determined for each heat at temperatures of 538, 760 and 871 C The Type 347 stainless steel exhibited equal or superior fatigue resistance to the Hastelloy Alloy X at all conditions of this study Author

N76-25375*# Martin Marietta Corp., Orlando, Fla.
HYDROGEN EMBRITTLEMENT OF STRUCTURAL ALLOYS. A TECHNOLOGY SURVEY
James L Carpenter, Jr and William F Stuhrke Jun 1976 133 p refs
(Contract NAS3-19530)
(NASA-CR-134962, OR-14178) Avail NTIS HC $6.00 CSCL 11F

Technical abstracts for about 90 significant documents relating to hydrogen embrittlement of structural metals and alloys are reviewed Particular note was taken of documents regarding hydrogen effects in rocket propulsion, aircraft propulsion and hydrogen energy systems, including storage and transfer systems Author

N76-26312*# TRW Equipment Labs Cleveland, Ohio
ULTRAHIGH VACUUM, HIGH TEMPERATURE, LOW CYCLE FATIGUE OF COATED AND UNCOATED RENE 80 Final Report, 17 Jun. 1974 - 17 Feb. 1976
C S Kortovich Apr. 1976 64 p refs
(Contract NAS3-17830)
(NASA-CR-135003; TRW-ER-7861) Avail: NTIS HC $4 50 CSCL 11F

A study was conducted on the ultrahigh vacuum strain controlled by low cycle fatigue behavior of uncoated and CODEP B-1 aluminide coated Rene' 80 nickel-base superalloy at 1000 C (1832 F) and 871 C (1600 F) The results indicated little effect of coating or temperature on the fatigue properties There was, however, a significant effect on fatigue life when creep was introduced into the strain cycles The effect of this creep component was analyzed in terms of the method of strainrange partitioning Author

N76-32292*# Mar-Test, Inc., Cincinnati, Ohio
HIGH TEMPERATURE, LOW-CYCLE FATIGUE OF COPPER-BASE ALLOYS FOR ROCKET NOZZLES. PART 2: STRAIN-RANGE PARTITIONING AND LOW-CYCLE FATIGUE RESULTS AT 538 DEG C Technical Report, Nov. 1975 - Jul. 1976
J B. Conway, R. H Stentz, and J T. Berling Aug 1976 159 p refs
(Contract NAS3-19720)
(NASA-CR-135073, MTI-R004-3-2-Pt-2) Avail NTIS HC $6 75 CSCL 11F

Low-cycle fatigue tests of 1/2 Hard AMZIRC Copper and NARloy Z were performed in argon at 538 C to determine partitioned strain range versus life relationships Strain-controlled low-cycle fatigue tests of a Zr-Cr-Mg copper-base alloy were also performed Strain ranges, lower than those employed in previous tests, were imposed in order to extend the fatigue life curve out to approximately 400,000 cycles An experimental copper alloy and an experimental silver alloy were also studied Tensile tests were performed in air at room temperature and in argon at 538 C. Strain-controlled low-cycle fatigue tests were performed at 538 C in argon to define the fatigue life over the regime from 300 to 3,000 cycles. For the silver alloy, three additional heat treatments were introduced, and a limited evaluation of the short-term tensile and low-cycle fatigue behavior at 538 C was performed. Author

A76-11169 * # **Mechanical behavior of the directionally solidified gamma/gamma prime - delta eutectic alloy.** R. H. Barkalow, J J. Jackson, M. Gell, and G. R. Leverant (United Technologies Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn.). *AIME, NASA, U.S. Army, and U S Navy, Conference on In-Situ Com-*

posites II, Lake George, N.Y., Sept. 2-5, 1975, Paper. 10 p 20 refs. Contracts No. F33657-71-C-0789; No. NAS3-17811.

The eutectic alloy Ni-20.0%Cb-2.5%Al-6 0%Cr was tested in short-term creep and long-term exposure to service conditions to assess its suitability for high temperature turbine blade applications Long-time exposure showed the lamellar microstructure of the alloy to be exceptionally stable. Other properties tested were notch sensitivity, isothermal and thermomechanical fatigue strength, shear strength, and transverse ductility. It was shown that this alloy is superior to the best currently available directionally solidified superalloys over the temperature/stress conditions encountered in turbine airfoils B J.

A76-11170 * # **The influence of chromium content on the solidification characteristics and microstructure-property relationships in the directionally solidified gamma/gamma prime - delta eutectic.** K. D. Sheffler, R. H Barkalow, and A. Yuen (United Technologies Corp., Pratt and Whitney Aircraft Div., East Hartford, Conn). *AIME, NASA, U S. Army, and U.S. Navy, Conference on In-Situ Composites II, Lake George, N.Y., Sept. 2-5, 1975, Paper.* 10 p. 9 refs Contract No. NAS3-17811.

A76-16212 * **The effect of forging history on the strength and microstructure of TDNiCr /Ni-20Cr-2ThO2/.** A. M. Filippi (Westinghouse Astronuclear Laboratory, Pittsburgh, Pa.). *Metallurgical Transactions A - Physical Metallurgy and Materials Science,* vol. 6A, Dec. 1975, p. 2171-2177. 10 refs. Contract No. NAS3-15548.

Forging variables were evaluated to determine their influence on the elevated temperature strength and microstructure of TDNiCr. Grain size was the principal microstructural feature related to elevated temperature strength and was controlled primarily by the thermomechanical variables of forging temperature and final annealing condition. Tests at 1366 K revealed a factor of eight increase in tensile strength as grain size increased from 1 to 150 microns, while stress-rupture strength improved by three to five times as grain size increased from 15 to 150 microns. Forged material of grain size greater than or equal to about 150 microns displayed a level of elevated temperature strength comparable to that of optimized TDNiCr sheet. The presence of a preponderance of small twins and a strong preferred orientation may have also been factors contributing to the excellent high temperature strength of large grain forged material. (Author)

27 NONMETALLIC MATERIALS

Includes physical, chemical, and mechanical properties of plastics, elastomers, lubricants, polymers, textiles, adhesives, and ceramic materials

N76-10317*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
SILICON NITRIDE-ALUMINUM OXIDE SOLID SOLUTION (SiAlON) FORMATION AND DENSIFICATION BY PRESSURE SINTERING
Hun C Yeh, William A Sanders, and Jere L Fiyalko Washington Oct 1975 30 p refs
(NASA-TM-X-3299, E-8317) Avail NTIS HC $3.75 CSCL 11B

Stirred-ball-mill-blended Si3N4 and Al2O3 powders were pressure sintered in order to investigate the mechanism of solid solution formation and densification in the Si3N4-Al2O3 system Powder blends with Si3N4-Al2O3 mole ratios of 4:1, 3 2, and 2:3 were pressure sintered at 27.6-MN/sq m pressure at temperatures to 17000 C (3090 F) The compaction behavior of the powder blends during pressure sintering was determined by observing the density of the powder compact as a function of temperature and time starting from room temperature. This information, combined with the results of X-ray diffraction and metallographic analyses regarding solutioning and phase transformation phenomena in the Si3N4-Al2O3 system, was used to describe the densification behavior. Author

N76-11289*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PMR POLYIMIDES WITH IMPROVED HIGH TEMPERATURE PERFORMANCE
Raymond D Vannucci and William B Alston [1975] 20 p refs Proposed for presentation at 31st Ann Reinforced Plastics Composites Conf, Washington, D C, 3-6 Feb 1976, Sponsored by Soc of Plastics Ind
(NASA-TM-X-71816; E-8513) Avail NTIS HC $3.50 CSCL 07C

Studies were performed to investigate the effect of substituting a hexafluoro isopropyl idene connecting group for a carbonyl group of a PMR polyimide monomeric reactant on the thermomechanical properties processability of graphite fiber reinforced PMR polyimide composites. Composites were fabricated utilizing PMR methodology. Monomeric reactant solutions of various stoichiometric ratios were used to impregnate Hercules HTS graphite fiber. The processing characteristics and elevated temperature (600 F) mechanical properties of the composites are described Author

N76-13296*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
RADIATION EFFECTS ON BETA 10.6 OF PURE AND EUROPIUM DOPED KCl
H H Grimes, J. E Maisel (Cleveland State Univ, Ohio), and R H Hartford (Shippensburg State Coll, Pa) 1975 12 p refs Presented at 5th Infrared Laser Window Materials Conf, Las Vegas, Nev, 1-5 Dec 1975
(NASA-TM-X-71847; E-8580) Avail NTIS HC $3.50 CSCL 11G

Changes in the optical absorption coefficient as a result of X-ray and electron bombardment of pure KCl (monocrystalline and polycrystalline), and divalent europium doped polycrystalline KCl were determined The optical absorption coefficients were measured by a constant heat flow calorimetric method Both 300 KV X-irradiation and 2 MeV electron irradiation produced significant increases in beta 10.6, measured at room temperature The X-irradiation of pure monocrystalline KCl increased beta 10.6 by 0 005/cm for a 113 MR dose. For an equivalent dose, 2 MeV electrons were found less efficient in changing beta 10.6. However, electron irradiation of pure and Eu-doped polycrystalline KCl produced marked increases in adsorption Beta increased to over 0 25/cm in Eu-doped material for a 30 x 10 to the 14th power electrons/sq cm dose, a factor of 20 increase over unirradiated material Moreover, bleaching the electron irradiated doped KCl with 649 m light produced and additional factor of 1 5 increase These findings will be discussed in light of known defect-center properties in KCl Author

N76-16229* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FUSED SILICIDE COATINGS CONTAINING DISCRETE PARTICLES FOR PROTECTING NIOBIUM ALLOYS Patent
Salvatore J Grisaffe and Stanley R Levine, inventors (to NASA) Issued 6 Jan 1976 4 p Filed 4 May 1973 Supersedes N73-22474 (11 - 13, p 1540)
(NASA-Case-LEW-11179-1, US-Patent-3,931,447, US-Patent-Appl-SN-357312, US-Patent-Class-428-450, US-Patent-Class-29-195A, US-Patent-Class-427-203, US-Patent-Class-427-204, US-Patent-Class-427-205, US-Patent-Class-427-270, US-Patent-Class-427-275, US-Patent-Class-427-287, US-Patent-Class-428-457; US-Patent-Class-428-469, US-Patent-Class-428-539) Avail: US Patent Office CSCL 11G

Fused silicide coatings for protecting niobium alloy substrates are modified by providing dispersed nucleation sites in the form of discrete particles in the coating The discrete particles have a thermal expansion coefficient lower than that of the fused silicide material. This alters the microstructure and reduces the thermal expansion coefficient of the coating so as to minimize the number of tensile cracks Official Gazette of the U S Patent Office

N76-17249*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FILM THICKNESS MEASUREMENTS ON FIVE FLUID FORMULATIONS BY THE MERCURY SQUEEZE FILM CAPACITANCE TECHNIQUE
William R Jones, Jr, Robert L Johnson, I Hyslop, and R Day Washington Feb 1976 22 p refs
(NASA-TN-D-8171, E-8554) Avail NTIS HC $3 50 CSCL 11H

The thinning characteristics of five fluids were studied by measuring film thickness as a function of time The mercury squeeze film capacitance technique was used All tests were performed at room temperature The synthetic hydrocarbon plus a nematic liquid crystal, N-(p-methoxybenzylidene)-p-butylaniline, thinned according to a Newtonian model and retained its bulk viscosity. The synthetic hydrocarbon plus a phosphonate antiwear additive and the synthetic hydrocarbon plus n-hexadecanol produced residual thick films The synthetic hydrocarbon base fluids and the synthetic hydrocarbon plus a paraffinic resin displayed viscosity increases during thinning, but no residual films were formed Author

N76-21337*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
SECOND GENERATION PMR POLYIMIDES
Tito T Serafini, Raymond D Vannucci, and William B Alston 1976 13 p refs Presented at Twenty-first Natl Symp and Exhibition of the Soc for the Advan of Mater and Process Eng, Los Angeles, 6-8 Apr 1976 Prepared in cooperation with Army Air Mobility Res. and Develop Lab, Cleveland
(NASA-TM-X-71894; E-8680) Avail NTIS CSCL 11D

Studies were conducted to develop PMR (polymerization of monomer reactants) polyimides with improved thermo-oxidative stability at 600 F. Composites were fabricated using Hercules HTS graphite fiber and the newly developed PMR polyimides The mechanical property retention characteristics of the composites at 600 F are described Author.

N76-22383*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
POLYIMIDE FILM WEAR: EFFECT OF TEMPERATURE AND ATMOSPHERE
Robert L Fusaro Washington Apr. 1976 22 p refs
(NASA-TN-D-8231, E-8487) Avail NTIS HC $3 50 CSCL 11G

Friction and wear experiments conducted on polyimide films bonded to 440C stainless steel disks indicated that a wear transition (from high wear to low wear) accompanied a friction transition (from high friction to low friction) In dry argon or dry air (less than 20 ppm H2O), the transition was found to occur at 40 plus or minus 10 C, when H2O was present in air (10,000 ppm H2O), the transition was found to be elevated to a temperature between 100 and 200 C Wear rate calculations made at 25, 100, and 200 C indicated that film wear was relatively constant for particular experimental conditions; however, the rate was strongly dependent on temperature and atmosphere Author

N76-22384*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

FRICTION OF IRON LUBRICATED WITH ALIPHATIC AND AROMATIC HYDROCARBONS AND HALOGENATED ANALOGS

Donald H. Buckley Washington Apr 1976 18 p refs (NASA-TN-D-8208 E-8558) Avail NTIS HC $3 50 CSCL 11G

The influence of oxygen and various organic molecules on the reduction of the friction of an iron (011) single crystal surface was investigated A comparison was made between aliphatic and aromatic structures, all of which contained six carbon atoms, and among various halogen atoms. Results of the investigation indicate that hexane and benzene give similar friction coefficients over a range of loads except at very light loads At light loads, the friction decreased with an increase in the load where the halogens fluorine and chlorine are incorporated into the benzene molecular structure, however, over the same load range when bromine and iodine were present the friction was relatively unchanged. The aliphatic compound chlorohexane exhibited lower friction coefficients than the aromatic structure chlorobenzene at very light loads With the brominated benzene structures, however, friction was essentially the same Oxygen was more effective in reducing friction than were the simple hydrocarbons Author

N76-27423*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EFFECT OF ATMOSPHERE AND TEMPERATURE ON WEAR, FRICTION, AND TRANSFER OF POLYIMIDE FILMS

Robert L Fusaro 1976 28 p refs Proposed for presentation at the Lubrication Conf., Boston, 5-7 Oct 1976, sponsored by the Am Soc of Lubrication Engr and the Am Soc of Mech Engr

(NASA-TM-X-73423; E-8761) Avail: NTIS HC $4 00 CSCL 11D

Friction and wear experiments conducted on polyimide films bonded to 440C stainless steel disks indicated that a wear transition (from high wear to low wear) accompanied the friction transition (from high friction to low friction) The transition was found to be atmosphere dependent as well as temperature dependent Wear rate calculations indicated that at temperatures above the transition, wear could be up to 600 times less than at temperatures below the transition Transfer to metallic riders was also investigated and found to be considerably different at temperatures above and below the transition Author

N76-27426*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THERMAL ANALYSIS OF PMR-POLYIMIDES BY DIELECTROMETRY

Richard E Gluyas 1976 27 p refs Presented at A Critical Rev. of Techniques for the Characterization of Polymeric Mater. held by the Tech Cooperation Program, Subgroup P, Tech Panel 3 (Organic Mater.) (TTCP-P-3), Watertown, Mass., 6-8 Jul 1976

(NASA-TM-X-73448, E-8807) Avail NTIS HC $4 00 CSCL 11G

A preliminary study was conducted to determine the dielectric properties of glass fabric reinforced composites as influenced by the reactions occurring during the preparation of crosslinked polyimides by the PMR process The variables studied included formulated molecular weight, staging temperature and time, rate of temperature increase to cure temperature; and cure temperature and time. The changes of capacitance and, particularly, of dissipation factor were found to be strongly dependent on each of the variables studied Author

N76-30371*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

EFFECTS OF TETRAAMINE CROSSLINKING AGENTS ON THE THERMOMECHANICAL PROPERTIES OF PMR POLYIMIDE COMPOSITES

Peter Delvigs 1976 13 p refs Presented at Chemistry and Properties of Crosslinked Polymers Symp at the 172d Natl Meeting of the Am. Chem Soc., San Francisco, 29 Aug - 3 Sep 1976

(NASA-TM-X-73477; E-8738) Avail NTIS HC $3 50 CSCL 07C

The effects were investigated of partial substitution of tetraamine crosslinking agents for diamine reactants on the thermomechanical properties of PMR polyimide resins and graphite fiber-reinforced composites The effect of tetraamine content on isothermal weight loss glass transition, and softening temperatures of neat resin samples is discussed Composites were fabricated using PMR methodology. Monomeric solution of various stoichiometric ratios was used to impregnate Hercules HTS graphite fiber. The mechanical property retention characteristics of the composites at 316 C (600 F) are described Author

A76-14762 * **Dendritic web - A viable material for silicon solar cells.** R. G. Seidensticker (Westinghouse Research Laboratories, Pittsburgh, Pa.), L. Scudder, and H W. Brandhorst, Jr. (NASA, Lewis Research Center, Cleveland, Ohio). In Photovoltaic Specialists Conference, 11th, Scottsdale, Ariz., May 6-8, 1975, Conference Record (A76-14727 04-44) New York, Institute of Electrical and Electronics Engineers, Inc., 1975, p. 299-302 11 refs.

The dendritic web process is a technique for growing thin silicon ribbon from liquid silicon. The material is suitable for solar cell fabrication and, in fact, cells fabricated on web material are equivalent in performance to cells fabricated on Czochralski-grown material. A recently concluded study has delineated the thermal requirements for silicon web crucibles, and a detailed conceptual design has been developed for a laboratory growth apparatus (Author)

A76-14851 * **Molecular relaxations, molecular orientation and the friction characteristics of polyimide films.** R. L. Fusaro (NASA, Lewis Research Center, Cleveland, Ohio). In: Joint Lubrication Conference, Miami Beach, Fla., October 21-23, 1975, Technical Preprints. (A76-14843 04-27) Park Ridge, Ill., American Society of Lubrication Engineers, 1975. 12 p 52 refs.

The friction characteristics of polyimide films bonded to metallic substrates were studied from 25 to 500 C. These results were interpreted in terms of molecular orientation and thermomechanical data obtained by torsional braid analysis (TBA). A large friction transition was found to occur at 40 plus or minus 10 C in a dry argon atmosphere (10 ppm H2O) It was postulated that the mechanical stresses of sliding transform or reorder the molecules on the surface into a configuration conducive to easy shear, such as an extended chain. The molecular relaxation which occurs in this temperature region appears to give the molecules the necessary freedom for this reordering process to occur. The effects of velocity, reversibility, and thermal prehistory on the friction properties of polyimide were also studied. (Author)

A76-14854 * **Graphite fluoride lubrication - The effect of fluorine content, atmosphere, and burnishing technique.** R L Fusaro (NASA, Lewis Research Center, Cleveland, Ohio). In: Joint Lubrication Conference, Miami Beach, Fla., October 21-23, 1975, Technical Preprints. (A76-14843 04-27) Park Ridge, Ill., American Society of Lubrication Engineers, 1975. 8 p. 15 refs.

Eight different graphite fluoride compounds with fluorine to carbon ratios varying from 0 25 to 1.1 were evaluated as burnished films in order to determine the effect of fluorine content on the solid lubricant properties of graphite fluoride. For comparison, similar experiments were conducted on graphite burnished films. It was found that even a small amount of fluorine in graphite fluoride with fluorine to carbon ratio of 0.25 improved the lubricating properties of graphite However, such factors as burnishing atmosphere, burnishing technique, test atmosphere, and specimen temperature affected the results as much as varying the fluorine to carbon ratio of the compound Best life was found for films that were machine-burnished in moist air and tested in moist air. (Author)

A76-14856 * Morphological growth of sputtered MoS2 films. T. Spalvins (NASA, Lewis Research Center, Cleveland, Ohio) In Joint Lubrication Conference, Miami Beach, Fla , October 21-23, 1975, Technical Preprints (A76-14843 04-27) Park Ridge, Ill , American Society of Lubrication Engineers, 1975. 6 p. 6 refs

Sputtered MoS2 films from 300 A to 20,000 A thick were deposited on metal and glass surfaces The substrate effects such as surface temperature; finish, pretreatment, and chemistry as they affect the film formation characteristics were investigated by optical, electron transmission, electron diffraction, and scanning electron microscopy. Substrate temperature and surface chemistry were found to be the prime variables as to the formation of a crystalline or amorphous film. The friction characteristics are strictly influenced by the type of film formed. Surface chemistry and surface pretreatment account for compound formation and corresponding grain growth, which directly affect the adhesion characteristics, resulting in poor adherence Scratches, impurities, inhomogeneities, etc., are favorable nucleation sites for the growth of isolated and complex nodules within the film (Author)

A76-28651 * Review of electrical and thermal properties of carbon and graphite. J. A. Woollam (NASA, Lewis Research Center, Cleveland, Ohio). In: Petroleum derived carbons. Washington, D.C., American Chemical Society (ACS Symposium Series, No. 21), 1975, p. 378-410 71 refs

Some of the electrical and thermal properties of ordered and partially ordered carbons are reviewed Earlier and current research areas are discussed relative to electrical properties of pyrolytic and polycrystalline graphite; thermal, electrical, and magnetic properties of graphitizable and glassy carbon with heat treatment temperatures in the range 600-2500 C, Josephson junction-like and switching behavior in carbon films; and some high-conductivity and superconducting compounds made from carbon. Due to the newness and complexity of many of the areas examined, the results are not always completely understood, nor have these areas been completely investigated experimentally. Suggestions for future research are made. S D.

N76-11286*# United Technologies Research Center, East Hartford, Conn.
GRAPHITE FIBER REINFORCED THERMOPLASTIC RESINS
R C Novak 17 Jul 1975 150 p refs
(Contract NAS3-17833)
(NASA-CR-134881, R75-911992-12) Avail NTIS HC $6 00 CSCL 11I

Mechanical properties of neat resin samples and graphite fiber reinforced samples of thermoplastic resins were characterized with particular emphasis directed to the effects of environmental exposure (humidity, temperature and ultraviolet radiation) Tensile, flexural, interlaminar shear, creep and impact strengths were measured for polysulfone, polyarylsulfone and a state-of-the-art epoxy resin samples In general, the thermoplastic resins exhibited environmental degradation resistance equal to or superior to the reference epoxy resin. Demonstration of the utility and quality of a graphite/thermoplastic resin system was accomplished by successfully thermoforming a simulated compressor blade and a fan exit guide vane. Author

N76-13295*# Douglas Aircraft Co , Inc , Long Beach, Calif
SEMICONDUCTING POLYMERS FOR GAS DETECTION Final Report, 1 Jul 1974 - 29 Jun 1975
N R Byrd and M B. Sheratte Dec. 1975 159 p refs
(Contract NAS3-18919)
(NASA-CR-134885) Avail. NTIS HC $6.75 CSCL 07C

Conjugated polyenes, and polyesters containing phthalocyanine in their backbone, were synthesized These polymers were characterized by chemical analysis, thermogravimetric analysis, spectral analysis, and X-ray diffraction studies for crystallinity, as well as for their film-forming capability and gas/polymer interactions Most of the polymers were relatively insensitive to water vapor up to 50 percent relative humidity, but the polyester/phthalocyanine (iron) polymer was relatively insensitive up to 100 percent RH. On the other hand, poly(p-dimethylaminophenylacetylene) was too conductive at 100 percent RH Of the gases tested, the only ones that gave any evidence of interacting with the polymers were SO2, NOx, HCN and NH3 Poly(imidazole)/thiophene responded to each of these gases at all relative humidities, while the other polymers gave varying response, depending upon the RH Thus, since most of these gases were electron-accepting, the electron-donating character of poly(imidazole)/thiophene substantiates the concept of electronegativity being the operating principle for interaction effects Of the six polymers prepared, poly(imidazole)/thiophene first showed a very good response to smoldering cotton, but it later became nonresponsive, presumably due to oxidation effects Author

N76-14268*# McDonnell-Douglas Corp , Long Beach, Calif.
SEMICONDUCTING POLYMERS FOR GAS DETECTION Final Report, 1 Jul. 1974 - 29 Jun. 1975
N R. Byrd and M B. Sheratte Dec 1975 175 p refs
(Contract NAS3-18919)
(NASA-CR-134885) Avail NTIS HC $6 75 CSCL 11G

Four conjugated polyenes, and two polyesters containing phthalocyanine in their backbone, were synthesized These polymers were characterized by chemical analysis, thermogravimetric analysis, spectral analysis, and X-ray diffraction studies for crystallinity, as well as for their film-forming capability and gas/polymer interactions Most of the polymers were relatively insensitive to water vapor up to 50 percent relative humidity, but the polyester/phthalocyanine (iron) polymer was relatively insensitive up to 100 percent RH On the other hand, poly(p-dimethylaminophenylacetylene) was too conductive at 100 percent RH Of the gases tested, the only ones that gave any evidence of interacting with the polymers were SO2, NOx, HCN and NH3 Poly(imidazole)/thiophene responded to each of these gases at all relative humidities, while the other polymers gave varying response, depending upon the RH Thus, since most of these gases were electron-accepting, the electron-donating character of poly(imidazole)/thiophene substantiates the concept of electronegativity being the operating principle for interaction effects Of the six polymers prepared, poly(imidazole)/thiophene first showed a very good response to smoldering cotton, but it later became non-responsive, presumably due to oxidation effects However, poly(imidazole)/ferocene generally gave consistent responses. The other four did not. The reason for this is not known. Author

N76-14270*# General Electric Co , Schenectady, N Y
IMPROVED TOUGHNESS OF SILICON CARBIDE Final Report
John A Palm Nov 1975 36 p refs
(Contract NAS3-17767)
(NASA-CR-134921; SRD-75-123) Avail NTIS HC $4 00 CSCL 11B

Several techniques were employed to apply or otherwise form porous layers of various materials on the surface of hot-pressed silicon carbide ceramic From mechanical properties measurements and studies, it was concluded that although porous layers could be applied to the silicon carbide ceramic, sufficient damage was done to the silicon carbide surface by the processing required so as to drastically reduce its mechanical strength It was further concluded that there was little promise of success in forming an effective energy absorbing layer on the surface of already densified silicon carbide ceramic that would have the

mechanical strength of the untreated or unsurfaced material Using a process for the pressureless sintering of silicon carbide powders it was discovered that porous layers of silicon carbide could be formed on a dense, strong silicon carbide substrate in a single consolidation process Author

N76-16237*# TRW Systems Group, Redondo Beach, Calif
DEVELOPMENT OF AUTOCLAVE MOLDABLE ADDITION-TYPE POLYIMIDES Final Report, 12 Jun 1974 - 30 Sep 1975
R. W Vaughan, R J Jones, M K ORell, and G A Zakrzewski Jan 1976 46 p refs
(Contract NAS3-17824)
(NASA-CR-134900, TRW-26446-6015-RU-00) Avail NTIS HC $4 00 CSCL 11G

Chemistry and processing modifications of the poly(Diels Alder) polyimide (PDA) resin were performed to obtain structural composites suitable for 589 K (600 F) service This work demonstrated that the PDA resin formulation is suitable for service at 589 K (600 F) for up to 125 hours when used in combination with Hercules HTS graphite fiber Sandwich panels were autoclave molded using PDA/HTS skins and polyimide/glass honeycomb core Excellent adhesion between honeycomb core and the facing skins was demonstrated Fabrication ease was demonstrated by autoclave molding three-quarter scale YF-12 wing panels Author

N76-20272*# General Electric Co, Schenectady N Y
IMPROVED TOUGHNESS OF SILICON CARBIDE Final Report
John A Palm Jan 1976 63 p refs
(Contract NAS3-17832)
(NASA-CR-134990, SRD-76-021) Avail NTIS HC $4.50 CSCL 11B

Impact energy absorbing layers (EALs) comprised of partially densified silicon carbide were formed in situ on fully sinterable silicon carbide substrates After final sintering, duplex silicon carbide structures resulted which were comprised of a fully sintered, high density silicon carbide substrate or core, overlayed with an EAL of partially sintered silicon carbide integrally bonded to its core member. Thermal cycling tests proved such structures to be moderately resistant to oxidation and highly resistant to thermal shock stresses The strength of the developed structures in some cases exceeded but essentially it remained the same as the fully sintered silicon carbide without the EAL Ballistic impact tests indicated that substantial improvements in the toughness of sintered silicon carbide were achieved by the use of the partially densified silicon carbide EALs. Author

N76-20273*# Mechanical Technology, Inc, Latham, N Y
DEVELOPMENT OF PROCEDURES FOR CALCULATING STIFFNESS AND DAMPING PROPERTIES OF ELASTOMERS. PART 3: THE EFFECTS OF TEMPERATURE, DISSIPATION LEVEL AND GEOMETRY Final Report
Anthony J Smalley and J. M Tessarzik Nov 1975 218 p refs
(Contracts NAS3-15334, NAS3-18546)
(NASA-CR-134939, MTI-76TR5-Pt-3) Avail NTIS HC $7 75 CSCL 11D

Effects of temperature, dissipation level and geometry on the dynamic behavior of elastomer elements were investigated Force displacement relationships in elastomer elements and the effects of frequency, geometry and temperature upon these relationships are reviewed Based on this review, methods of reducing stiffness and damping data for shear and compression test elements to material properties (storage and loss moduli) and empirical geometric factors are developed and tested using previously generated experimental data A prediction method which accounts for large amplitudes of deformation is developed on the assumption that their effect is to increase temperature through the elastomers, thereby modifying the local material properties Various simple methods of predicting the radial stiffness of ring cartridge elements are developed and compared Material properties were determined from the shear specimen tests as a function of frequency and temperature Using these material properties, numerical predictions of stiffness and damping for cartridge and compression specimens were made and compared with corresponding measurements at different temperatures, with encouraging results Author

N76-28417*# Avco Corp, Lowell, Mass Systems Div
QUINOXALINE POLYMERS AND COPOLYMERS DERIVED FROM 1,4-BIS(1'-NAPHTHALENYLOXALYL)BENZENE AND THEIR GRAPHITE COMPOSITES Final Report, 7 Feb. 1975 - 30 Apr. 1976
William S Port Jul 1976 92 p refs
(Contract NAS3-18936)
(NASA-CR-135042, AVSD-0199-76-RR) Avail NTIS HC $5 00 CSCL 11D

Experimental studies were performed with new polyquinoxalines and their graphite composites Four polymers were synthesized, and then were characterized with respect to their inherent viscosity, elemental chemical analysis, mechanical, and thermodynamic properties Structural formulas of the polymers and their precursors are given methods of synthesis are described, and specifically examined was the preparation of polymers from 3 3' diamino-benzidine from 1,4- and 1,3- bis ((1 -napthalenyl) oxalyl) benzene respectively Also considered was the preparation of polyquinoxalines from poly (p-benzil), and 1,2- aryldiamines Author

A76-15172 * Effect of high temperature aging on bonded and weld bonded joints. R. W. Vaughan (TRW Systems, Redondo Beach, Calif) In Materials review '75, Proceedings of the Seventh National Technical Conference, Albuquerque, N Mex , October 14-16, 1975 (A76-15151 04-27) Azusa, Calif , Society for the Advancement of Material and Process Engineering, 1975, p. 272-294. 10 refs. Contracts No NAS1-9532; No. NAS1-11689; No. NAS3-16780; No. NAS3-17824, No. F33615-74-C-5017.

Development of adhesives for applications requiring long-term service at temperatures up to 600 F is discussed. This development work utilizes polyimide (PI) and polyphenylquinoxaline (PPQ) resin technology worked out previously. The resultant adhesives are evaluated in structural joints of titanium, steel and composite adherends and in honeycomb sandwich panels. Suitable adhesives also are evaluated in weld bonded titanium alloy joints. Testing includes determination of long-term aging of stressed and unstressed specimens at temperatures from about 450 F to 600 F as well as under dynamic fatigue conditions (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*

N76-21341*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

SYNTHESIS AND ANALYSIS OF JET FUELS FROM SHALE OIL AND COAL SYNCRUDES

Albert C Antoine and James P. Gallagher (Atlantic Richfield Co) 1976 32 p refs To be presented at the 82d Natl. Meeting of the Am. Inst of Chem. Engr., Atlantic City, 29 Aug. - 1 Sep. 1976

(NASA-TM-X-73399, E-8722) Avail: NTIS HC $4 00 CSCL 21D

The technical problems involved in converting a significant portion of a barrel of either a shale oil or coal syncrude into a suitable aviation turbine fuel were studied TOSCO shale oil, H-Coal and COED coal syncrudes were the starting materials They were processed by distillation and hydrocracking to produce two levels of yield (20 and 40 weight percent) of material having a distillation range of approximately 422 to 561 K (300 F to 550 F) The full distillation range 311 to 616 K (100 F to 650 F) materials were hydrotreated to meet two sets of specifications (20 and 40 volume percent aromatics, 13 5 and 12 75 weight percent H, 0.2 and 0 5 weight percent S, and 0.1 and 0 2 weight percent N) The hydrotreated materials were distilled to meet given end point and volatility requirements The syntheses were carried out in laboratory and pilot plant equipment scaled to produce thirty-two 0 0757 cu m (2-gal) samples of jet fuel of varying defined specifications Detailed analyses for physical and chemical properties were made on the crude starting materials and on the products Author

N76-22399*# 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 13 Apr. 1976 10 p

(NASA-Case-LEW-12081-1, US-Patent-Appl-SN-676432) Avail: NTIS HC $3 50 CSCL 21I

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

A76-20149 * # Combustor exhaust-emissions and blowout-limits with diesel number 2 and Jet A fuels utilizing air-atomizing and pressure-atomizing nozzles. R. D Ingebo and C. T. Norgren (NASA, Lewis Research Center, Cleveland, Ohio) *Combustion Institute, Fall Meeting, Palo Alto, Calif., Oct. 20, 21, 1975, Paper.* 15 p. 7 refs

The effect of fuel properties on exhaust emissions and blowout limits of a high-pressure combustor segment is evaluated using a splash groove air-atomizing fuel injector and a pressure-atomizing simplex fuel nozzle to burn both diesel number 2 and Jet A fuels Exhaust emissions and blowout data are obtained and compared on the basis of the aromatic content and volatility of the two fuels. Exhaust smoke number and emission indices for oxides of nitrogen, carbon monoxide, and unburned hydrocarbons are determined for comparison As compared to the pressure-atomizing nozzle, the air-atomizing nozzle is found to reduce nitrogen oxides by 20%, smoke number by 30%, carbon monoxide by 70%, and unburned hydrocarbons by 50% when used with diesel number 2 fuel. The higher concentration of aromatics and lower volatility of diesel number 2 fuel as compared to Jet A fuel appears to have the most detrimental effect on exhaust emissions. Smoke number and unburned hydrocarbons are twice as high with diesel number 2 as with Jet A fuel. S D.

N76-19296*# Southwest Research Inst., San Antonio, Tex

WORKBOOK FOR PREDICTING PRESSURE WAVE AND FRAGMENT EFFECTS OF EXPLODING PROPELLANT TANKS AND GAS STORAGE VESSELS

W. E. Baker, J. J Kulesz, R E. Ricker, R. L Bessey, P S Westine, V B Parr, and G A. Oldham Nov. 1975 558 p refs

(Contract NAS3-19231)

(NASA-CR-134906; Rept-02-4130) Avail: NTIS HC $13 50 CSCL 21I

Technology needed to predict damage and hazards from explosions of propellant tanks and bursts of pressure vessels, both near and far from these explosions is introduced Data are summarized in graphs, tables, and nomographs For individual titles, see N76-19297 through N76-19302

N76-22398*# General Electric Co.; Evendale, Ohio

EXPERIMENTAL CLEAN COMBUSTOR PROGRAM, ALTERNATE FUELS ADDENDUM, PHASE 2 Final Report

C C Gleason and D. W. Bahr Jan. 1976 67 p refs

(Contract NAS3-18551)

(NASA-CR-134972; R76AEG268) Avail: NTIS HC $4 50 CSCL 21D

The characteristics of current and advanced low-emissions combustors when operated with special test fuels simulating broader range combustion properties of petroleum or coal derived fuels were studied Five fuels were evaluated, conventional JP-5, conventional No 2 Diesel, two different blends of Jet A and commercial aromatic mixtures - zylene bottoms and haphthalene charge stock, and a fuel derived from shale oil crude which was refined to Jet A specifications Three CF6-50 engine size combustor types were evaluated, the standard production combustor, a radial/axial staged combustor, and a double annular combustor Performance and pollutant emissons characteristics at idle and simulated takeoff conditions were evaluated in a full annular combustor rig Altitude relight characteristics were evaluated in a 60 degree sector combustor rig Carboning and flashback characteristics at simulated takeoff conditions were evaluated in a 12 degree sector combustor rig For the five fuels tested, effects were moderate, but well defined Author

N76-28429*# Pratt and Whitney Aircraft, East Hartford, Conn

EXPERIMENTAL CLEAN COMBUSTOR PROGRAM, PHASE 2

R Roberts, A Peduzzi, and G E Vitti Jul 1976 86 p refs

(Contract NAS3-18544)

(NASA-CR-134970; PWA-5370) Avail: NTIS HC $5 00 CSCL 21D

The alternate fuels investigation objective was to experimentally determine the impacts, if any, on exhaust emissions, performance, and durability characteristics of the hybrid and vorbix low pollution combustor concepts when operated on test fuels which simulate composition and property changes which might result from future broadened aviation turbine fuel specifications or use of synthetically derived crude feedstocks. Results of the program indicate a significant increase in CO and small NOX increase in emissions at idle for both combustor concepts, and an increase in THC for the vorbix concept Minimal impact was observed on gaseous emissions at high power The vorbix concept exhibited significant increase in exhaust smoke with increasing fuel aromatic content Altitude stability was not affected for the vorbix combustor, but was substantially reduced for the hybrid concept Severe carbon deposition was observed in both combustors following limited endurance testing with No 2 home heat fuel. Liner temperature levels were insensitive to variations in aromatic content over the range of conditions investigated.

Author

31 ENGINEERING (GENERAL)

Includes vacuum technology, control engineering, display engineering, and cryogenics

A76-20724 * # **Drive-train dynamics technology - State-of-the-art and design of a test facility for advanced development.** R. H. Badgley, D. P. Fleming (Mechanical Technology, Inc., Latham, N.Y.), and A. J Smalley (NASA, Lewis Research Center, Bearings and Mechanical Power Transfer Branch, Cleveland, Ohio). *American Society of Mechanical Engineers, Design Engineering Technical Conference, Washington, D C., Sept 17-19, 1975, Paper 75-DET-74* 11 p. 24 refs. Members, $1.00, nonmembers, $3.00 Contract No. NAS3-16824.

A program for the development and verification of drive-train dynamic technology is described along with its basis and the results expected from it. A central feature of this program is a drive-train test facility designed for the testing and development of advanced drive-train components, including shaft systems, dampers, and couplings Previous efforts in designing flexible dynamic drive-train systems are reviewed, and the present state of the art is briefly summarized The design of the test facility is discussed with major attention given to the formulation of the test-rig concept, dynamic scaling of model shafts, and the specification of design parameters Specific efforts envisioned for the test facility are briefly noted, including evaluations of supercritical test shafts, stability thresholds for various sources and types of instabilities that can exist in shaft systems, effects of structural flexibility on the dynamic performance of dampers, and methods for vibration control in two-level and three-level flexible shaft systems. F.G.M

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.*

N76-26368*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

COMPUTATION OF SCALAR FAR-FIELD PATTERNS OF LARGE-APERTURE ANTENNAS

Thomas A OMalley Washington Jun 1976 22 p refs (NASA-TM-X-3408, E-8746) Avail NTIS HC $3 50 CSCL 20N

In computer programs used for evaluating the performance of high-gain antennas, efficient numerical methods for calculating the far-field patterns must be used since the majority of computer time and storage requirements may be attributed to this phase of the program The numerical method most frequently used is the Fast Fourier Transform (FFT), which computes the far field as the Fourier transform of the field distribution in the antenna aperture A new numerical method that in many applications is superior to the FFT in terms of reducing computer time and storage requirements is described Author

A76-40694 * Performance characteristics of the 12 GHz, 200 watt Transmitter Experiment Package for CTS. E F. Miller, J. L Fiala, and I G. Hansen (NASA, Lewis Research Center, Cleveland, Ohio). In: EASCON '75, Electronics and Aerospace Systems Convention, Washington, D.C., September 29-October 1, 1975, Record. (A76-40642 20-32) New York, Institute of Electrical and Electronics Engineers, Inc , 1975, p. 202-A to 202-G.

Measured performance characteristics from ground test of the Transmitter Experiment Package (TEP) for the Communications Technology Satellite are presented. The experiment package consists of a 200 W Output Stage Tube (OST) powered by a Power Processing System (PPS). Descriptions of both the PPS and OST are given. The PPS provides the necessary voltages with a measured dc/dc conversion efficiency of 89 per cent The OST, a traveling wave tube with multiple collectors, has a saturated rf output power of 224 W and operates at an overall efficiency exceeding 40 per cent over an 85 MHz bandwidth at 12 GHz. OST performance given includes frequency response, saturation characteristics, group delay, AM to PM conversion, intermodulation distortion, and two channel gain suppression. Single and dual channel FM video performance is presented It was determined that for 12 MHz peak to peak frequency deviation on each channel, dual channel FM television signals can be transmitted through the TEP at 60 W, each channel, with 40 MHz channel spacing (center to center). (Author)

A76-46089 * # CTS United States experiments - A progress report. W H Robbins and P L Donoughe (NASA, Lewis Research Center, Cleveland, Ohio). *International Astronautical Federation, International Astronautical Congress, 27th, Anaheim, Calif., Oct. 10-16, 1976, Paper 76-228.* 13 p 17 refs.

The Communications Technology Satellite (CTS) is a high-power broadcast satellite-launched by NASA on January 17, 1976. CTS is the first satellite to operate at a frequency of 12 gigahertz and incorporates technology making possible new satellite telecommunications services CTS is a cooperative program of the United States and Canada This paper presents the results of the United States experimental activity to date Wide segments of the population are involved in the Experiments Program, including the scientific community, other government agencies, industry, and the education and health entities The experiments are associated with both technological objectives and the demonstration of new community and social services via satellite. (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.*

N76-13373*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

DESIGN AND PERFORMANCE OF A NO-SINGLE-FAILURE CONTROL SYSTEM FOR THE MINI-BRAYTON POWER CONVERSION SYSTEM

Arthur G Brichenough Washington Dec 1975 32 p refs (NASA-TN-D-8112 E-8444) Avail NTIS HC $4 00 CSCL 09C

The control system consists of the ac-dc conversion, voltage regulation speed regulation through parasitic load control and overload control A no-single-failure configuration was developed to attain the required reliability for a 10-year design life of unattended operation The design principles, complete schematics, and performance are reported Testing was performed on an alternator simulator pending construction of the actual Mini-Brayton alternator. Author

N76-15373* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

HIGH TEMPERATURE BERYLLIUM OXIDE CAPACITOR Patent

Russell A Lindberg, inventor (to NASA) Issued 2 Dec 1975 4 p Filed 28 Jan 1975 Supersedes N75-16746 (13 - 08, p 0878)
(NASA-Case-LEW-11938-1; US-Patent-3,924,164, US-Patent-Appl-SN-544611; US-Patent-Class-317-258, US-Patent-Class-317-261) Avail: US Patent Office CSCL 09A

A capacitor suitable for use in environments where the temperature is as high as 1500 C is described The capacitor is comprised of a BeO wafer which is off-sputtered on each side and an electrode of Iridium on each side which is deposited by sputtering, or ion plating A barrier layer of BeO is deposited on one or both of the electrodes to prevent diffusion bonding of the electrodes of adjacent capacitors due to temperature, pressure, and vacuum when several capacitors are stocked
Official Gazette of the U S Patent Office

N76-17298*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

REFOCUSING PROPERTIES OF PERIODIC MAGNETIC FIELDS

N. Stankiewicz Washington Feb 1976 20 p refs (NASA-TN-D-8170, E-8532) Avail NTIS HC $3 50 CSCL 09A

The use of depressed collectors for the efficient collection of spent beams from linear-beam microwave tubes depends on a refocusing procedure in which the space charge forces and transverse velocity components are reduced The refocusing properties are evaluated of permanent magnet configurations whose axial fields are approximated by constant plateaus or linearly varying fields. The results provide design criteria and show that the refocusing properties can be determined from the plateau fields alone. Author

N76-17299*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

HIGH EFFICIENCY SILICON SOLAR CELL REVIEW

Michael P Godlewski, ed Washington Dec 1975 235 p refs Meeting held at Cleveland, 14-15 Nov. 1974
(NASA-TM-X-3326, E-8425) Avail NTIS CSCL 10A

An overview is presented of the current research and development efforts to improve the performance of the silicon solar cell The 24 papers presented reviewed experimental and analytic modeling work which emphasizes the improvment of conversion efficiency and the reduction of manufacturing costs A summary is given of the round-table discussion, in which the near- and far-term directions of future efficiency improvements were discussed Author

N76-18346*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

DESIGN AND PERFORMANCE VERIFICATION OF ADVANCED MULTISTAGE DEPRESSED COLLECTORS

H Kosmahl and P Ramins [1975] 12 p refs Presented at the Intern Electron Devices Meeting, Washington, D C, 1-3 Dec 1975, sponsored by IEEE Sponsored in part by AF
(NASA-TM-X-71858) Avail. NTIS HC $3.50 CSCL 09A

Design and performance of a small size, 4 stage depressed collector are discussed The collector and a spent beam refocusing section preceding it are intended for efficiency enhancement of octave bandwidth, high CW power traveling wave tubes for use in ECM Author

N76-18348*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

SOLID STATE REMOTE POWER CONTROLLERS FOR 120 Vdc POWER SYSTEMS

G. R Sundberg and D E Baker (Westinghouse Electric Corp., Lima, Ohio) 1976 19 p refs To be presented at the 24th Ann. Natl. Relay Conf., Stillwater, Okla., 27-28 Apr 1976 Sponsored by Okla State Univ
(NASA-TM-X-71874) Avail NTIS HC $3 50 CSCL 09C

Solid state Remote Power Controllers (RPCs) developed for use in any dc power system with voltage up to 120 Vdc and distributed power up to 3 6 kW per bus are described The RPCs were demonstrated to be reliable, 99 percent efficient comparatively simple, and potentially low in cost Advantages of the RPCs include contactless switching; controlled rates of current rise and fall, current limiting, and fast, well-defined, repeatable response to overloads and faults Author

N76-20370*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

FORTRAN PROGRAM FOR INDUCTION MOTOR ANALYSIS

Gary Bollenbacher Washington Mar 1976 86 p refs (NASA-TN-D-8184, E-8486) Avail NTIS HC $5 00 CSCL 09C

A FORTRAN program for induction motor analysis is described The analysis includes calculations of torque-speed characteristics efficiency, losses, magnetic flux densities, weights, and various electrical parameters The program is limited to three-phase Y-connected squirrel-cage motors. Detailed instructions for using the program are given The analysis equations are documented, and the sources of the equations are referenced. The appendixes include a FORTRAN symbol list, a complete explanation of input requirements, and a list of error messages Author

N76-27474*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

REGULATION OF A LIGHTWEIGHT HIGH EFFICIENCY CAPACITATOR DIODE VOLTAGE MULTIPLIER dc-dc CONVERTER

William T Harrigill, Jr. and Ira T Myers 1976 9 p refs Presented at the Power Electron- Specialists Conf., Cleveland, 8-10 Jun 1976; sponsored by IEEE
(NASA-TM-X-73427, E-8768) Avail NTIS HC $3 50 CSCL 09C

A method for the regulation of a capacitor diode voltage multiplier dc-dc converter has been developed which has only minor penalties in weight and efficiency An auxiliary inductor is used, which only handles a fraction of the total power, to control the output voltage through a pulse width modulation method in a buck boost circuit Author

N76-27475*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ULTRASONIC EVALUATION OF HIGH VOLTAGE CIRCUIT BOARDS
Stanley J. Klima and Thomas J Riley 1976 11 p refs Presented at Power Electronics Specialists Conf., Cleveland, 8-10 Jun. 1976; sponsored by IEEE
(NASA-TM-X-73432, E-8779) Avail: NTIS HC $3 50 CSCL 09C

Preliminary observations indicate that an ultrasonic scanning technique may be useful as a quick, low cost, nondestructive method for judging the quality of circuit board materials for high voltage applications Corona inception voltage tests were conducted on fiberglass-epoxy and fiberglass-polyimide high pressure laminates from 20 to 140 C The same materials were scanned ultrasonically by utilizing the single transducer, through-transmission technique with reflector plate, and recording variations in ultrasonic energy transmitted through the board thickness A direct relationship was observed between ultrasonic transmission level and corona inception voltage. The ultrasonic technique was subsequently used to aid selection of high quality circuit boards for the Communications Technology Satellite
Author

N76-28472*# 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 26 Jul. 1976 11 p
(NASA-Case-LEW-12277-1; US-Patent-Appl-SN-708659) Avail: NTIS HC $3 50 CSCL 09A

A liquid metal slip ring is described which comprises a rotor in the form of a ring about an axis and a stator The rotor is rotatable relative to the stator and has a channel in which the liquid metal is retained during operation by surface tension The stator comprises a brush or probe which is partially immersed in the metal in the channel and is bidirectionally symmetrical. 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

N76-29490*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PROCESS FOR PREPARING LIQUID METAL ELECTRICAL CONTACT DEVICE Patent Application
Robert R Lovell, Frank D. Berkopec, and David H Culp, inventor (to NASA) Filed 26 Jul 1976 12 p
(NASA-Case-LEW-11978-1, US-Patent-Appl-SN-708658) Avail NTIS HC $3 50 CSCL 09A

The parts of an electrical contact device, such as a slip ring comprised of the ring to receive the liquid metal and the probe or brush for contacting the liquid metal, are treated by sputter etching to remove the parent metal oxide Prior to exposure of the electrodes to any oxygen, a sacrificial metal is sputter deposited on the parts Preferably this sacrificial metal is one that oxidizes slowly and is readily dissolved by the liquid metal The sacrifical metal may then be removed from unwanted areas. The remainder of the ring and the probe are submerged in the liquid metal or the liquid metal is flushed over these areas, preferably while they are being slightly abraded, until all the sacrificial material on these portions is wet by the liquid metal In doing so the liquid metal dissolves the sacrificial metal and permanently wets the parent metal Preferred materials used in the process and for the electrodes of electrical contact devices are high purity (99 0 percent) nickel or AISI type 304 stainless steel for the electrical contact devices, gallium as the liquid metal, and gold as the sacrificial material. NASA

N76-30444*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
DESIGN AND PERFORMANCE EVALUATION OF SMALL, TWO- AND FOUR-STAGE DEPRESSED COLLECTORS FOR A 4.8 TO 9.6 GHz HIGH-PERFORMANCE TRAVELING WAVE TUBE Interim Report, Apr. 1975 - Jun 1976
Peter Ramins, Henry G. Kosmahl, and Thomas A. Fox Aug 1976 58 p refs Prepared in cooperation with Air Force Systems Command, Wright-Patterson AFB, Ohio
(NASA-TM-X-73486; E-8873) Avail: NTIS HC $4 50 CSCL 09A

A program to improve the efficiency of traveling wave tubes (TWT's) for use in electronic countermeasure (ECM) systems by applying multistage depressed collector (MDC) and spent beam refocusing techniques is studied. Three dimensional electron trajectories are computed through-out the slow wave structure of the TWT, the spent beam refocuser, and the depressed collector. Both TWT and MDC performances are analytically evaluated
Author

N76-30445*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ENVIRONMENTAL CHARGING OF SPACECRAFT SURFACES: TESTS OF THERMAL CONTROL MATERIALS FOR USE ON THE GLOBAL POSITIONING SYSTEM FLIGHT SPACE VEHICLE PART 1: SPECIMENS 1 TO 5
N John Stevens, Vernon W Klinect, and Frank D Berkopec Jul 1976 42 p
(NASA-TM-X-73467, E-8836) Avail NTIS HC $4 00 CSCL 09C

The NASA/USAF program on Environmental Charging of Spacecraft Surfaces consists of experimental efforts directed toward evaluating the response of materials to the environmental charged particle flux Samples of thermal blankets and second surface mirrors of the type to be used on the Global Positioning System Flight Space Vehicle were tested to determine their response to electron flux. The primary result observed was that the ground connection of the metal layers of the blanket, as made by the baseline grounding technique using serrated washers and grommets, deteriorated with time at test The discharges observed on the blankets were the glow type, not the 'lightning' strike observed on past specimens Testing was performed at ambient laboratory temperatures
Author

N76-31415*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
SURFACE STUDIES OF THERMIONIC CATHODES AND THE MECHANISM OF OPERATION OF AN IMPREGNATED TUNGSTEN CATHODE
Ralph Forman Washington Sep 1976 31 p refs
(NASA-TN-D-8295, E-8515) Avail NTIS HC $4 00 CSCL 07D

The surface properties of conventional impregnated cathodes were investigated by the use of Auger spectroscopy and work function measurements, and these were compared with a synthesized barium or barium oxide coated tungsten surface. The barium and barium oxide coated surfaces were prepared by evaporating barium onto a tungsten surface that can be heated to elevated temperatures. Multilayer or monolayer coverages can be investigated using this technique. The results of this study show that the surface of an impregnated tungsten cathode is identical to that observed for a synthesized monolayer or partial monolayer of barium on partially oxidized tungsten, using the criteria of identical Auger patterns and work functions Desorption measurements of barium from a tungsten surface were also made These results in conjunction with Auger and work function data were interpreted to show that throughout most of its life an impregnated cathode operating in the range of 1100 C has a partial monolayer rather than a monolayer of barium on its surface
Author

A76-21677 * # Design and performance verification of advanced multistage depressed collectors. H Kosmahl and P Ramins (NASA, Lewis Research Center, Cleveland, Ohio) *Institute of Electrical and Electronics Engineers, International Electron Devices Meeting, Washington, D.C., Dec 1-3, 1975, Paper.* 11 p

Design and performance of a small size, 4-stage depressed collector are discussed. The collector and a spent-beam refocusing section preceding it are intended for efficiency enhancement of octave bandwidth, high CW power traveling wave tubes for use in ECM.
(Author)

A76-29839 * Determination of the interaction impedance of coupled cavity slow wave structures. D. J. Connolly (NASA, Lewis Research Center, Cleveland, Ohio). *IEEE Transactions on Electron Devices*, vol ED-23, May 1976, p 491-493. 12 refs.

The interaction impedance of coupled cavity slow wave structures can be measured by perturbing the resonances of a shorted length of the structure using a dielectric rod. An analysis of this procedure is presented. The analysis retains radial as well as axial electric fields and all significant space harmonics. The results obtained are easily programmed formulas for calculating total interaction impedance or Pierce impedance using the experimental data. (Author)

A76-31510 * # Solid state remote power controllers for 120 VDC power systems G R. Sundberg (NASA, Lewis Research Center, Cleveland, Ohio) and D E. Baker (Westinghouse Electric Corp., Aerospace Electrical Div., Lima, Ohio) *Oklahoma State University, Annual National Relay Conference, 24th, Stillwater, Okla., Apr. 27, 28, 1976, Paper.* 18 p 7 refs.

Remote Power controllers (RPCs) are devices that combine in one unit the capability to perform all the needed functions of load switching and provide total system protection of equipment and wires The unique developments of solid-state RPCs for 120 Vdc power distribution systems are reviewed. The discussion covers design guidelines, power switch design concepts, and performance effectiveness An NPN transistor is used as the the basic switch element Since the ultimate goal of the 120 Vdc RPC program is to demonstrate technology readiness, the final phase is directed to the design, fabrication, and testing of multi-chip hybrid prototypes in hermetically sealed packages RPCs have potential application in spacecraft and aircraft electrical systems, in transportation systems, and various industrial applications The upper voltage limitation on the RPC design is related to the capability and availability of suitable high-voltage power transistors The merits of solid-state RPCs are noted. S D

A76-34263 * System reliability analysis through corona testing. V R. Lalli, L. A. Mueller (NASA, Lewis Research Center, Reliability and Quality Assurance Directorate, Cleveland, Ohio), and E. A Koutnik (U S. Veterans Administration, Central Design Div., Washington, D.C.) In Power Electronics Specialists Conference, Culver City, Calif., June 9-11, 1975, Record. (A76-34258 16-33) New York, Institute of Electrical and Electronics Engineers, Inc., 1975, p 51-61. 25 refs

In the Reliability and Quality Engineering Test Laboratory at the NASA Lewis Research Center a nondestructive, corona-vacuum test facility for testing power system components was developed using commercially available hardware The test facility was developed to simulate operating temperature and vacuum while monitoring corona discharges with residual gases This facility is being used to test various high voltage power system components (Author)

A76-37352 * Design and development of a 5 kV isolated solid state switch. R. J. Holbrook, R. Y. Scapple, F. Z Keister (Hughes Aircraft Co., Culver City, Calif.), and S. T. Gooder (NASA, Lewis Research Center, Cleveland, Ohio) In Electronic Components Conference, 25th, Washington, D.C., May 12-14, 1975, Proceedings (A76-37351 18-33) New York, Institute of Electrical and Electronics Engineers, Inc., 1975, p. 22-29. NASA-supported research.

This paper describes the design and fabrication of a 5000 volt isolated hybrid switch developed by Hughes Aircraft Company under contract to NASA/Lewis. Hughes did the packaging design and NASA did the circuit design. This unique microcircuit is intended for use as a shorting switch for large extraterrestrial solar cell arrays The packaging design for the 5 kV isolated hybrid switch is different from most hybrid microcircuits in that it utilizes a compartmentalized plastic case (a portion of which is encapsulated), is not hermetic, and is designed for high voltage operation. (Author)

N76-18350*# Litton Industries, San Carlos, Calif Electron Tube Div.

DEVELOPMENT OF A HIGH POWER 12GHz PPM FOCUSED TRAVELING WAVE TUBE Final Report

Richard Lewis May 1975 89 p refs

(Contract NAS3-14391)

(NASA-CR-134856) Avail NTIS HC $5.00 CSCL 09A

An analytical and experimental program to demonstrate the technical feasibility of a high efficiency coupled cavity traveling wave tube with periodic permanent magnetic focusing operating at 12.06 GHz, with 1 to 2 kilowatts CW power is described Such a tube would ultimately be used for broadcasting power transmission from a satellite The electron gun was designed to be demountable with a replaceable cathode and the tube to be operable in a bakeable vacuum chamber with its collector replaced by a collector Therefore, the high efficiency design was concerned with the slow wave structure only, utilizing velocity resynchronization. A special adapter was designed which incorporated an electromagnet refocusing section and a collector baseplate to facilitate testing the collector CW output power of 1000 watts yielding 21.5% electronic efficiency was demonstrated, with a minimum output power of 525 watts across the specified 160 MHz bandwidth Author

N76-18351*# Hughes Aircraft Co., Culver City, Calif Systems Group

TECHNOLOGICAL DEVELOPMENT OF HIGH ENERGY DENSITY CAPACITORS Final Technical Report

Robert D Parker Feb 1976 126 p

(Contract NAS3-18925)

(NASA-CR-124926, P75-477) Avail NTIS HC $6.00 CSCL 09A

A study was conducted to develop cylindrical wound metallized film capacitors rated 2 micron F 500 VDC that had energy densities greater than 0.1J/g Polysulfone (PS) and polyvinylidene (PVF2) were selected as dielectrics Single film PS capacitors of 0.2J/g (uncased) were made of 3.75 micron material. Single film PVF2 capacitors of 0.19J/g (uncased) were made of 6.0 micron material. Corona measurements were made at room temperature, and capacitance and dissipation factor measurements were made over the ranges 25 C to 125 C and 120 Hz to 100 kHz Nineteen of twenty PVF2 components survived a 2500 hour dc plus ac life test. Failure analyses revealed most failures occurred at wrinkles, but some edge failures were also seen A 0.989g case was designed When the case was combined with the PVF2 component, a finished energy density of 0.11J/g was achieved Author

N76-21391*# General Electric Co., Schenectady, N Y Corporate Research and Development.

DEVELOPMENT AND FABRICATION OF IMPROVED SCHOTTKY POWER DIODES

L F. Cordes, M Garfinkel, and E A Taft Nov 1975 118 p refs.

(Contract NAS3-16749)

(NASA-CR-134925, SRD-75-127) Avail NTIS HC $5.50 CSCL 09A

Reproducible methods for the fabrication of silicon Schottky diodes have been developed for tungsten, aluminum, conventional platinum silicide, and low temperature platinum silicide Barrier heights and barrier lowering under reverse bias have been measured, permitting the accurate prediction of forward and reverse diode characteristics Processing procedures have been developed that permit the fabrication of large area (about 1 sq cm) mesageometry power Schottky diodes with forward and reverse characteristics that approach theoretical values A theoretical analysis of the operation of bridge rectifier circuits has been performed which indicates the ranges of frequency and voltage for which Schottky rectifiers are preferred to p-n junctions Power Schottky rectifiers have been fabricated and tested for voltage ratings up to 140 volts Author

N76-28470*# Westinghouse Research Labs., Pittsburgh, Pa.
DEVELOPMENT AND FABRICATION OF IMPROVED POWER TRANSISTOR SWITCHES
P. L. Hower and C. K. Chu Feb. 1976 49 p. refs
(Contract NAS3-18916)
(NASA-CR-135013) Avail: NTIS HC $4.00 CSCL 09A

A new class of high-voltage power transistors has been achieved by adapting present interdigitated thyristor processing techniques to the fabrication of NPN Si transistors. Present devices are 2.3 cm in diameter. The electrical performance obtained is consistent with the predictions of an optimum design theory specifically developed for power switching transistors. The forward safe operating area of the experimental transistors shows a significant improvement over commercially available devices. The report describes device design, wafer processing, and various measurements which include dc characteristics, forward and reverse second breakdown limits, and switching times. Author

A76-34270 * Three types of solid state remote power controllers. D. E. Baker (Westinghouse Electric Corp., Aerospace Electrical Div., Lima, Ohio). In: Power Electronics Specialists Conference, Culver City, Calif., June 9-11, 1975, Record. (A76-34258 16-33) New York, Institute of Electrical and Electronics Engineers, Inc., 1975, p. 151-160. Contract No. NAS3-17771.

Three types of solid state Remote Power Controller (RPC) circuits for 120 Vdc spacecraft distribution systems have been developed and evaluated. Both current limiting and noncurrent limiting modes of overload protection were developed and were demonstrated to be feasible. A second generation of circuits was developed which offers comparable performance with substantially less cost and complexity. Electrical efficiency for both generations is 98.5 to 99%. This paper describes various aspects of the circuit design, trade off studies, and experimental test results. Comparisons of design parameters, component requirements, and engineering model evaluations will emphasize the high efficiency and reliability of the designs. (Author)

A76-47817 * Gate-assisted turnoff thyristors. E. S. Schlegel (Westinghouse Research Laboratories, Pittsburgh, Pa.) *IEEE Transactions on Electron Devices*, vol. ED-23, Aug. 1976, p. 888-892. 6 refs. Contract No. NAS3-16801.

A study of the turnoff physics in gate-assisted turnoff thyristors (GATT's) leads to a proposed mechanism involving the gate bias acting to prevent a forward voltage from appearing on the cathode rather than, as was previously thought, to sweep out excess carriers. It is shown that cathode shunting can be used in GATT's to virtually eliminate an important failure mode and to decrease the gate voltage needed to produce the desired improvement in turnoff time. Implications for designing GATT's are given, one being that a change in the lateral resistance of the p base will have opposite effects depending on whether the cathode is shunted or not. (Author)

A76-47818 * A technique for optimizing the design of power semiconductor devices. E. S. Schlegel (Westinghouse Electric Research and Development Center, Pittsburgh, Pa.) *IEEE Transactions on Electron Devices*, vol. ED-23, Aug. 1976, p. 924-927. 10 refs. Contract No. NAS3-16801.

A technique is described that provides a basis for predicting whether any device design change will improve or degrade the unavoidable trade-off that must be made between the conduction loss and the turn-off speed of fast-switching high-power thyristors. The technique makes use of a previously reported method by which, for a given design, this trade off was determined for a wide range of carrier lifetimes. It is shown that by extending this technique, one can predict how other design variables affect this trade-off. The results show that for relatively slow devices the design can be changed to decrease the current gains to improve the turn-off time without significantly degrading the losses. On the other hand, for devices having fast turn-off times design changes can be made to increase the current gain to decrease the losses without a proportionate increase in the turn-off time. Physical explanations for these results are proposed. (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*

N76-10411*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

ANALYSIS OF A HEAT TRANSFER DEVICE FOR MEASURING FILM COEFFICIENTS

R A Medrow (Missouri Univ., Rolla), R L Johnson, W R Loomis, and L D Wedeven Sep 1975 33 p refs

(NASA-TM-X-71809, E-8156) Avail NTIS HC $3 75 CSCL 20D

A heat transfer device consisting of a heated rotating cylinder in a bath was analyzed for its effectiveness to determine heat transfer coefficient of fluids A time dependent analysis shows that the performance is insensitive to the value of heat transfer coefficient with the given rig configuration Author

N76-13418*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

ANALYSIS OF LIQUID-METAL-JET IMPINGEMENT COOLING IN A CORNER REGION AND FOR A ROW OF JETS

Robert Siegel Washington Dec 1975 54 p refs

(NASA-TN-D-8096; E-8325) Avail. NTIS HC $4.50 CSCL 20D

A conformal mapping method was used to analyze liquid-metal-jet impingement heat transfer. The jet flow region and energy equation are transformed to correspond to uniform flow in a parallel plate channel with nonuniform heat addition along a portion of one wall The exact solution for the wall-temperature distribution was obtained in the transformed channel, and the results are mapped back into the physical plane Two geometries are analyzed. One is for a single slot jet directed either into an interior corner formed by two flat plates, or over the external sides of the corner, the flat plates are uniformly heated, and the corner can have various included angles The heat-transfer coefficient at the stagnation point at the apex of the plates is obtained as a function of the corner angle, and temperature distributions are calculated along the heated walls The second geometry is an infinite row of uniformly spaced parallel slot jets impinging normally against a uniformly heated plate. The heat-transfer behavior is obtained as a function of the spacing between the jets Results are given for several jet Peclet numbers from 5 to 50. Author

N76-13429*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

AN EMPIRICAL MODEL FOR THE MIXING OF A ROW OF DILUTION JETS WITH A CONFINED CROSSFLOW

J. D Holdeman and R. E Walker (Aerojet Liquid Rocket Co.) 1976 18 p refs Proposed for presentation at 14th Aerospace Sci Meeting, Washington, D. C., 26-28 Jan. 1976; sponsored by AIAA

(NASA-TM-X-71787; E-8200) Avail NTIS HC $3 50 CSCL 20D

An empirical model was developed for predicting the temperature distribution downstream from a row of cool jets injected normally into a hot confined crossflow The model is based on the assumption that all properly non-dimensionalized vertical temperature profiles can be expressed in a self-similar form The scaling parameters in this form were correlated in terms of the independent flow and geometric variables. The effect of parametric variation of each of the independent variables on the experimental and predicted profiles are examined. The predicted distributions show excellent agreement with the data over a wide range of the independent variables Author

N76-18376*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

TWO-PHASE CHOKED FLOW OF SUBCOOLED OXYGEN AND NITROGEN

Robert C Hendricks, Robert J Simoneau, and Richard F Barrows Washington Feb 1976 42 p refs

(NASA-TN-D-8169, E-8499) Avail NTIS HC $4 00 CSCL 20D

Data are presented for two-phase critical flow through nozzles Test results from two converging-diverging nozzles and two separate test facilities are in excellent agreement. The critical flow rate and critical flow pressure ratio data conclusively demonstrate that the principle of corresponding states can be applied to two-phase choked flow through nozzles Normalizing parameters were developed to correlate these data, and current theories can provide an adequate means for extrapolating to other fluids Such information can be useful for cryogenic fluid storage applications Author

N76-18383*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

STREAKLINE FLOW VISUALIZATION OF DISCRETE HOLE FILM COOLING WITH HOLES INCLINED 30 DEG TO SURFACE

Raymond S Colladay, Louis M Russell, and Jan M. Lane Washington Mar 1976 16 p refs Prepared in cooperation with Army Air Mobility R and D Lab Cleveland

(NASA-TN-D-8175, E-8570) Avail NTIS HC $3 50 CSCL 20D

Film injection from three rows of discrete holes angled 30 deg to the surface in line with mainstream flow and spaced 5 diameters apart in a staggered array was visualized by using helium bubbles as tracer particles. Both the main stream and the film-injectant were ambient air Detailed streaklines showing the turbulent motion of the film mixing with the main stream were obtained by photographing small, neutrally buoyant helium-filled soap bubbles which followed the flow field The ratio of boundary layer thickness to hole diameter and the Reynolds number were typical of gas turbine film cooling applications The results showed the behavior of the film and its interaction with the main stream for a range of blowing rates and two initial boundary layer thicknesses Author

N76-21427*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

A THEORETICAL STUDY OF THE ACOUSTIC IMPEDANCE OF ORIFICES IN THE PRESENCE OF A STEADY GRAZING FLOW

Edward J Rice 1976 23 p refs Presented at 91st Meeting of the Acoustical Soc of Am., Washington, D C., 5-9 Apr 1976

(NASA-TM-X-71903, G-8692) Avail NTIS HC $3 50 CSCL 20D

An analysis of the oscillatory fluid flow in the vicinity of a circular orifice with a steady grazing flow is presented The study is similar to that of Hersh and Rogers but with the addition of the grazing flow. Starting from the momentum and continuity equations, a considerably simplified system of partial differential equations is developed with the assumption that the flow can be described by an oscillatory motion superimposed upon the known steady flow The equations are seen to be linear in the region where the grazing flow effects are dominant, and a solution and the resulting orifice impedance are presented for this region The nonlinearity appears to be unimportant for the usual conditions found in aircraft noise suppressors Some preliminary conclusions of the study are that orifice resistance is directly proportional to grazing flow velocity (known previously from experimental data) and that the orifice inductive (mass reactance) end correction is not a function of grazing flow This latter conclusion is contrary to the widely held notion that grazing flow removes the effect of the orifice inductive end correction This conclusion also implies that the experimentally observed total inductance reduction with grazing flow might be in the flow within the orifice rather than in the end correction. Author

N76-21457*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
AXIAL JET MIXING OF ETHANOL IN SPHERICAL CONTAINERS DURING WEIGHTLESSNESS
John C. Audelott Washington Apr. 1976 27 p refs
(NASA-TM-X-3380, E-8605) Avail NTIS HC $4 00 CSCL 20D

An experimental program was conducted to examine the liquid flow patterns that result from the axial jet mixing of ethanol in 10-centimeter-diameter spherical containers in weightlessness Complete liquid circulation flow patterns were easily established in containers that were less than half full of liquid, while for higher liquid fill conditions, vapor was drawn into the inlet of the simulated mixer unit Increasing the liquid-jet or lowering the position at which the liquid jet entered the container caused increasing turbulence and bubble formation Author

N76-22492*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
LIQUID JET IMPINGEMENT NORMAL TO A DISK IN ZERO GRAVITY Ph D. Thesis - Toledo Univ.
Thomas L Labus Jul 1976 259 p refs
(NASA-TM-X-73405) Avail NTIS HC $9 00 CSCL 20D

An experimental and analytical investigation was conducted to determine the free surface shapes of circular liquid jets impinging normal to sharp-edged disks under both normal and zero gravity conditions An order of magnitude analysis was conducted indicating regions where viscous forces were not significant when computing free surface shapes. The demarcation between the viscous and inviscid region was found to depend upon the flow Reynolds number and the ratio between the jet and disk radius. Author

N76-24506*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
GRAVITY EFFECTS ON FLAME SPREADING OVER SOLID SURFACES
Charles R. Andracchio and Thomas H. Cochran Washington May 1976 24 p refs
(NASA-TN-D-8228, E-8601) Avail NTIS HC $3 50 CSCL 21B

The effects of gravity on the spreading of a flame over a solid combustible surface were determined Flame propagation rates were measured from specimens of thin cellulose acetate sheets burning in both normal gravity (1 g) and reduced gravity (0 g) environments, the specimens were burned in various quiescent mixtures of oxygen, helium, argon, and nitrogen A correlation for normal gravity and reduced gravity burning was obtained based on theoretical models of previous investigators Author

N76-27518*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
FLOW VISUALIZATION IN LONG NECK HELMHOLTZ RESONATORS WITH GRAZING FLOW
Kenneth J Baumeister and Edward J. Rice 1976 9 p refs Presented at the 3rd Aero-Acoustics Conf., Palo Alto, Calif., 20-23 Jan 1976, sponsored by AIAA
(NASA-TM-X-73400, E-8723) Avail NTIS HC $3 50 CSCL 20D

Both oscillating and steady flows were applied to a single plexiglass resonator cavity with colored dyes injected in both the orifice and grazing flow field to record the motion of the fluid For oscillatory flow, the instantaneous dye streamlines were similar for both the short and long-neck orifices. The orifice flow blockage appears to be independent of orifice length for a fixed amplitude of flow oscillation and magnitude of the grazing flow The steady flow dye studies showed that the acoustic and steady flow resistances do not necessarily correspond for long neck orifices Author

N76-28512*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
RADIATIVE BEHAVIOR OF A GAS LAYER SEEDED WITH SOOT
Robert Siegel Washington Jul 1976 36 p refs
(NASA-TN-D-8278, E-8595) Avail NTIS HC $4 00 CSCL 20D

Gaseous film or transpiration cooling may be used to reduce the heat flux reaching the wall of a container or other structures Such a protective film, however, is usually not effective for reducing radiative heat transfer as most gases are transparent in the temperature range for which solid walls can exist Therefore, heat transfer was examined for a gaseous layer seeded with radiation-absorbing carbon particles (soot) and flowing along a surface The layer was subjected to an external high temperature source of blackbody radiation The radiative behavior was found to depend on a parameter containing particle concentration, layer thickness and source temperature Only a very small particle volume concentration, in the range of 0001, was required to obtain high absorption in a 1-cm-thick layer for typical conditions The results provide the distance along the surface for which the heat transfer to the wall remains within an acceptable limit and the particles remain below a temperature at which they will melt or vaporize The wall protection by the layer lasts only until the particles vaporize or the layer becomes so hot that it reradiates substantially to the wall Depending on the layer mass velocity the protection may be effective for a distance along the wall of only a few layer thickness Hence, to protect greater wall lengths, it will be necessary to introduce the suspension through multiple slots or holes along the wall Author

N76-31454*# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio
NORMAL IMPINGEMENT OF A CIRCULAR LIQUID JET ONTO A SCREEN IN A WEIGHTLESS ENVIRONMENT
Eugene P Symons Washington Aug 1976 31 p refs
(NASA-TM-X-3415, E-8710) Avail NTIS HC $4 00 CSCL 20D

The normal impingement of a circular liquid jet onto a fine-mesh screen in a weightless environment was investigated Equations were developed to predict the velocity of the emerging jet on the downstream side of the screen as a function of screen and liquid parameters and of the velocity of the impinging jet. Additionally, the stability of the emerging jet was found to be Weber number dependent In general, excepting at high velocities, the screen behaved much as a baffle, deflecting the major portion of the impinging flow Author

N76-31456*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
STREAKLINE FLOW VISUALIZATION OF DISCRETE-HOLE FILM COOLING WITH NORMAL, SLANTED, AND COMPOUND ANGLE INJECTION
Raymond S Colladay and Louis M. Russell Washington Sep 1976 20 p refs
(NASA-TN-D-8248; E-8418) Avail: NTIS HC $3 50 CSCL 20D

Film injection from discrete holes in a three-row, staggered array with five-diameter spacing was studied for three hole angles: (1) normal, (2) slanted 30 deg to the surface in the direction of the main stream, and (3) slanted 30 deg to the surface and 45 deg laterally to the main stream. The ratio of the boundary layer thickness-to-hole diameter and Reynolds number were typical of gas-turbine film-cooling applications. Detailed streaklines showing the turbulent motion of the injected air were obtained by photographing very small neutrally buoyant, helium-filled soap bubbles which follow the flow field Author

N76-33440*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
STEADY-STATE HEAT TRANSFER IN TRANSVERSELY HEATED POROUS MEDIA WITH APPLICATION TO FOCUSED SOLAR ENERGY COLLECTORS
Lester D Nichols Washington Oct 1976 46 p refs

(NASA-TN-D-8310, E-8739) Avail. NTIS HC $4.00 CSCL 20D

A fluid flowing in a porous medium heated transversely to the fluid flow is considered. This configuration is applicable to a focused solar energy collector for use in an electric power generating system. A fluidized bed can be regarded as a porous medium with special properties. The solutions presented are valid for describing the effectiveness of such a fluidized bed for collecting concentrated solar energy to heat the working fluid of a heat engine. Results indicate the advantage of high thermal conductivity in the transverse direction and high operating temperature of the porous medium. Author

A76-10160 * **Comparison of theory and experiment for homogeneous turbulence with shear.** R. G. Deissler (NASA, Lewis Research Center, Cleveland, Ohio). *Physics of Fluids*, vol. 18, Oct. 1975, p. 1237-1240. 8 refs

Solutions for uniformly-sheared turbulence, in which the interaction of the turbulence with the mean shear dominates the turbulent self-interaction, are compared with experiment. An anisotropic spectral tensor, which appears general enough to represent the initial experimental turbulence, is used for the initial condition in the calculations. The evolution of one-point turbulence components and microscales, as well as two-point velocity correlations, are considered. In most cases the agreement with experiment is good. The theory correctly predicts the presence of a negative region for two-point longitudinal-velocity correlations only for point separations in the direction normal to the flow and the mean gradient. (Author)

A76-18759 * # **An empirical model for the mixing of a row of dilution jets with a confined crossflow.** J. D. Holdeman (NASA, Lewis Research Center, Combustion and Pollution Research Branch, Cleveland, Ohio) and R. E. Walker (Aerojet Liquid Rocket Co., Sacramento, Calif.). *American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 14th, Washington, D.C., Jan. 26-28, 1976, Paper 76-48*. 10 p. 7 refs

An empirical model has been developed for predicting the temperature distribution downstream of a row of cool jets injected normal to a hot confined crossflow. The model is based on the assumption that all properly non-dimensionalized vertical temperature profiles can be expressed in a self-similar form. The scaling parameters in this form have been correlated in terms of the independent flow and geometric variables. The effect of parametric variation of each of the independent variables on the experimental and predicted profiles are examined. The predicted distributions show excellent agreement with the data over a wide range of the independent variables. (Author)

A76-22449 * **Pressure distribution in a converging-diverging nozzle during two-phase choked flow of subcooled nitrogen.** R. J. Simoneau (NASA, Lewis Research Center, Cleveland, Ohio). In: Non-equilibrium two-phase flows; Proceedings of the Winter Annual Meeting, Houston, Tex., November 30-December 5, 1975. Meeting sponsored by the American Society of Mechanical Engineers. New York, American Society of Mechanical Engineers, 1975, p. 37-45. 10 refs.

Choked flow rates and axial pressure distributions were measured for subcooled nitrogen in a converging-diverging nozzle with a constant area section in the throat region. Stagnation pressures ranged from slightly above saturation to twice the thermodynamic critical pressure. Stagnation temperatures ranged from 0.75 to 1.03 times the thermodynamic critical temperature. The choking plane appears to be at the divergence end of the constant area throat section. At high stagnation pressures the fluid appears to stay liquid well into the constant area throat region; however, at near saturation stagnation pressures it appears that vaporization occurs at or before the entrance to the constant area throat region. The throat-to-stagnation pressure ratio data exhibits an anomalous flat region. This anomaly appears to be fundamentally related to the two-phase process and not merely to the present specific nozzle geometry. The fluid appears to be metastably all liquid below the saturation pressure. The data are compared to various flow models. No model adequately describes the whole range of the experiment. (Author)

A76-36127 * **The low frequency sound from multipole sources in axisymmetric shear flows. II.** M. E. Goldstein (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Fluid Mechanics*, vol. 75, May 13, 1976, p. 17-28

A previous analysis of the acoustic radiation from multipole sources is extended to include additional components of the dipole and quadrupole sources. It is found that, unlike the components of the sources considered in the previous paper, the exponent of the Doppler factor now depends on the location of the sources within the jet. (Author)

A76-37061 * # **Finite difference procedure for boundary layers including effects of longitudinal and transverse curvatures.** Y. Tassa, E. Reshotko (Case-Western-Reserve University, Cleveland, Ohio), and B. H. Anderson (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976, Paper 76-427*. 9 p. 7 refs. NASA-supported research.

A second order viscous layer solution procedure has been developed that does in a consistent way include curvature effects and the corresponding normal pressure gradients. In the present system, the normal momentum equation is retained. The parabolic system of nonlinear partial differential equations is converted by linear finite differencing procedures to a system of linear algebraic equations and solved in primitive coordinates. The solutions have been shown to give smooth stable distributions for all the variables, most particularly the normal velocity which plays an important role in the interaction procedure. An algorithm for matching the viscous layer solution with a rotational characteristics outer solution has been developed. (Author)

N76-17330*# Stanford Univ., Calif.
TURBULENT BOUNDARY LAYER ON A FULL-COVERAGE FILM-COOLED SURFACE: AN EXPERIMENTAL HEAT TRANSFER STUDY WITH NORMAL INJECTION. Final Report
H. Choe, W. M. Kays, and R. J. Moffat. Jan. 1976. 296 p. ref. (Contract NAS3-14336)
(NASA-CR-2642, HMT-22) Avail. NTIS HC $9.25 CSCL 20D

Heat transfer behavior was studied in a turbulent boundary layer with full-coverage film cooling through an array of discrete holes and with injection normal to the wall surface. Stanton numbers were measured for a staggered hole pattern with pitch-to-diameter ratios of 5 and 10, an injection mass flux ratio range of 0.1 to 1.0, and a range of Reynolds number 170 thousand to 5 million. Air was used as the working fluid with the mainstream velocity varied from 14 to 33.5 m/sec (30 to 110 ft/sec). The data were taken for secondary injection temperatures equal to the wall temperature and also equal to the mainstream temperature. By use of linear superposition theory, the data may be used to obtain Stanton number as a continuous function of the injectant temperature. The heat transfer coefficient is defined on the basis of a mainstream-to-wall temperature difference. This difinition permits direct comparison of performance between film cooling and transpiration cooling. Author

N76-18382*# Stanford Univ., Calif.
FULL-COVERAGE FILM COOLING HEAT TRANSFER STUDY: SUMMARY OF DATA FOR NORMAL-HOLE INJECTION AND 30 DEG SLANT-HOLE INJECTION. Final Report
M. E. Crawford, H. Choe, W. M. Kays, and R. J. Moffat. Washington NASA, Mar. 1976. 145 p. refs
(Contract NAS3-14336)

(NASA-CR-2648, SU-HMT-19) Avail. NTIS HC $6.00 CSCL 20D

Heat transfer to a full coverage film cooled turbulent boundary layer over a flat surface was studied. The surface consisted of a discrete hole test section containing 11 rows of holes spaced 5 diameters apart in a staggered array and an instrumented recovery region. Ten diameter spacing was also studied by plugging appropriate holes. Two test sections were used, one having holes normal to the surface and the other having holes angled 30 deg to the surface in the downstream direction. Stanton number data were obtained both in the full coverage region and in the downstream recovery region for a range of blowing ratios, or mass flux ratios, from 0 to 1.3. Initial conditions at the upstream edge of the blowing region were varied from 500 to 5000 for momentum thickness Reynolds number and from 100 to 1800 for enthalpy thickness Reynolds number. The range of Reynolds numbers based on hole diameter and mainstream velocity was 6000 to 22000. Initial boundary layer thicknesses range from 0.5 to 2.0 hole diameters. Air was used as the working fluid. The data were taken for the secondary injection temperature equal to the wall temperature and also equal to the mainstream temperature. Superposition was then used to obtain Stanton number as a continuous function of the injectant temperature. The heat transfer coefficient was defined on the basis of a mainstream-to-wall temperature difference. This definition permits direct comparison of performance between film cooling and transpiration cooling. Author

N76-22495*# Thermo Mechanical Systems Co., Canoga Park, Calif.

NUMERICAL CALCULATION OF THE INTERNAL FLOW FIELD IN A CENTRIFUGAL COMPRESSOR IMPELLER Final Report

Leonard Wahtt, James L. Harp, Jr., and C. Y. Liu. Dec. 1975. 100 p. refs

(Contract NAS3-18016)

(NASA-CR-134984, SR-27) Avail. NTIS HC $5.00 CSCL 20D

An iterative numerical method has been developed for the calculation of steady, three-dimensional, viscous, compressible flow fields in centrifugal compressor impellers. The computer code, which embodies the method, solves the steady three dimensional, compressible Navier-Stokes equations in rotating, curvilinear coordinates. The solution takes place on blade-to-blade surfaces of revolution which move from the hub to the shroud during each iteration. Author

N76-24502*# General Dynamics/Convair, San Diego, Calif.

LOW-G FLUID TRANSFER TECHNOLOGY STUDY Final report, May 1974 - Feb. 1976

J. A. Stark. May 1976. 289 p. refs

(Contract NAS3-17814)

(NASA-CR-134911, CASD-NAS-76-014) Avail. NTIS HC $9.25 CSCL 20D

Technology gaps and system characteristics critical to cryogenic and noncryogenic in-orbit fluid transfer were identified. Four different supply systems were conceptually designed as space shuttle payloads. These were: (1) space tug supply - LH2, LO2, N2H4, He - linear acceleration for liquid acquisition with supply module and tug separated from shuttle, (2) tug supply using orbiter drag, (3) orbiter supply - N2O4,MMH,He, H2,O2 - surface tension screens, (4) multiple receivers supply O solar electric propulsion stage, Hg, diaphragm - HEAO B, HEe, paddle fluid rotation-satellite control section, N2H4, screens. It was found that screens had the best overall potential for low weight and simplicity, however, thermal problems with cryogenics still need final resolution. Author

N76-24503*# General Dynamics/Convair, San Diego, Calif.

LOW-G FLUID TRANSFER TECHNOLOGY STUDY, EXECUTIVE SUMMARY Summary Report, May 1974 - Feb. 1976

J. A. Stark. May 1976. 26 p.

(Contract NAS3-17814)

(NASA-CR-135020; CASD-NAS-76-017) Avail. NTIS HC $4.00 CSCL 20D

For abstract see N76-24502

N76-24504*# General Dynamics/Convair, San Diego, Calif.

AN ANALYTICAL STUDY OF REDUCED-GRAVITY FLOW DYNAMICS

Robert D. Bradshaw, James L. Kramer, and John L. Zich. Apr. 1976. 67 p. refs

(Contract NAS3-17839)

(NASA-CR-135023; CASD-NAS-76-015) Avail. NTIS HC $4.50 CSCL 20D

Addition of surface tension forces to a marker-and-cell code and the performance of four incompressible fluid simulations in reduced gravity, were studied. This marker-and-cell code has a variable grid capability with arbitrary curved boundaries and time dependent acceleration fields. The surface tension logic includes a spline fit of surface marker particles as well as contact angle logic for straight and curved wall boundaries. Three types of flow motion were simulated with the improved code: impulsive settling in a model Centaur LH2 tank, continuous settling in a model and full scale Centaur LO2 tank and mixing in a Centaur LH2 tank. The impulsive settling case confirmed a drop tower analysis which indicated more orderly fluid collection flow patterns with this method providing a potential savings in settling propellants. In the LO2 tank, fluid collection and flow simulation into the thrust barrel were achieved. The mixing simulation produced good results indicating both the development of the flow field and fluid interface behavior. Author

N76-26423*# Lockheed Missiles and Space Co., Sunnyvale, Calif.

NUMERICAL SIMULATION OF LOW GRAVITY DRAINING Final Report

G. D. Bizzell and G. E. Crane. May 1976. 145 p. refs

(Contract NAS3-17798)

(NASA-CR-135004, LMSC-D52181) Avail. NTIS HC $6.00 CSCL 20D

A boundary value problem was solved numerically for a liquid that is assumed to be inviscid and incompressible, having a motion that is irrotational and axisymmetric, and having a constant (5 degrees) solid-liquid contact angle. The avoidance of excessive mesh distortion, encountered with strictly Lagrangian or Eulerian kinematics, was achieved by introducing an auxiliary kinematic velocity field along the free surface in order to vary the trajectories used in integrating the ordinary differential equations simulating the moving boundary. The computation of the velocity potential was based upon a nonuniform triangular mesh which was automatically revised to varying depths to accommodate the motion of the free surface. These methods permitted calculation of draining induced axisymmetric slosh through the many (or fractional) finite amplitude oscillations that can occur depending upon the balance of draining, gravitational, and surface tension forces. Velocity fields, evolution of the free surface with time, and liquid residual volumes were computed for three and one half decades of Weber number and for two Bond numbers, tank fill levels, and drain radii. Comparisons with experimental data are very satisfactory. Author

N76-31449*# General Dynamics Corp., San Diego, Calif.

THERMAL PERFORMANCE OF A CUSTOMIZED MULTI-LAYER INSULATION (MLI) Final Report

Karl E. Leonhard. Apr. 1976. 274 p. refs

(Contract NAS3-17756)

(NASA-CR-135051, CASD-NAS-76-018) Avail. NTIS HC $9.00 CSCL 20D

The thermal performance of a LH2 tank on a shroudless vehicle was investigated. The 1.52 m (60 in) tank was insulated with 2 MLI blankets consisting of 18 double aluminized Mylar radiation shields and 19 silk net spacers. The temperature of outer space was simulated by using a cryoshroud which was maintained at near liquid hydrogen temperature. The heating effects of a payload were simulated by utilizing a thermal payload simulator (TPS) viewing the tank. The test program consisted of three major test categories: (1) null testing, (2) thermal

performance testing of the tank installed MLI system and (3) thermal testing of a customized MLI configuration TPS surface temperatures during the null test were maintained at near hydrogen temperature and during test categories 2 and 3 at 289 K (520R) The heat flow rate through the tank installed MLI at a tank/TPS spacing of 0 457 m was 1 204 watts with no MLI on the TPS and 0 059 watts through the customized MLI with three blankets on the TPS Reducing the tank/TPS spacing from 0 457 m to 0.152 m the heat flow through the customized MLI increased by 10 percent Author

A76-26728 * # Pressure and velocity in a developing coaxial jet. L. F. Moon (Bell Aerospace Textron, Buffalo, N.Y.). *AIAA Journal*, vol. 14, Jan 1976, p. 43-49. 20 refs. Contract No. NAS3-16798

Determinations of static pressure, mean velocity and turbulence intensity in the developing region of coaxial jets are presented. Detailed profiles were obtained at twelve axial locations (extending from the nozzle exit for a distance of 5 diameters) downstream from a single element of the Bell Aerospace H2/O2 19-element coaxial injector. Measurements of mass-flux per unit area (using a constant temperature anemometer), total pressure and local temperature were used in the determination of local static pressure and velocity. These data show a low pressure region exists near the nozzle exit. Although this pressure reduction is small (0 34 psi), it substantially altered the flow development. Comparison of results shows that velocity near the nozzle exit decreases initially (no central velocity core) as a result of both pressure gradients and viscous mixing. These data are compared with analytical predictions made using available computer codes. Results show the need to consider pressure effects in any proposed mathematical model. (Author)

A76-32584 * # Stability of laser heated flows. P K. S. Wu and A N. Pirri (Physical Sciences, Inc., Wakefield, Mass.) *AIAA Journal*, vol. 14, Mar 1976, p 390-392. 9 refs Contract No. NAS3-18528.

A local stability analysis is utilized to determine the stability of disturbances generated at each point along a nozzle of variable area ratio for a one-dimensional flow heated by laser radiation entering from the upstream direction. The governing equations for the quasi-one-dimensional flow without viscous dissipation, diffusion, and thermal conduction but including radiative heat transfer are given The governing equations are combined to yield a relationship which governs the Mach number variation through the nozzle. The complete steady-state solution can be calculated from knowledge of the Mach number profile, the inlet conditions, and the laser power. The local stability analysis permits obtaining contour (or contours) of neutral stability. Solutions have been obtained for various nozzle configurations, but only one set of example calculations is presented. The results obtained indicate that the analysis serves as an important indicator as to where potential absorption wave phenomena may be initiated. S D.

A76-42158 * Velocity and pressure characterization of coaxial jets. J. H Morgenthaler (Bell Aerospace Textron, Buffalo, N.Y.). In: Turbulent mixing in nonreactive and reactive flows; Proceedings of the SQUID Workshop, Purdue University, West Lafayette, Ind., May 20, 21, 1974. (A76-42151 21-34) New York, Plenum Press, 1975, p. 231-234 Contract No. NAS3-16798.

Mean velocity and stagnation pressures of a coaxial air jet injected into an ambient atmosphere were measured and local free-stream static pressure profiles were derived from these measurements. The mean velocity profiles show a dramatic decrease in the velocity of the central jet immediately downstream of the injection station It is found that the high velocity outer jet creates a reduction in static pressure through an aspiration effect, which causes the central jet to spread, thereby reducing its velocity. Results demonstrate that even for the simple coaxial injector geometry often used in H2/O2 rockets, conventional modeling techniques do not apply. B J.

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 *19 Spacecraft Instrumentation*

N76-13454*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
THERMOCOUPLES OF TANTALUM AND RHENIUM ALLOYS FOR MORE STABLE VACUUM-HIGH TEMPERATURE PERFORMANCE Patent Application
James F. Morris, inventor (to NASA) Filed 6 Nov 1975 13 p (NASA-Case-LEW-12050-1, US-Patent-Appl-SN-629457) Avail NTIS HC $3 50 CSCL 14B

Thermocouples that provide stability and performance reliability in systems involving high temperatures, and vacuums through the use bimetallic sensors are examined All metal components of the sensor are selected from a group of metals comprising tantalum and rhenium and alloys containing only those two metals The tantalum, rhenium thermocouple sensor alloys provide bare metal thermocouple sensors with superior vapor pressure compatibilities and performance characteristics. These improved compatibility and physical characteristics sensors result in improvement emf, temperature properties and thermocouple hot junction performance. The thermocouples also exhibit reliability and performance stability in systems involving high temperatures and vacuums and are adaptable to space propulsion and power systems and nuclear environments. NASA

N76-14431* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
SHOCK POSITION SENSOR FOR SUPERSONIC INLETS Patent
Miles O Dustin inventor (to NASA) 7 Oct 1975 7 p Filed 30 May 1974 Supersedes N74-25805 (12-15, p 1774)
(NASA-Case-LEW-11915-1; US-Patent-3,911,260, US-Patent-Appl-SN-474744; US-Patent-Class-235-151 34, US-Patent-Class-60-39 29; US-Patent-Class-137-15 2) CSCL 14B

Static pressure taps or ports are provided in the throat of a supersonic inlet, and signals indicative of the pressure at each of the ports is fed to respective comparators Means are also provided for directing a signal indicative of the total throat pressure to the comparators A periodic signal is superimposed on the total throat pressure so that the signal from the static pressure tabs is compared to a varying scan signal rather than to total throat pressure only. This type of comparison causes each comparator to provide a pulse width modulated output which may vary from 0% 'time on' to 100% 'time on The pulse width modulated outputs of the comparators are summed, filtered and directed to a controller which operates a bypass valve such as a door whereby air is dumped from the inlet to prevent the shock wave from being expelled out the front
Official Gazette of the U.S Patent Office

N76-15434* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THERMOCOUPLE TAPE Patent
Ralph D. Thomas, inventor (to NASA) Issued 9 Dec. 1975 5 p Filed 17 May 1972 Supersedes N72-28443 (10 - 19, p 2562) Division of US Patent Appl SN-104885, filed 8 Jan. 1971, US-Patent-3,729,343
(NASA-Case-LEW-11072-2, US-Patent-3,925,104, US-Patent-Appl-SN-254323, US-Patent-Class-136-225, US-Patent-Class-136 211, US-Patent-Class-136-212, US-Patent-Appl-SN-104885, US-Patent-3,729,343) Avail US Patent Office CSCL 14B

A thermocouple which may be rolled as a tape until needed and a method of making same are described Thermoelectrically different metals are applied to a strip of electrically nonconductive material in longitudinally overlapping relationship Apertures may be provided along the tape in the overlapping region at predetermined intervals An adhesive material is applied to the side of the tape opposite the thermoelectric metals either before or after the thermoelectric metals are deposited. The tapes may be cut or torn to form a thermocouple device which is ready for application to a body whose temperature is to be monitored or measured Official Gazette of the U S Patent Office

N76-19407*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THERMOCOUPLES OF MOLYBDENUM AND IRIDIUM ALLOYS FOR MORE STABLE VACUUM-HIGH TEMPERATURE PERFORMANCE Patent Application
James F Morris, inventor (to NASA) Filed 18 Mar 1976 14 p
(NASA-Case-LEW-12174-1, US-Patent-Appl-SN-667929) Avail NTIS HC $3 50 CSCL 14B

Thermocouples that provide stability and performance reliability in systems involving high temperatures and vacuums are presented the device employs a bimetallic thermocouple sensor where each metal of the sensor is selected from a group of metals comprising molybdenum and iridium and alloys containing only those two metals The molybdenum, iridium thermocouple sensor alloys provide bare metal thermocouple sensors with advantageous vapor pressure compatibilities and performance characteristics The compatibility and physical characteristics of the thermocouple sensor alloys result in improved emf, temperature properties and thermocouple hot junction performance Thermocouples formed of the molybdenum, iridium alloys are adaptable to space propulsion and power systems and nuclear environments NASA

N76-21491*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
MICROPROCESSOR-BASED MULTICHANNEL FLUTTER MONITOR USING DYNAMIC STRAIN GAGE SIGNALS
Robert R Smalley 1976 18 p Presented at Natl Instrumentation Symp , San Diego, Calif , 25-27 May, 1976; Sponsored by the Instr. Soc of Am
(NASA-TM-X-71884, E-8659) Avail NTIS HC $3 50 CSCL 14B

Two microprocessor-based multichannel monitors for monitoring strain gage signals during aerodynamic instability (flutter) testing in production type turbojet engines were described One system monitors strain gage signals in the time domain and gives an output indication whenever the signal amplitude of any gage exceeds a pre-set alarm or abort level for that particular gage The second system monitors the strain gage signals in the frequency domain and therefore is able to use both the amplitude and frequency information Thus, an alarm signal is given whenever the spectral content of the strain gage signal exceeds, at any point, its corresponding amplitude vs frequency limit profiles Each system design is described with details on design trade-offs, hardware, software and operating experience Author

N76-18404*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland Ohio.
AN AUTOMATED SECONDARY STANDARD FOR CALIBRATING LIQUID FLOWMETERS
Howard F Hobart 1976 9 p refs To be presented at the 22d Intern. Instr. Symp , San Diego, Calif , 25-27 May 1976, sponsored by the Instr. Soc of Am
(NASA-TM-X-71876; E-8649) Avail NTIS HC $3 50 CSCL 14B

A secondary working standard of flow calibration has been developed to be used in place of a primary weight-time standard, and which can thereby effect a 75 percent reduction in calibration time while maintaining acceptable accuracies The secondary standard uses six previously calibrated turbine-type flowmeters built into two manifold systems containing automatically switched flow valves The pair of systems is capable of covering the flow range of 0 0004 to 19 l/s (0 007 to 300 gpm) with the uncertainty in volume flow rate not exceeding + or - 0 25 percent over

the range of 0 06 to 19 l/s and not exceeding + or - 0 5 percent over the range 0.0004 to 0.06 1/s Data reduction and plotting of results are by computer. Author

N76-18406*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PERFORMANCE OF SOME MINIATURE PRESSURE TRANSDUCERS SUBJECTED TO HIGH ROTATIONAL SPEEDS AND CENTRIPETAL ACCELERATIONS
Herbert L Minkin 1976 10 p refs Proposed for presentation at 22nd Intern. Instr Symp., San Diego, Calif., 25-27 May, 1976; sponsored by Instr. Soc of Am
(NASA-TM-X-71791, E-8643) Avail NTIS HC $3 50

The performance characteristics of several miniature pressure transducers were determined at centripetal accelerations up to 11,200 g s at a rotational speed of 23 000 rpm The variation in centripetal acceleration was produced by changing radial position of the transducer relative to the center of rotation Residual zero outputs and transducer sensitivities were determined at 23, 000 rpm and compared with those determined at 0 rpm The actual pressures at the various transducer locations differ from the center line impressed pressures due to a rotational effect Corrections for this effect were made A brief description of the test apparatus is included Author

N76-18408*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
A NEW APPROACH TO THE PULSED THERMOCOUPLE FOR HIGH GAS TEMPERATURE MEASUREMENTS
George E Glawe, Herbert A Will, and Lloyd N Krause 1976 13 p refs Proposed for presentation at 22nd Intern Instr Symp., San Diego, Calif., 25-27 May 1976, sponsored by Instr Soc of Am
(NASA-TM-X-71883, E-8656) Avail NTIS HC $3 50 CSCL 14B

Pulsed thermocouple systems can be used to measure gas temperatures above the melting point of the thermocouple by various techniques of short term of intermittent exposure of the thermocouple operating at lower temperatures. An approach is described which uses a thermocouple cooled by a small jet of inert gas. When a measurement is to be made, the cooling jet is turned off and the thermocouple allowed to heat up to near its melting point, at which time the cooling is reapplied The final temperature which the thermocouple should have attained is then calculated by extrapolating an exponential curve fit to the data Temperature measurements can be recorded and displayed in near real time by using modern high-speed computing systems to perform these calculations Examples of the technique applied to high temperature jet engine combustor development are presented Author

N76-23539*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
INFRARED PYROMETER FOR HIGH RESOLUTION SURFACE TEMPERATURE MEASUREMENT ON ROTATING TURBINE BLADES
Orlando W Uguccini 1976 20 p ref Presented at the Laser and Electro-Optical Systems Conf., San Diego, Calif., 25-27 May 1976, sponsored in cooperation with IEEE and Opt Soc of Am
(NASA-TM-X-73414, E-8613) Avail NTIS HC $3 50 CSCL 14B

A high resolution pyrometer was developed and used to obtain temperature profiles of rotating turbine blades at tip speeds up to 366 meters per second Surface temperature variations from 920 to 1250 K can be measured and variations over distances of 0 05 cm can be resolved Temperature profiles were obtained in near real time as hard copies from a computer display terminal Temperatures measured with the prototype pyrometer and with thermocouples agreed to within 2 percent over the temperature range from 977 to 1144 Author

N76-23542*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
HIGH-RESOLUTION SURFACE TEMPERATURE MEASUREMENTS ON ROTATING TURBINE BLADES WITH AN INFRARED PYROMETER
Orlando W. Uguccini and Frank G. Pollack Washington May 1976 20 p refs
(NASA-TN-D-8213 E-8613) Avail NTIS HC $3 50 CSCL 14B

A high-resolution pyrometer was developed and tested on a modified turbine engine The pyrometer was used to obtain temperature profiles of the viewed surface of turbine blades in the engine at tip speeds up to 366 meters per second The combination of coherent fiber optics, a silicon avalanche detector, and high-speed electronics enabled surface resolution of a spot diameter of 0.05 centimeter The data, in the form of temperature profiles, was obtained in near real time as a hard copy output from a computer display terminal. Temperatures measured with the pyrometer and with thermocouples agreed within 2 percent at temperatures between 977 to 1144 K Author

N76-33473*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland Ohio
COMPUTER PROGRAM FOR CALCULATING PRESSURE-BROADENED RAMAN SPECTRA FOR MOLECULAR NITROGEN AND OXYGEN
Gustave C Fralick Washington Oct 1976 31 p refs
(NASA-TM-X-3427, E-8608) Avail NTIS HC $4 00 CSCL 07D

A computer program is given for calculating the rotational Raman spectrum for molecular nitrogen and oxygen Provision is made for pressure broadening Several sample calculations at various pressures are shown The relative heights of some of the lines are affected by pressure broadening Author

A76-21923 * # **Flow visualization of discrete hole film cooling for gas turbine applications.** R. S Colladay and L. M. Russell (NASA, Lewis Research Center, Cleveland, Ohio) *American Society of Mechanical Engineers, Winter Annual Meeting, Houston, Tex., Nov. 30-Dec. 4, 1975, Paper 75-WA/HT-12* 9 p 9 refs. Members, $1.50; nonmembers, $3.00.

Film injection from discrete holes in a three row staggered array with 5-diameter spacing is studied for three different hole angles: (1) normal, (2) slanted 30 deg to the surface in the direction of the mainstream, and (3) slanted 30 deg to the surface and 45 deg laterally to the mainstream The boundary layer thickness-to-hole diameter ratio and Reynolds number are typical of gas turbine film cooling applications Two different injection locations are studied to evaluate the effect of boundary layer thickness on film penetration and mixing Detailed streaklines showing the turbulent motion of the injected air are obtained by photographing very small neutrally buoyant helium filled 'soap' bubbles which follow the flow field. Unlike smoke, which diffuses rapidly in the high turbulent mixing region associated with discrete hole blowing, the bubble streaklines passing downstream injection locations are clearly identifiable and can be traced back to their origin Visualization of surface temperature patterns obtained from infrared photographs of a similar film cooled surface are also included. (Author)

A76-25963 * **An automated atmospheric sampling system operating on 747 airliners.** P. J. Perkins (NASA, Lewis Research Center, Cleveland, Ohio) and U. R. C. Gustafsson (United Airlines, San Francisco, Calif.). In: International Conference on Environmental Sensing and Assessment, Las Vegas, Nev., September 14-19, 1975, Proceedings. Volume 2. (A76-25876 11-45) New York, Institute of Electrical and Electronics Engineers, Inc , 1976, p. 1 26-4 to 10 26-4. 9 refs

An air sampling system that automatically measures the temporal and spatial distribution of particulate and gaseous constituents of the atmosphere is collecting data on commercial air routes covering the world. Measurements are made in the upper troposphere and lower stratosphere (6 to 12 km) of constituents

related to aircraft engine emissions and other pollutants. Aircraft operated by different airlines sample air at latitudes from the Arctic to Australia. This unique system includes specialized instrumentation, a special air inlet probe for sampling outside air, a computerized automatic control, and a data acquisition system. Air constituent and related flight data are tape recorded in flight for later computer processing on the ground. (Author)

A76-33394 * # Infrared pyrometer for high resolution surface temperature measurements on rotating turbine blades. O. W. Ugucini (NASA, Lewis Research Center, Cleveland, Ohio). *Institute of Electrical and Electronics Engineers and Optical Society of America, Laser and Electro-optical Systems Conference, San Diego, Calif., May 25-27, 1976, Paper.* 19 p

A high resolution pyrometer was developed and used to obtain temperature profiles of rotating turbine blades at tip speeds up to 366 meters per second (1200 fps). Surface temperature variations from 920 to 1250 K (1200 to 1800 F) can be measured and variations over distances of 0.05 cm (0 020 in.) can be resolved Temperature profiles were obtained in near real time as hard copies from a computer display terminal. Temperatures measured with the prototype pyrometer and with thermocouples agreed to within 2 percent over the temperature range from 977 to 1144 K (1300 to 1600 F). (Author)

A76-45354 * # Design, development, and test of a laser velocimeter for high speed turbomachinery. P. W. Runstadler, Jr. and F X Dolan (Creare, Inc., Hanover, N.H) In: The accuracy of flow measurements by laser Doppler methods; Proceedings of the LDA-Symposium, Copenhagen, Denmark, August 25-28, 1975 (A76-45326 23-35) Skovlunde, Denmark, Proceedings LDA-Symposium Copenhagen, 1976, p. 523-552. 7 refs Contract No. NAS3-17860

The paper describes the design, development, and test of a laser Doppler velocimeter (LDV) to map the velocity fields in a small, high speed, 8 1 pressure ratio, 0.91 kg/s (2 lbm/s), centrifugal compressor This instrument is being used as a diagnostic tool for the study of the basic fluid dynamics of the inducer, impeller and the diffuser regions of high pressure ratio, small, centrifugal compressors The LDV instrumentation has been optimized to permit the measurement of instantaneous velocities up to approximately 500 m/s, measured in absolute coordinates, within a rotating compressor impeller. Velocities of the same magnitude can also be measured in the two-dimensional radial plane of the diffuser. It is shown that LDV can make nondisturbing gas velocity measurements and surmount the difficulties found in applying other types of aerodynamic instrumentation to this measurement problem. (Author)

36 LASERS AND MASERS

Includes parametric amplifiers

N76-21515* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
APPLICATION OF HIGH POWER LASERS TO SPACE POWER AND PROPULSION
Donald L Nored *In its* 2d NASA Conf on Laser Energy Conversion 1976 p 95-108 refs (For availability see N76-21505 12-36)
CSCL 20E

The transmission of laser power over long distances for applications such as direct conversion to propulsive thrust or electrical power is considered Factors discussed include problems inherent in transmitting, propagating, and receiving the laser beam over long ranges, high efficiency closed-cycle, continuous wave operation; advancement of CO2 laser technology; and compatibility with photovoltaic power conversion devices J M S

N76-30550*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THE NASA HIGH POWER CARBON DIOXIDE LASER· A VERSATILE TOOL FOR LASER APPLICATIONS
R B Lancashire, D L Alger, E J Manista, J G Slaby, J W Dunning, and R M Stubbs 1976 12 p refs Presented at Technical Symp on Industrial Applications of High Power Laser Technol., San Diego Calif., 23-27 Aug 1976; sponsored by Soc of Photo-Optical Instrumentation Engineers
(NASA-TM-X-73485; E-8871) Avail NTIS HC $3 50 CSCL 20E

A closed-cycle, continuous wave, carbon dioxide high power laser has been designed and fabricated to support research for the identification and evaluation of possible high power laser applications The device is designed to generate up to 70 kW of laser power in annular shape beams from 1 to 9 cm in diameter Electric discharge either self sustained or electron beam sustained, is used for excitation This laser facility provides a versatile tool on which research can be performed to advance the state-of-the-art technology of high power CO2 lasers in such areas as electric excitation, laser chemistry, and quality of output beams The facility provides a well defined, continuous wave beam for various application experiments, such as propulsion, power conversion, and materials processing Author

A76-18509 * # Radiation effects on beta /10.6/ of pure and europium doped KCl. H. H. Grimes (NASA, Lewis Research Center, Cleveland, Ohio), J. E. Maisel (Cleveland State University, Cleveland, Ohio), and R. H. Hartford (Shippensburg State College, Shippensburg, Pa.). *U.S. Defense Advanced Research Projects Agency, Infrared Laser Window Materials Conference, 5th, Las Vegas, Nev., Dec. 1-5, 1975, Paper.* 11 p. 9 refs.

Changes in the optical absorption coefficient as the result of X-ray and electron bombardment of pure monocrystalline and polycrystalline KCl and of divalent europium doped polycrystalline KCl were determined. A constant heat flow calorimetric method was used to measure the optical absorption coefficients. Both 300 kV X-ray irradiation and 2 MeV electron irradiation produced increases in the optical absorption coefficient at room temperature. X-ray irradiation produced more significant changes in pure monocrystalline KCl than equivalent amounts of electron irradiation. Electron irradiation of pure and Eu-doped polycrystalline KCl produced increases in the absorption by as much as a factor of 20 over untreated material Bleaching of the electron-irradiated doped KCl with 649 millimicron light produced a further increase C.K.D.

N76-11421*# Itek Corp., Lexington, Mass
FEASIBILITY OF A 30-METER SPACE BASED LASER TRANSMITTER Final Report
R R Berggren and G E. Lenertz Oct 1975 111 p refs
(Contract NAS3-19400)
(NASA-CR-134903; Rept-8254-1) Avail NTIS HC $5.50 CSCL 20E

A study was made of the application of large expandable mirror structures in future space missions to establish the feasibility and define the potential of high power laser systems for such applications as propulsion and power transmission Application of these concepts requires a 30-meter diameter, diffraction limited mirror for transmission of the laser energy Three concepts for the transmitter are presented. These concepts include consideration of continuous as well as segmented mirror surfaces and the major stow-deployment categories of inflatable, variable geometry and assembled-in-space structures The mirror surface for each concept would be actively monitored and controlled to maintain diffraction limited performance at 10 6 microns during operation The proposed mirror configurations are based on existing aerospace state-of-the-art technology The assembled-in-space concept appears to be the most feasible, at this time Author

N76-19419*# Phaser Telepropulsion, Inc., Los Angeles, Calif
PERFORMANCE ANALYSIS OF A LASER PROPELLED INTERORBITAL TANSFER VEHICLE Final Report, 24 Jun. 1974 - 31 May 1975
M A Minovitch Feb 1976 143 p refs
(Contract NAS3-18536)
(NASA-CR-134966; Rept-2M833) Avail NTIS HC $6 00 CSCL 21C

Performance capabilities of a laser-propelled interorbital transfer vehicle receiving propulsive power from one ground-based transmitter was investigated The laser transmits propulsive energy to the vehicle during successive station fly-overs By applying a series of these propulsive maneuvers large payloads can be economically transferred between-low earth orbits and synchronous orbits Operations involving the injection of large payloads onto escape trajectories are also studied The duration of each successive engine burn must be carefully timed so that the vehicle reappears over the laser station to receive additional propulsive power within the shortest possible time The analytical solution for determining these time intervals is presented as a solution to the problem of determining maximum injection payloads. Parameteric computer analysis based on these optimization studies is presented The results show that relatively low beam powers, on the order of 50 MW to 60 MW, produce significant performance capabilities Author

N76-21521* Physical Sciences, Inc Wakefield, Mass
CONVERSION OF LASER ENERGY TO GAS KINETIC ENERGY
George E Caledonia *In* NASA Ames Res Center 2d NASA Conf on Laser Energy Conversion 1976 p 157-165 refs (For availability see N76-21505 12-36)
(Contract NAS3-18528)
CSCL 20E

Techniques for the gas phase absorption of laser radiation for ultimate conversion to gas kinetic energy are discussed Particular emphasis is placed on absorption by the vibration rotation bands of diatomic molecules at high pressures This high pressure absorption appears to offer efficient conversion of laser energy to gas-translational energy Bleaching and chemical effects are minimized and the variation of the total absorption coefficient with temperature is minimal Author

37 MECHANICAL ENGINEERING

Includes auxiliary systems (non-power); machine elements and processes; and mechanical equipment.

N76-10475*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
EFFECT OF STARVATION ON FILM THICKNESS AND TRACTION UNDER ELASTOHYDRODYNAMIC ROLLING-AND SLIDING CONDITIONS
Lavern D Wedeven Washington Oct 1975 41 p refs
(NASA-TN-D-8087; E-8412) Avail: NTIS HC $3.75 CSCL 11H

Traction measurements under starved elastohydrodynamic conditions were obtained for a point-contact geometry. Simultaneous measurements of the film thickness and the location of the inlet lubricant boundary were made. Optical interferometry was used to measure film thickness. The thickness of a starved film for combined rolling and sliding conditions varies with the location of the inlet boundary in the same way as previously found for pure rolling conditions. When the fluid velocity distribution is calculated in the inlet region by a Reynolds lubrication analysis, backflow is seen to occur over a portion of the inlet region. Backflow is essential for the establishment of a flooded condition. The location of certain fluid velocity conditions within the inlet region, as suggested in the literature, does not adequately describe the onset of starvation. For the same slide-roll ratio a starved film was observed to possess greater traction than a flooded film. Traction measurements under starved conditions were also compared with those under flooded conditions for equivalent shear rates in the Hertzian region. When the shear rates within the Hertzian region were low and the film was severely starved, the measured tractions were lower than expected. This may be due to large shear stresses developed by the large pressure gradients that are generated in the inlet region when it is severely starved. Author

N76-14461* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
APPARATUS FOR FORMING DISHED ION THRUSTER GRIDS Patent
Bruce A Banks, inventor (to NASA) Issued 28 Oct 1975 5 p Filed 22 Apr 1974 Supersedes N74-22147 (12 - 13, p 1561) Division of US Patent Appl SN-352381, filed 18 Apr 1973, US-Patent-3,864,797
(NASA-Case-LEW-11694-2; US-Patent-3,914,969, US-Patent-Appl-SN-462903, US-Patent-Class-72-63, US-Patent-Class-72-363, US-Patent-Class-29-421; US-Patent-Class-72-54, US-Patent-Appl-SN-352381, US-Patent-3,864,797) Avail: US Patent Office CSCL 13H

The patent of an invention dealing with an apparatus for forming dished ion thruster grids was reported. The apparatus consists in an assembly of grid blanks which is separated and covered by impervious metal sheets. The assembly is placed on top of an elastic sheet, and the assembled sheets are clamped at their edges, preventing random slippage and forming an expansible fluid chamber. Pressurized fluid in this chamber inflates the elastic sheet which, in turn, forces the impervious sheets and grid blanks to dish to their natural contour which is approximately hemispheroidal. The impervious sheet between the grid blanks prevents distortion caused by slight misalignment of the holes in the screen and accelerator grids. The dished grids are stress relieved simultaneously in matched dies. Author

N76-14466*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EXPERIMENTAL PERFORMANCE OF 75-MILLIMETER-BORE ARCHED OUTER-RACE BALL BEARINGS TO 2.1 MILLION DN
Harold H Coe Washington Jan 1976 17 p refs
(NASA-TN-D-8145, E-8504) Avail: NTIS HC $3.50 CSCL 13I

An experimental investigation was performed to determine the operating characteristics of arched outer-race bearings and to compare the data with those for a similar, but conventional, deep-groove ball bearing. The bearings were tested over a range of shaft speeds up to 28,000 rpm at a thrust load of 2200 newtons (500 lb). One bearing was operated at 26,000 rpm with a range of thrust loads. The amounts of arching were 0.13, 0.25, and 0.51 millimeter (0.005, 0.010, and 0.020 in.). All bearings operated satisfactorily; the arched bearing outer-race temperatures and torques were consistently higher than those for the conventional bearing. Author

N76-15461* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FLUID JOURNAL BEARINGS Patent
Frederick T Schuller and Warren A Moore, inventors (to NASA) Issued 16 Dec 1975 4 p Filed 25 Feb 1974 Supersedes N74-18134 (12 - 09, p 1055) Division of US Patent Appl SN-346483, filed 30 Mar 1973, US-Patent-3,830,552, which is a Division of US Patent Appl SN-238264, filed 27 Mar 1972, US-Patent-3,804,472
(NASA-Case-LEW-11076-4; US-Patent-3,926,482, US-Patent-Appl-SN-445178; US-Patent-Class-308-9, US-Patent-Class-308-72, US-Patent-Class-308-73; US-Patent-Class-308-122, US-Patent-Class-308-160, US-Patent-Appl-SN-346483, US-Patent-3,830,552, US-Patent-Appl-SN-238264, US-Patent-3,804,472) Avail: US Patent Office CSCL 13T

A plurality of bearing sectors are mounted on a housing. The sectors function as lobed areas in the bearing to obtain the required lubricant film geometry. Each sector has a pad flexibly mounted on a base with a thin neck which forms a pivot. Official Gazette of the U.S. Patent Office

N76-16447*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
D-1A NOSE FAIRING SEPARATION FITTING LOAD TEST
James O VanVleet Jan 1976 119 p
(NASA-TM-X-71862; E-8618) Avail: NTIS HC $5.50 CSCL 13E

Structural testing of the D-1A Centaur nose fairing was completed to determine the loads imposed during flight on the latch bolts of the fairing separation system. This testing was conducted to supplement and/or verify the analytic techniques used in calculating bolt loads for the D-1A, and to gain insight into the general structural behavior of separation latch systems. It was shown that the assumed bolt load magnification due to prying action of the latch fittings on the bolt does occur, but is strongly dependent on fairing shell stiffness. Author

N76-17400*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ISOTHERMAL ELASTOHYDRODYNAMIC LUBRICATION OF POINT CONTACTS. 2: ELLIPTICITY PARAMETER RESULTS
Bernhard J Hamrock and Duncan Dowson (Leeds Univ., England) Washington Feb 1976 21 p refs
(NASA-TN-D-8166; E-8467) Avail: NTIS HC $3.50 CSCL 13I

A numerical solution of the isothermal elastohydrodynamic problem for point contacts is presented which reproduces all the essential features of experimental observations based upon optical interferometry. In particular, the two side lobes in which minimum film thickness regions occur, emerge in the theoretical solutions. The influence of the ellipticity parameter on solutions to the point contact problem is explored. The ellipticity parameter k was varied from 1 (a ball on a plate) to 8 (a configuration approaching line contact). It is shown that the minimum film thickness can be related to the well known line contact solutions by a remarkably simple expression involving either k or the effective radius of curvature ratio R sub y/R sub x. Author

N76-17395*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ION PLATING WITH AN INDUCTION HEATING SOURCE
Talivaldis Spalvins and William A Brainard Washington Jan 1976 6 p
(NASA-TM-X-3330, E-8517) Avail NTIS HC $3 50 CSCL 13H

Induction heating is introduced as an evaporation heat source in ion plating A bare induction coil without shielding can be directly used in the glow discharge region with no arcing The only requirement is to utilize an rf inductive generator with low operating frequency of 75 kHz Mechanical simplicity of the ion plating apparatus and ease of operation is a great asset for industrial applications, practically any metal such as nickel, iron, and the high temperature refractories can be evaporated and ion plated Author

N76-17396*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland Ohio
KINEMATIC STABILITY OF ROLLER PAIRS IN FREE ROLLING CONTACT
Michael Savage and Stuart H Loewenthal Washington Feb 1976 19 p refs Prepared in cooperation with Army Air Mobility R and D Lab , Cleveland
(NASA-TN-D-8146; E-8419) Avail NTIS HC $3 50 CSCL 20K

A set of generalized stability equations was developed for roller pairs in free rolling contact A symmetric, dual contact model was used Four possible external contact profiles that possess continuous contacting surfaces were studied It was found that kinematic stability would be insured if the larger radius of transverse curvature, in absolute value, and the smaller rolling radius both exist on the roller that has the apex of its conical surface outboard of its main body The stability criteria developed are considered to be useful for assessing axial restraint requirements for a variety of roller mechanisms and in the selection of roller contact geometry for traction drive devices Author

N76-17399*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
DYNAMIC SEALING PRINCIPLES
John Zuk 1976 56 p refs Proposed for presentation at Conf on Theory and Pract of Lubrication, Dayton, Ohio, 26-29 Apr 1976, sponsored by Dayton Univ.
(NASA-TM-X-71851, E-8587) Avail: NTIS HC $4.50 CSCL 11A

The fundamental principles governing dynamic sealing operation are discussed Different seals are described in terms of these principles Despite the large variety of detailed construction, there appear to be some basic principles, or combinations of basic principles, by which all seals function, these are presented and discussed Theoretical and practical considerations in the application of these principles are discussed. Advantages, disadvantages, limitations, and application examples of various conventional and special seals are presented Fundamental equations governing liquid and gas flows in thin film seals, which enable leakage calculations to be made, are also presented Concept of flow functions, application of Reynolds lubrication equation and nonlubrication equation flow, friction and wear; and seal lubrication regimes are explained Author

N76-18458* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PROCESS FOR MAKING ANHYDROUS METAL HALIDES Patent
Warren H. Philipp Stanley J Marsik, and Charles E. May, inventors (to NASA) Issued 17 Feb. 1976 5 p Filed 27 Nov 1974 Supersedes N75-13053 (13 - 04, p 0396)
(NASA-Case-LEW-11860-1, US-Patent-3,939,048, US-Patent-Appl-SN-527728, US-Patent-Class-204-157 1H, US-Patent-Class-250-527) Avail US Patent Office CSCL 13H

A process for the preparation and isolation of high purity anhydrous lower valence state metal halides is reported that dissolves the corresponding higher valence state metal halide in an organic liquid, which is selected such that the higher valence state metal halide is soluble therein and the lower valence state metal halide is insoluble therein Subjecting the solution to high energy radiation reduces the higher valence state metal halide to its corresponding lower valence state metal halide, at a temperature in the range of from about 0 C to about room temperature Official Gazette of the U S Patent Office

N76-18498*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
DESIGN AND EVALUATION OF A 3 MILLION DN SERIES-HYBRID THRUST BEARING
Herbert W Scibbe, Leo W Winn (Mech Tech , Inc , Latham, N Y), and Martin Eusepi 1976 39 p refs To be presented at the Spring Lubrication Symp , Atlanta, 24-26 May 1976, sponsored by Am Soc Mech Engr
(NASA-TM-X-71873 E-8646) Avail NTIS HC $4 00 CSCL 13I

The bearing, consisting of a 150-mm ball bearing and a centrifugally actuated, conical, fluid-film bearing, was fatigue tested Test conditions were representative of a mainshaft ball bearing in a gas turbine engine operating at maximum thrust load to simulate aircraft takeoff conditions Tests were conducted up to 16000 rpm and at this speed an axial load of 15568 newtons (3500 lb) was safely supported by the hybrid bearing system Through the series-hybrid bearing principle, the effective ball bearing speed was reduced to approximately one-half of the shaft speed It was concluded that a speed reduction of this magnitude results in a ten-fold increase in the ball bearing fatigue life A successful evaluation of fluid-film bearing lubricant supply failure was performed repeatedly at an operating speed of 10,000 rpm, A complete and smooth changeover to full-scale ball bearing operation was effected when the oil supply to the fluid-film bearing was cut off Reactivation of the fluid-film oil supply system resulted in a flawless return to the original mode of hybrid operation Author

N76-18499*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ENDURANCE AND FAILURE CHARACTERISTICS OF MAIN-SHAFT JET ENGINE BEARINGS AT 3X10 TO THE 6TH POWER DN
E N Bamberger (General Elec Co , Evendale Ohio), E V Zaretsky, and H Signer (Ind Tectonics Inc , Compton, Calif) 1976 27 p refs To be presented at the Spring Lubrication Symp , Atlanta, 24-26 May 1976; sponsored by Am Soc Mech Engr
(NASA-TM-X-71877; E-8651) Avail NTIS HC $4 00 CSCL 13I

Groups of thirty 120-mm bore angular contact ball bearings were endurance tested at a speed of 12,000 and 25,000 rpm and a thrust load of 66 721 N. The bearings were manufactured from a single heat of VIM-VAR AISI M-50 steel. At 1.44X1 million and 3 0x1 million DN, 84 483 and 74 800 bearing test hours were accumulated, respectively. Test results were compared with similar bearings made from CVM AISI M-50 steel run under the same conditions Bearing lives at speeds of 3x1 million DN with the VIM-VAR AISI M-50 steel were nearly equivalent to those obtained at lower speeds A combined processing and material life factor of 44 was found for VIM-VAR AISI M-50 steel Continuous running after a spall has occurred at 3 0x1 million DN can result in a destructive fracture of the bearing inner race Author

N76-18503*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ROLLING-ELEMENT FATIGUE LIFE WITH TWO SYNTHETIC CYCLOALIPHATIC TRACTION FLUIDS
Stuart H Loewenthal and Richard J Parker Washington Mar 1976 17 p refs
(NASA-TN-D-8124, E-8457) Avail NTIS HC $3 50 CSCL 11H

The life potential of two synthetic cycloaliphatic hydrocarbon traction fluids in rolling element fatigue was evaluated in a five ball fatigue tester. Life comparisons with a MIL-L-23699 qualified tetraester oil showed that the traction test oils had good fatigue life performance, comparable to that of the tetraester

oil No statistically significant life differences between the traction fluids and the tetraester oil were exhibited under the accelerated fatigue test conditions Erratic operating behavior was occasionally encountered during tests with the antiwear additive containing traction fluid for reasons thought to be related to excessive chemical activity under high contact pressure This behavior occasionally resulted in premature test termination due to excessive surface distress and overheating Author

N76-19440*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
HYDROSTATIC BEARING SUPPORT Patent Application
R. E Cunningham, inventor (to NASA) Filed 2 Mar 1976 12 p
(NASA-Case-LEW-11158-1, US-Patent-Appl-SN-663008) Avail NTIS HC S3 50 CSCL 13I

A hydrostatic bearing support system is provided which comprises a bearing housing having a polygonally configured outer surface which defines at least three symmetrically disposed working faces and a plurality of pressure plates, each of which is disposed relatively opposite a corresponding working face and spaced therefrom to define a gap there between. A hydrostatic support film is created in the gap for supporting the housing in spaced relationship to the pressure plates NASA

N76-19460*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
SIMULATED STUDIES OF WEAR AND FRICTION IN TOTAL HIP PROSTHESIS COMPONENTS WITH VARIOUS BALL SIZES AND SURFACE FINISHES
Max A Swikert and Robert L Johnson Washington Mar 1976 27 p refs
(NASA-TN-D-8174, E-8528) Avail NTIS HC $4 00 CSCL 06B

Experiments were conducted on a newly designed total hip joint simulator. The apparatus closely simulates the complex motions and loads of the human hip in normal walking The wear and friction of presently used appliance configurations and materials were determined A surface treatment of the metal femoral ball specimens was applied to influence wear. The results of the investigation indicate that wear can be reduced by mechanical treatment of metal femoral ball surfaces A metallographic examination and surface roughness measurements were made Author

N76-19462*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FUNDAMENTALS OF FLUID SEALING
John Zuk Mar 1976 167 p refs
(NASA-TN-D-8151, E-6910) Avail NTIS HC $6 75 CSCL 11A

The fundamentals of fluid sealing, including seal operating regimes, are discussed and the general fluid-flow equations for fluid sealing are developed Seal performance parameters such as leakage and power loss are presented Included in the discussion are the effects of geometry, surface deformations, rotation, and both laminar and turbulent flows The concept of pressure balancing is presented, as are differences between liquid and gas sealing Mechanisms of seal surface separation, fundamental friction and wear concepts applicable to seals, seal materials, and pressure-velocity (PV) criteria are discussed Author

N76-20484*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FACE-SEAL LUBRICATION. 2: THEORY OF RESPONSE TO ANGULAR MISALIGNEMENT
Lawrence P Ludwig and Gordon P Allen Washington Mar 1976 26 p refs
(NASA-TN-D-8102, E-8410) Avail NTIS HC $4 00 CSCL 11A

A theoretical analysis was made of a hypothetical seal operating mode. The hypothetical seal model provides for three degrees of primary ring motion and includes the force and moments induced by primary ring response to seat angular misalignment This ring response causes a relative angular misalignment between the faces of the primary seal Hydrodynamic pressure generation is produced by this misalignment The analysis is based on the Reynolds equation in short bearing form and on a balance of forces and moments that arise from hydrodynamic and secondary seal friction effects A closed form solution was obtained that can be solved for film thickness and relative angular misalignment Author

N76-20486*# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio
CLOSED LOOP SPRAY COOLING APPARATUS Patent Application
Donald L Alger, William Schwab, and Edward R Furman, inventors (to NASA) Filed 31 Mar 1976 11 p
(NASA-Case-LEW-11981-1; US-Patent-Appl-SN-672220) Avail NTIS HC S3 50 CSCL 13I

A closed loop apparatus for spraying coolant against the back of a radiation target is described The coolant is circulated through a closed loop with a bubble of inert gas being maintained around the spray Mesh material is disposed between the bubble and the surface of the liquid coolant which is below the bubble at a predetermined level. In a second embodiment no inert gas is used, the bubble consisting of vapor produced when the coolant is sprayed against the target NASA

N76-20487*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
COUNTER PUMPING DEBRIS EXCLUDER AND SEPARATOR Patent Application
Lawrence P. Ludwig, inventor (to NASA) Filed 31 Mar 1976 13 p
(NASA-Case-LEW-11855-1; US-Patent-Appl-SN-672222) Avail NTIS HC $3 50 CSCL 13I

A dirt separator and excluder is described for removing entrained debris from gas turbine shaft seals 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 is 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 Since the outer groove pattern has a pumping direction opposite from that of the seal, dirt is pumped away from the seal and collected in a suitable debris trap NASA

N76-20488*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CIRCUMFERENTIAL SHAFT SEAL Patent Application
L P Ludwig, inventor (to NASA) Filed 31 Mar 1976 9 p
(NASA-Case-LEW-12119-1, US-Patent-Appl-SN-672219) Avail NTIS HC $3 50 CSCL 11A

A circumferential shaft seal comprising two sealing rings held to a rotating shaft by means of a surrounding elastomeric band is described The rings are segmented and are of a rigid sealing material such as carbon or a polyimide and graphite fiber composite NASA

N76-21556*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FRICTION AND WEAR OF TITANIUM ALLOYS AND COPPER ALLOYS SLIDING AGAINST TITANIUM 6-PERCENT-ALUMINUM - 4-PERCENT-VANADIUM ALLOY IN AIR AT 430 C
Donald W Wisander Washington Apr 1976 15 p refs

(NASA-TN-D-8207, E-8522) Avail NTIS HC $3 50 CSCL 20K

Experiments were conducted to determine the friction and wear characteristics of aluminum bronzes and copper-tin, titanium-tin, and copper-silver alloys sliding against a titanium-6% aluminum-4% vanadium alloy (Ti-6Al-4V) Hemispherically tipped riders of aluminum bronze and the titanium and copper alloys were run against Ti-6Al-4V disks in air at 430 C The sliding velocity was 13 cm/sec, and the load was 250 g Results revealed that high tin content titanium and copper alloys underwent significantly less wear and galling than commonly used aluminum bronzes Also friction force was less erratic than with the aluminum bronzes Author

N76-21560*# National Aeronautics and Space Administration, Lewis Research Center Cleveland, Ohio.

FACE-SEAL LUBRICATION: 1: PROPOSED AND PUBLISHED MODELS

Lawrence P Ludwig Washington Apr 1976 38 p refs (NASA-TN-D-8101, E-8460) Avail NTIS HC $4.00 CSCL 11A

The numerous published theories on the mechanism of hydrodynamic lubrication of face seals were reviewed These theories employ either an inclined-slider-bearing macrogeometry or an inclined-slider-bearing microgeometry to produce hydrodynamic pressure that separates the surfaces of the primary seal. Secondary seal friction and primary ring inertia effects are not considered Hypothetical seal operating models were devised to include secondary seal friction and primary ring inertia effects It was hypothesized that these effects induce relative angular misalinement of the primary seal faces and that this misalinement is, in effect, an inclined slider macrogeometry Stable running was postulated for some of these hypothetical operating models In others, periodic loss of hydrodynamic lubrication was postulated to be possible with certain combinations of waviness and angular misalinement. Application of restrictions that apply to seal operation led to a hydrodynamic governing equation for the new model that is a two-dimensional, time-dependent Reynolds equation with the short-bearing approximation Author

N76-22541* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

FLUID SEAL FOR ROTATING SHAFTS Patent

Lawrence P Ludwig inventor (to NASA) Issued 27 Apr 1976 6 p Filed 19 Feb 1975 Supersedes N75-18576 (13 - 10, p 1113)

(NASA-Case-LEW-11676-1, US-Patent-3,953 038 US-Patent-Appl-SN-551184, US-Patent-Class-277-93R US-Patent-Class-277-4 US-Patent-Class-277-41, US-Patent-Class-277-74) Avail US Patent Office CSCL 11A

An improved fluid seal for a rotating shaft is provided which includes an inner annular ring or runner adapted to be secured to the rotating shaft and a composite sealing ring which is keyed to the inner ring and includes a radial sealing surface An outer, nonrotating, annular ring or housing which is concentrically disposed with respect to the runner and sealing ring includes a radial sealing surface which engages the sealing surface of the sealing ring A circular wave spring is anchored to the housing and is disposed between the composite sealing ring and a snap ring secured to the housing: an axial force is provided which forces the two sealing surfaces into sealing contact. The waves of the spring act as individual hydrodynamic bearings, and the axial force is transmitted across an oil film This eliminates rubbing contact and the need for a separate thrust bearing

Official Gazette of the U S Patent Office

N76-23570* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

METHOD OF MAKING AN APERTURED CASTING Patent

Andrew Terray, inventor (to NASA) Issued 18 May 1976 4 p Filed 27 Feb 1974 Supersedes N74-18131 (12 - 09, p 1055)

(NASA-Case-LEW-11169-1, US-Patent-3,957,104; US-Patent-Appl-SN-446568, US-Patent-Class-164-132) Avail US Patent Office CSCL 13H

An apertured casting is made by first forming a duplicate in the shape of the finished casting, positioning refractory metal bodies such as wires in the duplicate at points corresponding to apertures or passageways in finished products, forming a ceramic coating on the duplicate, removing the duplicate material, firing the ceramic in a vacuum or inert atmosphere, vacuum casting the metal in the ceramic form, removing the ceramic form, heating the cast object in an atmospheric furnace to oxidize the refractory metal bodies and then leaching the oxidized refractory bodies from the casting with a molten caustic agent or acid solution

Official Gazette of the U S Patent Office

N76-23582*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

OIL-AIR MIST LUBRICATION AS AN EMERGENCY SYSTEM AND AS A PRIMARY LUBRICATION SYSTEM

William R Loomis May 1976 19 p refs (NASA-TM-X-71892, E-8678) Avail NTIS HC $3 50 CSCL 13I

The feasibility of an emergency aspirator once-through lubrication system was demonstrated as a viable survivability concept for Army helicopter mainshaft engine bearings for periods as long as 30 minutes It was also shown in an experimental study using a 46-mm bore bearing test machine that an oil-air mist once-through system with auxiliary air cooling is an effective primary lubrication system at speeds up to 2,500,000 DN for extended operating periods of at least 50 hours Author

N76-23583*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EXPERIMENTAL EVALUATION OF TWO PREMIXING-PREVAPORIZING FUEL INJECTION CONCEPTS FOR A GAS TURBINE CATALYTIC COMBUSTOR

Robert Tacina 1976 15 p refs Presented at Catalytic Combustor Workshop, Raleigh, N C, 25-26 May 1776, sponsored by EPA (NASA-TM-X-73422, E-8760) Avail NTIS HC $3 50 CSCL 21E

A premixing-prevaporizing fuel system to be used with a catalytic combustor was evaluated for possible application in an automotive gas turbine Spatial fuel distribution and degree of vaporization were measured using jet A fuel Two types of air blast injectors were tested, a splash groove injector and a multiple jet cross stream injector Air swirlers with vane angles of 15 deg and 30 deg were used to improve the spatial fuel distribution in a 12 cm diameter tubular rig Distribution and vaporization measurements were made 35 5 cm downstream of the injector The spatial fuel distribution was nearly uniform with the multiple jet contrastream injector and the splash-groove injector with a 30 deg air swirler The vaporization was nearly 100 percent at an inlet air temperature of 600 K, and at 800 K inlet air temperature fuel oxidation reactions were observed The total pressure loss was less than 0 5 percent of the total pressure for the multiple jet cross stream injector and the splash groove injector (without air swirler) and less than 1 percent for the splash groove with a 30 deg air swirler Author

N76-24588*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

ANALYSIS AND DESIGN OF A CANTILEVER-MOUNTED RESILIENT-PAD GAS-LUBRICATED THRUST BEARING

Izhak Etsion Washington May 1976 22 p refs (NASA-TN-D-8221, E-8667) Avail NTIS HC $3 50 CSCL 13I

A thrust bearing consisting of pads mounted on resilient metallic, cantilever beams is described and analyzed Compliance and stiffness of the bearing assembly are discussed, and the effects of bearing design parameters on performance are shown. After the general analysis, a design example is presented for a flat sector-shaped gas bearing A special case where zero axial movement of the runner can be obtained is pointed out. Author

N76-26510*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
MICROECONOMIC ANALYSIS OF MILITARY AIRCRAFT BEARING RESTORATION
Gerald F. Hein 1976 20 p refs Presented at Bearing Restoration by Grinding Seminar, St Louis, 20-21 May 1976, sponsored by Army Aviation Systems Command and NASA, Lewis
(NASA-TM-X-73439; E-8728) Avail: NTIS HC $3.50 CSCL 13I

The risk and cost of a bearing restoration by grinding program was analyzed. A microeconomic impact analysis was performed. The annual cost savings to U.S. Army aviation is approximately $950,000.00 for three engines and three transmissions. The capital value over an indefinite life is approximately ten million dollars. The annual cost savings for U.S. Air Force engines are approximately $313,000.00 with a capital value of approximately 3.1 million dollars. Author

N76-26512*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EVALUATION OF BALL AND ROLLER BEARINGS RESTORED BY GRINDING
R. J. Parker, E. V. Zaretsky, and S. M. Chen (Army Aviations Systems Command, St. Louis) 1976 35 p refs Presented at Bearing Restoration by Grinding Seminar, St. Louis, 20-21 May 1976; sponsored by Army Aviation Systems Command and NASA, Lewis
(NASA-TM-X-73440, E-8728b) Avail. NTIS HC $4.00 CSCL 13I

The restoration by grinding of those rolling element bearings which are currently being discarded at aircraft engine and transmission overhaul is considered. Three bearing types were selected from the UH-1 helicopter engine and transmission for the pilot program. Groups of each of these bearings were visually and dimensionally inspected for suitability for restoration. A total of 250 bearings were restored by grinding. Of this number, 30 bearings from each type were endurance tested to a TBO of 1600 hours. No bearing failures occurred related to the restoration by grinding process. The two bearing failures which occurred were due to defective rolling elements and were typical of those which may occur in new bearings. The restorable component yield to the three groups was in excess of 90 percent. Author

N76-26513*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PERFORMANCE OF 75 MILLIMETER-BORE ARCHED OUTER-RACE BALL BEARINGS
Harold H. Coe and Bernard J. Hamrock 1976 23 p refs Proposed for presentation at Joint Lubrication Conf., Boston, 5-7 Oct. 1976, sponsored by ASME and Am. Soc. of Lubrication Engrs
(NASA-TM-X-73442, E-8504) Avail: NTIS HC $3.50 CSCL 13I

An investigation was performed to determine the operating characteristics of 75-mm bore, arched outer-race bearings, and to compare the data with those for a similar, but conventional, deep groove ball bearing. Further, results of an analytical study, made using a computer program developed previously, were compared with the experimental data. Bearings were tested up to 28,000 rpm shaft speed with a load of 2200 N (500 lb). The amount of arching was 0.13, 0.25, and 0.51 mm (.005, .010, and .020 in.). All bearings operated satisfactorily. The outer-race temperatures and the torques, however, were consistently higher for the arched bearings than for the conventional bearing. Author

N76-26515*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EXPERIMENTAL DYNAMIC STIFFNESS AND DAMPING OF EXTERNALLY PRESSURIZED GAS-LUBRICATED JOURNAL BEARINGS
David P. Fleming, William J. Thayer, and Robert E. Cunningham Washington Jun. 1976 28 p refs Prepared in cooperation with Army Air Mobility R and D Lab., Cleveland
(NASA-TN-D-8270, E-8636) Avail: NTIS HC $4.00 CSCL 13I

A rigid vertical shaft was operated with known amounts of unbalance at speeds to 30,000 rpm and gas supply pressure ratios to 4.8. From measured amplitude and phase angle data, dynamic stiffness and damping coefficients of the bearings were determined. The measured stiffness was proportional to the supply pressure, while damping was little affected by supply pressure. Damping dropped rapidly as the fractional frequency whirl threshold was approached. A small-eccentricity analysis overpredicted the stiffness by 20 to 70 percent. Predicted damping was lower than measured at low speeds but higher at high speeds. Author

N76-26516*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ANALYSIS OF THE GAS-LUBRICATED FLAT-SECTOR-PAD THRUST BEARING
Izhak Etsion Washington Jun. 1976 29 p refs
(NASA-TN-D-8220, E-8623) Avail: NTIS HC $4.00 CSCL 13I

A flat sector-shaped pad geometry for a gas-lubricated thrust bearing is analyzed considering both the pitch and roll of the pad. It is shown that maximum load capacity is achieved when the pad is tilted so as to create uniform minimum film thickness along the pad trailing edge. Performance characteristics for various geometries and operating conditions of gas thrust bearings are presented in the form of design curves, and a comparison is made with the rectangular slider approximation. It is found that this approximation is unsafe for practical design, since it always overestimates load capacity. Author

N76-26517*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
SIMPLIFIED SOLUTION FOR POINT CONTACT DEFORMATION BETWEEN TWO ELASTIC SOLIDS
David E. Brewe and Bernard J. Hamrock Washington Jun. 1976 8 p refs Prepared in cooperation with Army Air Mobility R and D Lab., Cleveland
(NASA-TM-X-3407, E-8711) Avail: NTIS HC $3.50 CSCL 13I

A linear-regression by the method of least squares is made on the geometric variables that occur in the equation for point 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). These simplified equations enable one to calculate easily the point-contact deformation to within 3 percent without resorting to charts or numerical methods. Author

N76-27569*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
DYNAMICS OF SOLID LUBRICATION AS OBSERVED BY OPTICAL MICROSCOPY
Harold E. Sliney 1976 22 p refs Proposed for presentation at the Joint Lubrication Conf., Boston, 5-7 Oct. 1976, sponsored by the Am. Soc. of Mech. Engineers and the Am. Soc. of Lubrication Engineers
(NASA-TM-X-71880; E-8653) Avail: NTIS HC $3.50 CSCL 11H

A bench metallograph was converted into a micro contact imager by the addition of a tribometer employing a steel ball in sliding contact with a glass disk. The sliding contact was viewed in real time by means of projection microscope optics. The dynamics of abrasive particles and of solid lubricant particles within the contact were observed in detail. The contact was characterized by a constantly changing pattern of elastic strain with the passage of surface discontinuities and solid particles. Abrasive particles fragmented upon entering the contact, embedded in one surface and scratched the other; in contrast, the solid lubricant particles flowed plastically into thin films. The rheological behavior of the lubricating solids gave every appearance of a paste-like consistency within the Hertzian contact. Author

N76-27570*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ROLLING-ELEMENT FATIGUE LIVES OF AISI 52100 STEEL BALLS WITH SEVERAL SYNTHETIC LUBRICANTS
Richard J Parker 1976 22 p refs Proposed for presentation at the Inst of Petroleum Symp on Rolling-Element Fatigue Performance Testing of Lubricants London, 13-14 Oct 1976
(NASA-TM-X-73406, E-8731) Avail NTIS HC $3 50 CSCL 13I

Rolling-element fatigue tests were run with three synthetic lubricants with and without antiwear additives and with a paraffinic mineral oil at race temperatures of 336 to 353 K (146 146 to 175 F). The five-ball fatigue tester was used with steel balls to evaluate the relative fatigue lives with each of six lubricant-additive combinations The tests were run at 5,520 MPa (800 000psi) maximum Hertz stress, 10,000 rpm shaft speed, and 30 deg contact angle The lubricants tested have similar kinetic viscosities at 372 K (210 F) ranging from 0 034 to 0 089 sq cm/sec (3 4 to 8 9 cS) At these conditions, the mode of failure in the five-ball fatigue tester was classical subsurface rolling-element fatigue The baseline for comparison of fatigue life was the paraffinic mineral oil without additives The effects of the synthetic lubricants and their additives which are useful for boundary lubrication, oxidation or foam inhibition, were evaluated Author

N76-27571*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ELASTOHYDRODYNAMIC LUBRICATION OF POINT CONTACTS Ph.D. Thesis - Leeds Univ.
B. J Hamrock Jun. 1976 275 p refs
(NASA-TM-X-73454, E-7964) Avail NTIS HC $9 00 CSCL 11H

A procedure for the numerical solution of the complete isothermal, elastohydrodynamic lubrication problem for point contacts is given This procedure calls for the simultaneous solution of the elasticity and Reynolds equations By using this theory the influence of the ellipticity parameter and the dimensionless speed load, and material parameters on the minimum and central film thicknesses was investigated Thirty-four different cases were used in obtaining the fully flooded minimum- and central-film-thickness formulas Lubricant starvation was also studied From the results it was possible to express the minimum film thickness for a starved condition in terms of the minimum film thickness for a fully flooded condition, the speed parameter, and the inlet distance Fifteen additional cases plus three fully flooded cases were used in obtaining this formula Contour plots of pressure and film thickness in and around the contact have been presented for both fully flooded and starved lubrication conditions Author

N76-29588* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THRUST BEARING Patent
William J Anderson, inventor (to NASA) Issued 27 Jul. 1976 6 p Filed 25 Jun 1975 Supersedes N75-26378 (13 - 17, p 2123)
(NASA-Case-LEW-11949-1, US-Patent-3,971,602, US-Patent-Appl-SN-590182; US-Patent-Class-308-160, US-Patent-Class-308-163, US-Patent-Class-308-170) Avail US Patent Office CSCL 13I

A gas lubricated thrust bearing is described which employs relatively rigid inwardly cantilevered spokes carrying a relatively resilient annular member or annulus This annulus acts as a beam on which are mounted bearing pads The resilience of the beam mount causes the pads to accept the load and, with proper design, responds to a rotating thrust-transmitting collar by creating a gas film between the pads and the thrust collar. The bearing may be arranged for load equalization thereby avoiding the necessity of gimbal mounts or the like for the bearing It may also be arranged to respond to rotation in one or both directions Official Gazette of the U S. Patent Office

N76-29598*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
DUAL-ACTION GAS THRUST BEARING FOR IMPROVING LOAD CAPACITY
Izhak Etsion Washington Jul 1976 18 p refs
(NASA-TN-D-8279, E-8701) Avail NTIS HC $3 50 CSCL 13I

The principle of utilizing hydrodynamic effects in diverging films to improve the load carrying capacity in gas thrust bearings is discussed A new concept of a dual action bearing based on that principle is described and analyzed The potential of the new bearing is demonstrated both analytically for an infinitely long slider and by numerical solution for a flat sector shaped thrust bearing It is shown that the dual action bearing can extend substantially the range of load carrying capacity in gas lubricated thrust-bearings and can improve their efficiency Author

N76-30565*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CERAMIC THERMAL-BARRIER COATINGS FOR COOLED TURBINES
Curt H Liebert and Francis S Stepka 1976 14 p refs Presented at 12th Propulsion Conf., Palo Alto, Calif., 26-29 Jul 1976; sponsored by AIAA and SAE
(NASA-TM-X-73426, E-8766) Avail NTIS HC $3 50 CSCL 21E

Coating systems consisting of a plasma sprayed layer of zirconia stabilized with either yttria, magnesia or calcia over a thin alloy bond coat have been developed, their potential was analyzed and their durability and benefits evaluated in a turbojet engine The coatings on air cooled rotating blades were in good condition after completing as many as 500 two-minute cycles of engine operation between full power at a gas temperature of 1644 K and flameout, or as much as 150 hours of steady state operation on cooled vanes and blades at gas temperatures as high as 1644 K with 35 start and stop cycles On the basis of durability and processing cost, the yttria stabilized zirconia was considered the best of the three coatings investigated Author

N76-33508*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FLEXURAL FATIGUE OF HOLLOW ROLLING ELEMENTS
Eric N Bamberger, Richard J Parker, and Marshall W Dietrich Washington Oct. 1976 24 p refs
(NASA-TN-D-8313, E-8621) Avail NTIS HC $3 50 CSCL 13I

Hollow cylindrical bars were tested in the rolling-contact fatigue tester to determine the effects of material and outside diameter to inside diameter (OD/ID) ratios of 2 0, 1 6, 1 4, and 1 2 on fatigue failure mode and subsequent failure propagation The range of applied loads with these OD/ID ratios resulted in maximum tangential tensile stresses ranging from 165 to 655 megapascals (24,000 to 95,000 psi) at the bore surface Flexural failures of the hollow test bars occurred when this bore stress was 490 megapascals (71,000 psi) or greater with AISI 52100 hollow bars and 338 megapascals (49,000 psi) 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 previously published full scale bearing tests Author

N76-33509*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
ISOTHERMAL ELASTOHYDRODYNAMIC LUBRICATION OF POINT CONTACTS. 4: STARVATION RESULTS
Bernard J. Hamrock and Duncan Dowson Washington Oct 1976 33 p refs
(NASA-TN-D-8318, E-8733) Avail NTIS HC $4 00 CSCL 13I

The influence of lubricant starvation on minimum film thickness was investigated by moving the inlet boundary closer to the contact center The following expression was derived for the dimensionless inlet distance at the boundary between the fully flooded and starved conditions $m^* = 1 + 3.06((R/b)(R/b)H)$ to the power 0 58, where R is the effective radius of curvature, b is the semiminor axis of the contact ellipse, and H is the central film thickness for fully flooded conditions A corresponding

expression was also given based on the minimum film thickness for fully flooded conditions Therefore, for $m < m^*$, starvation occurs and, for $m > m^*$, a fully flooded condition exists Two other expressions were also derived for the central and minimum film thicknesses for a starved condition Contour plots of the pressure and the film thickness in and around the contact are shown for the fully flooded and starved lubricating conditions, from which the film thickness was observed to decrease substantially as starvation increases Author

A76-14639 * # **Design of a squeeze-film damper for a multi-mass flexible rotor.** R. E. Cunningham, D. P. Fleming (NASA, Lewis Research Center, Cleveland, Ohio), and E. J Gunter (Virginia, University, Charlottesville, Va.). *(American Society of Mechanical Engineers, Design Engineering Technical Conference, Washington, D.C., Sept. 17-19, 1975, Paper 75-DET-40.) ASME, Transactions, Series B - Journal of Engineering for Industry,* vol. 97, Nov. 1975, p. 1383-1389. 10 refs.

A single mass flexible rotor analysis was used to optimize the stiffness and damping of a flexible support for a symmetric five-mass rotor. The flexible support attenuates the rotor motions and forces transmitted to the support bearings when the rotor operates through and above its first bending critical speed An oil squeeze-film damper was designed based on short bearing lubrication theory. The damper design was verified by an unbalance response computer program Rotor amplitudes were reduced by a factor of 16 and loads reduced by a factor of 36 compared with the same rotor on rigid bearing supports. (Author)

A76-14640 * # **Dynamic behavior of an inherently compensated air squeeze film damper.** R. E. Cunningham (NASA, Lewis Research Center, Cleveland, Ohio). *(American Society of Mechanical Engineers, Design Engineering Technical Conference, Washington, D.C., Sept. 17-19, 1975, Paper 75-DET-59.) ASME, Transactions, Series B - Journal of Engineering for Industry,* vol. 97, Nov. 1975, p. 1399-1404. 13 refs.

Experimental values of damping and stiffness were determined for an externally pressurized, inherently compensated, compressible squeeze-film damper up to excitation frequencies of 36,000 cycles/min Experimental values of damping were higher than predicted by a small pressure perturbation theory at low squeeze numbers and less than predicted at high squeeze numbers. Experimental values of air film stiffness were less than the theory predicted at low squeeze numbers and much greater at higher squeeze numbers (Author)

A76-14862 * # **Bending stresses in spherically hollow ball bearing and fatigue experiments.** L. J. Nypan (NASA, Lewis Research Center, Cleveland, Ohio; California State University, Northridge, Calif.), H. H. Coe, and R. J Parker (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Mechanical Engineers and American Society of Lubrication Engineers, Joint Lubrication Conference, Miami Beach, Fla., Oct. 21-23, 1975, ASME Paper 75-Lub-8.* 4 p 11 refs. Members, $1 50, nonmembers, $3 00.

Spherically hollow balls of 21.7, 50.0 and 56.5 per cent mass reduction have been operated in ball bearings and in a 5-ball fatigue tester with differing outcomes Available theoretical and experimental treatments of stresses in spherically hollow balls are reviewed and compared. Bending stresses are estimated for these spherically hollow balls to better understand the differences in ball bearing and fatigue test experience. (Author)

A76-14864 * # **Isothermal elastohydrodynamic lubrication of point contacts. II - Ellipticity parameter results.** B J. Hamrock (NASA, Lewis Research Center, Cleveland, Ohio) and D Dowson (Leeds University, Leeds, England). *American Society of Mechanical Engineers and American Society of Lubrication Engineers, Joint Lubrication Conference, Miami Beach, Fla , Oct 21-23, 1975, ASME Paper 75-Lub-12.* 7 p. 13 refs Members, $1.50; nonmembers, $3 00.

A numerical solution of the isothermal elastohydrodynamic problem for point contacts has been presented which reproduces all the essential features of the previously reported experimental observations based upon optical interferometry In particular, the two 'side lobes' in which minimum film thickness regions occur are shown to emerge in the theoretical solutions. The influence of the ellipticity parameter upon solutions to the point contact problem has been explored in the present paper. The ellipticity parameter (k) was varied from one (a ball on a plate) to eight (a configuration approaching line contact), and it has been shown that both the central and minimum film thicknesses can be related to the well known line contact solutions by remarkably simple expressions involving either (k) or the effective radius of curvature ratio (Ry/Rx). (Author)

A76-14865 * # **Isothermal elastohydrodynamic lubrication of point contacts. I - Theoretical formulation.** B. J. Hamrock (NASA, Lewis Research Center, Cleveland, Ohio) and D. Dowson (Leeds University, Leeds, England). *American Society of Mechanical Engineers and American Society of Lubrication Engineers, Joint Lubrication Conference, Miami Beach, Fla., Oct 21-23, 1975, ASME Paper 75-Lub-11* 6 p. 14 refs. Members, $1.50; nonmembers, $3 00.

The analysis of an isothermal elastohydrodynamic lubrication (EHL) point contact was evaluated numerically This required the simultaneous solution of the elasticity and Reynolds equations. In the elasticity analysis the contact zone is divided into equal rectangular areas and it is assumed that a uniform pressure is applied over each element. In the numerical analysis of the Reynolds' equation a phi analysis where phi is equal to the pressure times the film thickness to the 3/2 power is used to help the relaxation process The EHL point contact analysis is applicable for the entire range of elliptical parameters and is valid for any combination of rolling and sliding within the contact. (Author)

A76-14871 * # **Dynamic capacity and surface fatigue life for spur and helical gears.** J. J. Coy (U.S. Army, Air Mobility Research and Development Laboratory, Cleveland, Ohio), D. P. Townsend, and E. V Zaretsky (NASA, Lewis Research Center, Cleveland, Ohio) *American Society of Mechanical Engineers and American Society of Lubrication Engineers, Joint Lubrication Conference, Miami Beach, Fla., Oct. 21-23, 1975, ASME Paper 75-Lub-19.* 8 p. 30 refs. Members, $1.50; nonmembers, $3.00.

A mathematical model for surface fatigue life of gear, pinion, or entire meshing gear train is given. The theory is based on the statistical approach used by Lundberg and Palmgren for rolling-element bearings Also equations are presented which give the dynamic capacity of the gear set. The dynamic capacity is the transmitted tangential load which gives a 90 percent probability of survival of the gear set for one million pinion revolutions. The analytical results were compared with test data for a set of AISI 9310 spur gears operating at a maximum Hertz stress of 1.71 billion N per sq m (248,000 psi) and 10,000 rpm. The theoretical life predictions were very good when material constants obtained from rolling-element bearing tests were used in the gear life model. (Author)

A76-14872 * # **A life study of ausforged, standard forged, and standard machined AISI M-50 spur gears.** D P. Townsend, E V. Zaretsky (NASA, Lewis Research Center, Cleveland, Ohio), and E. N Bamberger (General Electric Co., Evendale, Ohio). *American Society of Mechanical Engineers and American Society of Lubrication Engineers, Joint Lubrication Conference, Miami Beach, Fla , Oct. 21-23, 1975, ASME Paper 75-Lub-20.* 8 p. 24 refs Members, $1.50; nonmembers, $3.00.

Tests were conducted at 350 K with three groups of 8.9 cm pitch diameter spur gears made of vacuum-induction melted (VIM), vacuum-arc remelted (VAR), AISI M-50 steel and one group of vacuum-arc remelted (VAR) AISI 9310 steel. The pitting fatigue life of the standard forged and ausforged gears was approximately five times that of the VAR AISI 9310 gears and ten times that of the

bending fatigue life of the standard machined VIM-VAR AISI M-50 gears run under identical conditions. There was a slight decrease in the 10-percent life of the ausforged gears from that for the standard forged gears. However, the difference is not statistically significant. The standard machined gears failed primarily by gear tooth fracture while the forged and ausforged VIM-VAR AISI M-50 and the VAR AISI 9310 gears failed primarily by surface pitting fatigue. The ausforged gears had a slightly greater tendency to fail by tooth fracture than the standard forged gears. (Author)

A76-14873 * # **Operating limitations of high-speed jet-lubricated ball bearings.** E. V Zaretsky (NASA, Lewis Research Center, Cleveland, Ohio), H. Signer (Industrial Tectonics, Inc., Compton, Calif.), and E. N Bamberger (General Electric Co., Cincinnati, Ohio) *American Society of Mechanical Engineers and American Society of Lubrication Engineers, Joint Lubrication Conference, Miami Beach, Fla., Oct. 21-23, 1975, ASME Paper 75-Lub-21.* 8 p. 13 refs. Members, $1.50; nonmembers, $3 00.

A parametric study was performed with 120-mm bore angular-contact ball bearings having a nominal contact angle of 20 deg. The bearings either had an inner- or an outer-race land riding cage. Lubrication was by recirculating oil jets. The oil jets either had a single or dual orifice Thrust load, speed, and lubricant flow rate were varied. Test results were compared with those previously reported and obtained from bearings of the same design which were under-race lubricated but run under the same conditions. Jet lubricated ball bearings were limited to speeds less than 2,500,000 DN. Bearings having inner-race land riding cages produced lower temperatures than bearings with outer-race land riding cages For a given lubricant flow rate dual orifice jets produced lower bearing temperatures than single orifice jets. However, under-race lubrication produced under all conditions of operation lower bearing temperatures with no apparent bearing speed limitation. (Author)

A76-18510 * # **Wear and interfacial transport of material.** D. H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio). *American Vacuum Society, National Vacuum Symposium, 22nd, Philadelphia, Pa., Oct. 28-31, 1975, Paper.* 30 p. 19 refs

The paper is a review of adhesion or bonding across an interface between two solids in contact, transfer or transport to one or both surfaces, wear with tangential motion, and the effect of surface films on adhesion, transfer, and wear. The discussion is limited to the case of adhesive wear which deals with the interfacial transport of material from one surface to another. The data presented suggest that the resulting interfacial adhesive bond for metals in contact is generally stronger than the cohesive bond in the cohesively weaker of the two materials so that upon separation of the surfaces transfer will occur from the cohesively weaker material to the cohesively stronger; that with tangential motion of two metal surfaces in contact such as encountered with sliding, rolling, or rubbing contact, the frictional energy can be dissipated in a number of ways, where heating of the surfaces can produce metallurgical changes such as alloying; and that the presence of adsorbed and reacted films on the surface of metals and alloys even in fractions of a monolayer can reduce interfacial bonding, adhesion, and transfer. S.D.

A76-20723 * # **Experimental evaluation of multiplane-multispeed rotor balancing through multiple critical speeds.** J. M. Tessarzik, R. H. Badgley (Mechanical Technology, Inc., Latham, N.Y.), and D. P Fleming (NASA, Lewis Research Center, Bearings and Mechanical Power Transfer Branch, Cleveland, Ohio). *American Society of Mechanical Engineers, Design Engineering Technical Conference, Washington, D.C., Sept. 17-19, 1975, Paper 75-DET-73.* 11 p. 18 refs. Members, $1.00; nonmembers, $3.00. Contract No. NAS3-14420.

The experimentally proven range of application of the influence-coefficient balancing method, especially the least-squares procedure, is extended to include the case of multiple bending critical speeds within the operating range of a test rotor Tests were conducted on a laboratory quality machine capable of speeds up to 18,000 rpm in order to investigate several distinct practical aspects of flexible-rotor balancing These include (1) balancing for operation through four bending critical speeds, (2) balancing of rotors mounted in both rigid and flexible bearing supports, (3) balancing of rotors with various amounts of measured vibration-response data and different numbers of correction planes, and (4) balancing of rotors with different arbitrary initial-unbalance configurations The results show that a lightly damped, flexible rotor can be balanced systematically and efficiently through four bending critical speeds. It is concluded that the influence-coefficient method should be equally applicable to rotors or shafts having more than four bending critical speeds in their operating-speed ranges. F.G.M

A76-27750 * **Spherical artifacts on ferrograms.** W. R. Jones, Jr. (NASA, Lewis Research Center, Cleveland, Ohio). *Wear,* vol. 37, Apr. 1976, p. 193-195. 9 refs.

In the past, hollow spheres detected on ferrograms have been interpreted as being due to fretting, abrasion, cavitation erosion, and fatigue-related processes Here it is reported that such spheres were found to result from the fact that a routine grinding operation on a steel plate was carried out about 20 feet away from the ferrograph. A similar grinding operation was performed on a piece of low carbon steel a few feet from the ferrograph, and after a few minutes of grinding, the resulting ferrogram contained thousands of particles of which more than 90% were spherical. Because of the widespread occurrence of ordinary grinding operations, it seems prudent that those utilizing the ferrograph be cognizant of this type of artifact. P.T.H.

A76-31511 * " Dynamic sealing principles J Zuk (NASA, Lewis Research Center, Cleveland, Ohio). *University of Dayton, Conference on Theory and Practice of Lubrication, Dayton, Ohio, Apr. 26-29, 1976, Paper* 55 p 27 refs.

The fundamental principles governing dynamic sealing operation are discussed Different seals are described in terms of these principles Despite the large variety of detailed construction, there appear to be some basic principles, or combinations of basic principles, by which all seals function They are (1) selection and control of seal geometry, (2) control of leakage-fluid properties, and (3) control of forces acting on leakage fluids Theoretical and practical considerations in the application of these principles are discussed Advantages, disadvantages, limitations, and application examples of various conventional and special seals are presented Fundamental equations governing liquid and gas flows in thin-film seals, which enable leakage calculations to be made, are also presented. (Author)

A76-39347 * # Leakage-free journal bearings O. Pinkus (Mechanical Technology, Inc., Latham, N.Y.) and I Etsion (NASA, Lewis Research Center, Cleveland, Ohio) *(American Society of Mechanical Engineers, Paper 76-Lub-F,* 1976) *ASME, Transactions, Series F - Journal of Lubrication Technology,* vol 98, July 1976, p. 441-445, 471 5 refs.

A new concept of a journal bearing is developed which prevents side leakage of the lubricant, thus eliminating the need for sealing and collecting this leakage The cooling of the bearing is accomplished by the prevailing circumferential flow. An analysis is performed and solutions are given for the bearing geometries and inlet pressures required to achieve the above purpose (Author)

A76 43147 * # **The metal to metal interface and its effect on adhesion and friction** D. H. Buckley (NASA, Lewis Research Center, Cleveland, Ohio) *American Chemical Society and International Union of Pure and Applied Chemistry, International Conference on Colloids and Surfaces, San Juan, P R., June 21-25, 1976, Paper* 38 p 26 refs.

The paper considers the interface between two bulk metals and the effect of this interface on adhesive bonding, resistance to

tangential displacements, friction and the interfacial transport from one surface to another. Using Auger emission spectroscopy, field ion microscopy, and low energy electron diffraction techniques, the influence of surface orientation, lattice registry, crystal lattice structure and defects, metal surface chemistry and alloying on the characteristics of the interface was studied for noble, platinum, transition, and Group 4B metals. With dissimilar metals in contact, epitaxial transfer of the cohesively weaker to the cohesively stronger metal has been observed. Surface-chemical activity of-the-noble and platinum metals is shown to affect interfacial behavior as does a valence bonding in the transition metals, and the degree of metallic nature in the Group 4B elements Alloying elements, e.g , Si and Fe, can alter interfacial behavior by segregation to the surface of metals or by altering bulk properties such as crystal transformation kinetics.
S N

A76-43148 * # Evaluation of ball and roller bearings restored by grinding R. J Parker, E V Zaretsky (NASA, Lewis Research Center, Cleveland, Ohio), and S. M. Chen (NASA, Lewis Research Center, Cleveland, Ohio, U.S. Army, Aviations Systems Command, St Louis, Mo.) *U.S Army and NASA Lewis Research Center, Bearing Restoration by Grinding Seminar, St. Louis, Mo , May 20, 21, 1976, Paper.* 35 p 18 refs.

A joint program was undertaken to restore by grinding those rolling-element bearings which are currently being discarded at aircraft engine and transmission overhaul. Three bearing types were selected from the UH-1 helicopter engine (T-53) and transmission for the pilot program Groups of each of these bearings were visually and dimensionally inspected for suitability for restoration A total of 250 bearings were restored by grinding Of this number, 30 bearings from each type were endurance tested to a TBO of 1600 hours. No bearing failures occurred related to the restoration by grinding process. The two bearing failures which occurred were due to defective rolling elements and were typical of those which may occur in new bearings The restorable component yield to the three groups was in excess of 90 percent. (Author)

A76-43149 * # Microeconomic analysis of military aircraft bearing restoration. G F Hein (NASA, Lewis Research Center, Cleveland, Ohio) *U.S. Army and NASA Lewis Research Center, Bearing Restoration by Grinding Seminar, St. Louis, Mo., May 20, 21, 1976, Paper.* 20 p

The risk and cost of a bearing restoration by grinding program was analyzed. A microeconomic impact analysis was performed The annual cost savings to U S. Army aviation is approximately $950,000.00 for three engines and three transmissions. The capital value over an indefinite life is approximately ten million dollars. The annual cost savings for U.S Air Force engines is approximately $313,000 00 with a capital value of approximately 3 1 million dollars. The program will result in the government obtaining bearings at lower costs at equivalent reliability. The bearing industry can recover lost profits during a period of reduced demand and higher costs. (Author)

A76-44122 * Stability experiments with hydrodynamic tilted-lobe journal bearings of various numbers of lobes and length-to-diameter ratios. F. T. Schuller (NASA, Lewis Research Center, Cleveland, Ohio). *American Society of Lubrication Engineers, Annual Meeting, 31st, Philadelphia, Pa., May 10-13, 1976, Preprint 76-AM-1C-3* 8 p 9 refs.

A76-44246 * # Endurance and failure characteristic of mainshaft jet engine bearing at 3 million DN. E N. Bamberger (General Electric Co., Evendale, Ohio), E. V. Zaretsky (NASA, Lewis Research Center, Cleveland, Ohio), and H Signer (Industrial Tectonics, Inc., Compton, Calif.). *American Society of Mechanical Engineers, Lubrication Symposium, Atlanta, Ga., May 24-26, 1976, Paper 76-LubS-16.* 6 p 21 refs Members, $1.50, nonmembers, $3.00.

Groups of thirty 120-mm bore angular-contact ball bearings were endurance tested at a speed of 12,000 and 25,000 rpm (1.44 million and 3.0 million DN, where DN is the product of the bearing bore in mm and the shaft speed in rpm) and a thrust load of 66,721 N The bearings were manufactured from a single heat of VIM-VAR AISI M-50 steel. At 1.44 million and 3.0 million DN, 84,483 and 74,800 bearing test hours were accumulated, respectively. Test results were compared with similar bearings made from CVM AISI M-50 steel run under the same conditions. Bearing lives at speeds of 3 million DN with the VIM-VAR AISI M-50 steel were nearly equivalent to those obtained at lower speeds A combined processing and material life factor of 44 was found for VIM-VAR AISI M-50 steel. Continuous running after a spall has occurred at 3 0 million DN can result in a destructive fracture of the bearing inner race. (Author)

A76-44247 * # Design and evaluation of a 3 million DN series-hybrid thrust bearing H W Scibbe (NASA, Lewis Research Center, Cleveland, Ohio), L. W. Winn, and M. Eusepi (Mechanical Technology, Inc , Latham, N Y.). *American Society of Mechanical Engineers, Lubrication Symposium, Atlanta, Ga., May 24-26, 1976, Paper 76-LubS-17.* 9 p 10 refs. Members, $1.50; nonmembers, $3 00

The design and experimental evaluation of a series-hybrid thrust bearing, consisting of a 150 mm ball bearing and a centrifugally actuated, conical, fluid-film bearing, is presented Tests were conducted up to 16,000 rpm and at this speed an axial load of 15,600 N (3500 lb) was safely supported by the hybrid bearing system. Through the series-hybrid bearing principle, the effective ball bearing speed was reduced to approximately one-half of the shaft speed A speed reduction of this magnitude would result in a tenfold increase in the ball bearing fatigue life. A successful evaluation of fluid-film bearing lubricant supply failure was performed repeatedly at an operating speed of 10,000 rpm A complete and smooth changeover to full-scale ball bearing operation was effected when the oil supply to the fluid-film bearing was cut off. Reactivation of the fluid-film oil supply system produced a flawless return to the original mode of hybrid operation. (Author)

N76-19459*# Sun Oil Co., Marcus Hook ,Pa.
INFRARED EMISSION SPECTRA FROM OPERATING ELASTOHYDRODYNAMIC SLIDING CONTACTS
James L Lauer 8 Mar. 1976 86 p refs
(Contract NAS3-18531)
(NASA-CR-134973) Avail NTIS HC $5 00 CSCL 11H

Infrared emission spectra from an operating EHD sliding contact were obtained through a diamond window for an aromatic polymer solute present in equal concentration in four different fluids Three different temperature ranges, three different loads, and three different speeds for every load were examined Very sensitive Fourier spectrophotometric (Interferometric) techniques were employed Band intensities and band intensity ratios found to depend both on the operating parameters and on the fluid Fluid film and metal surface temperatures were calculated from the spectra and their dependence on the mechanical parameters plotted The difference between these temperatures could be plotted against shear rate on one curve for all fluids However, at the same shear rate the difference between bulk fluid temperature and diamond window temperature was much higher for one of the fluids a traction fluid, than for the others Author

N76-20481*# Bell Aerospace Co., Buffalo, N.Y.
INVESTIGATION OF ELECTROFORMING TECHNIQUES Final Report, Jun 1974 - Dec. 1975
G A Malone Dec 1975 131 p refs
(Contract NAS3-17823)
(NASA-CR-134959, BAC-8756-953003) Avail NTIS HC $6 00 CSCL 13H

Copper and nickel electroforming was examined for the purpose of establishing the necessary processes and procedures for repeatable, successful fabrication of the outer structures of regeneratively cooled thrust chambers The selection of electrolytes for copper and nickel deposition is described The development studies performed to refine and complete the processes

necessary for successful chamber shell fabrication and the testing employed to verify the applicability of the processes and procedures to small scale hardware are described Specifications were developed to afford a guideline for the electroforming of high quality outer shells on regeneratively cooled thrust chamber liners Test results indicated repeatable mechanical properties could be produced in copper deposits from the copper sulfate electrolyte with periodic current reversal and in nickel deposits from the sulfamate solution Use of inert, removable channel fillers and the conductivizing of such is described Techniques (verified by test) which produce high integrity bonds to copper and copper alloy liners are discussed Author

N76-20482*# TRW, Inc, Jamestown, N Y
EFFECT OF BALL GEOMETRY ON ENDURANCE LIMIT IN BENDING OF DRILLED BALLS
Harold E Munson 19 Dec 1975 56 p refs
(Contract NAS3-17351)
(NASA-CR-134930) Avail NTIS HC $4 50 CSCL 13I

Four designs of drilled (cylindrically hollow) balls were tested for resistance to bending fatigue Bending fatigue has been demonstrated to be a limiting factor in previous evaluations of the drilled ball concept A web reinforced drilled ball was most successful in resisting bending fatigue Another design of through drilled design involving a heavier wall than the standard reference ball, also showed significant improvement in resistance to bending fatigue Author

N76-26514*# Pratt and Whitney Aircraft, East Hartford, Conn
EXPERIMENTAL STUDY OF TRANSIENT DYNAMICS OF A FLEXIBLE ROTOR Final Report
D H Hibner and D F Buono Washington Jun 1976 45 p
(Contract NAS3-18523)
(NASA-CR-2703, PWA-5333) Avail NTIS HC $4 00 CSCL 21E

The results of an experimental program to investigate the transient response of a flexible rotor are presented The program consisted of a series of tests conducted on a rig with a roter designed to operate above its first bending critical speed. The purpose of the tests was to obtain experimental data on the transient behavior of a flexible rotor under conditions simulating those which might occur in a jet aircraft engine The scope of the program included tests to measure the response of both balanced and unbalanced rotors during steady-state operation acceleration, deceleration, and simulated blade loss Author

N76-28553*# SKF Industries, Inc , King of Prussia, Pa
MICROFOG LUBRICATION FOR AIRCRAFT ENGINE BEARINGS Technical Report, Sep 1972 - Jun 1975
J W Rosenlieb Apr. 1976 135 p refs
(Contract NAS3-16826)
(NASA-CR-134977, SKF-AL75T032) Avail NTIS HC $6 00 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 bearing oil mist (microfog) and coolant air system Both static and dynamic tests were performed. Static tests were executed to evaluate and calibrate the mist supply system A total of thirteen dynamic step speed bearing tests were performed using four different lubricants and several different mist and air supply configurations. The most effective configuration consisted of supplying the mist and the major portion of the cooling air axially through the bearing The results of these tests have shown the feasibility of using a once through oil mist and cooling air system to lubricate and cool a high speed, high temperature aircraft engine mainshaft bearing Author

N76-29592*# Boeing Commercial Airplane Co , Seattle, Wash
TESTING OF MOLDED HIGH TEMPERATURE PLASTIC ACTUATOR ROAD SEALS FOR USE IN ADVANCED AIRCRAFT HYDRAULIC SYSTEMS Technical Report, Jun. 1974 - Jul. 1976
A W Waterman, R L Huxford, and W G Nelson Jul 1976 55 p refs
(Contract NAS3-18529)
(NASA-CR-135059, D6-42995) Avail NTIS HC $4.50 CSCL 11A

Molded high temperature plastic first and second stage rod seal elements were evaluated in seal assemblies to determine performance characteristics These characteristics were compared with the performance of machined seal elements The 6 35 cm second stage Chevron seal assembly was tested using molded Chevrons fabricated from five molding materials Impulse screening tests conducted over a range of 311 K to 478 K revealed thermal setting deficiencies in the aromatic polyimide molding materials Seal elements fabricated from aromatic copolyester materials structurally failed during impulse cycle calibration Endurance testing of 3.85 million cycles at 450 K using MIL-H-83283 fluid showed poorer seal performance with the unfilled aromatic polyimide material than had been attained with seals machined from Vespel SP-21 material The 6 35 cm first stage step-cut compression loaded seal ring fabricated from copolyester injection molding material failed structurally during impulse cycle calibration Molding of complex shape rod seals was shown to be a potentially controllable technique, but additional molding material property testing is recommended Author

A76-12247 * **Weldability of three forms of chemically vapor deposited tungsten.** W. A. Bryant (Westinghouse Astronuclear Laboratory, Pittsburgh, Pa) and R E. Gold (Princeton University, Princeton, N J). *Welding Journal, Research Supplement*, vol. 54, Nov. 1975, p. 405-s to 408-s. Contract No NAS3-13222.

Methods were developed for electron-beam welding several forms of chemically vapor-deposited tungsten. Weld ductility was evaluated from the results of ductile-brittle transition-temperature determinations. Welds in tungsten produced from WF6 were considerably more ductile than those associated with WCl6-produced tungsten. The larger grain size of the latter material was largely responsible for this behavior. (Author)

A76-14863 * # **Infrared emission spectra of elastohydrodynamic contacts** J L Lauer and M. E. Peterkin (Sun Oil Co , Marcus Hook, Pa) *American Society of Mechanical Engineers and American Society of Lubrication Engineers, Joint Lubrication Conference, Miami Beach, Fla., Oct. 21-23, 1975, ASME Paper 75-Lub-10.* 6 p 8 refs. Members, $1.50, nonmembers, $3 00 Contracts No F44620-74-0036; No. NAS3-18531.

A small diamond disk mounted as a window in a steel plate was covered with test fluid, and a weighted steel ball was rotated over the window so as to form a sliding elastohydrodynamic (EHD) contact region. Some of the radiant energy generated in this region, both in the fluid and at the boundaries, passed through the window into an infrared interferometer, giving rise to an emission spectrum This spectrum could be separated into contributions from the fluid and from the ball surface, making it possible, by appropriate calibrations, to estimate their temperatures separately under operating conditions. Moreover, the shape of the discrete spectral bands of the fluid permitted some inferences on its state. Two fluids were studied under identical mechanical conditions, a polyester and a naphthenic oil, each containing an equal amount of polymethylstyrene as a spectral indicator Differences of band intensity, band width, and frequency could, therefore, be attributed to differences in the behavior of the base fluid. (Author)

A76-21627 * **Recent developments in multiplane-multispeed balancing of flexible rotors in the United States.** R. H. Badgley (Mechanical Technology, Inc , Latham, N.Y) In: Dynamics of rotors, Proceedings of the Symposium, Lyngby, Denmark, August 12-16, 1974 (A76-21626 08-37) Berlin, Springer-Verlag, 1975, p. 1-26. 8 refs. Contracts No. NAS3-14420; No F33615-72-C-1801

This paper describes current developments in the evolution of a computer-implemented balancing procedure which permits flexible rotors to be precisely balanced in a cost-effective manner. Correc-

tions in virtually any reasonable number of planes, computed by the procedure using signals from vibration sensors at critical locations, permit rotor operation over any design speed range. Steady-state operation at undamped critical speeds has been demonstrated. Results of recent test efforts indicate that the procedure can be applied with equal effectiveness to rotors of any size. Manufacturing and overhaul cost reductions are expected to flow from its adoption, together with performance advantages from operation in hitherto restricted dynamic regimes. (Author)

A76-25836 * # **Powder metallurgy processing of high strength turbine disk alloys.** D J. Evans (United Technologies Materials Engineering and Research Laboratory, East Hartford, Conn.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La , Mar 21-25, 1976, Paper 76-GT-96.* 6 p. Members, $1.50; nonmembers, $3.00. Contract No. NAS3-15841.

Using vacuum-atomized AF2-1DA and Mar-M432 powders, full-scale gas turbine engine disks were fabricated by hot isostatically pressing (HIP) billets which were then isothermally forged using the Pratt & Whitney Aircraft GATORIZING forging process While a sound forging was produced in the AF2-1DA, a container leak had occurred in the Mar-M432 billet during HIP. This resulted in billet cracking during forging. In-process control procedures were developed to identify such leaks. The AF2-1DA forging was heat treated and metallographic and mechanical property evaluation was performed. Mechanical properties exceeded those of Astroloy, one of the highest temperature capability turbine disk alloys presently used. (Author)

38 QUALITY ASSURANCE AND RELIABILITY

Includes product sampling procedures and techniques, and quality control

N76-33526*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
INSPECTION OF COMPOSITES USING A COMPUTER-BASED REAL-TIME RADIOGRAPHIC FACILITY
Ernest Roberts, Jr and Alex Vary 1976 12 p refs Presented at the 2d Conf. on Automated Inspection and Product Control, Chicago, 19-21 Oct 1976
(NASA-TM-X-73504) Avail NTIS HC $3 50 CSCL 14D

A radiographic inspection facility was developed at the NASA Lewis Research Center The facility uses a digital computer to provide enhanced images in near real-time Some capabilities of the facility are demonstrated in the inspection of a fan frame ring for an experimental aircraft gas turbine The ring was fabricated from a carbon-fiber-reinforced epoxy composite material Inspection procedures were evaluated, and comparisons were made with an ultrasonic C-scan and conventional film X-ray Author

N76-20509*# Pratt and Whitney Aircraft, West Palm Beach, Fla Research and Development Center.
STRAINRANGE PARTITIONING BEHAVIOR OF AN AUTOMOTIVE TURBINE ALLOY Final Report, 13 Dec 1974 - 13 Dec 1975
C G Annis, M C VanWanderham, and R M. Wallace Feb 1976 80 p
(Contract NAS3-18930)
(NASA-CR-134974, FR-7424) Avail NTIS HC $5 00 CSCL 14D

This report addresses Strainrange Partitioning, an advanced life prediction analysis procedure, as applied to CA-101 (cast IN 792 + Hf), an alloy proposed for turbine disks in automotive gas turbine engines The methodology was successful in predicting specimen life under thermal-mechanical cycling, to within a factor of + or - 2. Author

N76-25577*# Martin-Marietta Corp, Orlando, Fla
NDE AN EFFECTIVE APPROACH TO IMPROVED RELIABILITY AND SAFETY. A TECHNOLOGY SURVEY
James L Carpenter, Jr and William F Stuhrke Jun 1976 167 p refs
(Contract NAS3-19530)
(NASA-CR-134963; OR-14176) Avail NTIS HC $6 75 CSCL 14D

Technical abstracts are presented for about 100 significant documents relating to nondestructive testing of aircraft structures or related structural testing and the reliability of the more commonly used evaluation methods Particular attention is directed toward acoustic emission; liquid penetrant, magnetic particle, ultrasonics eddy current, and radiography The introduction of the report includes an overview of the state-of-the-art represented in the documents that have been abstracted Author

N76-28565*# Martin Marietta Corp Orlando, Fla
BIBLIOGRAPHY OF INFORMATION ON MECHANICS OF STRUCTURAL FAILURE (HYDROGEN EMBRITTLEMENT, PROTECTIVE COATINGS, COMPOSITE MATERIALS, NDE)
James L Carpenter, Jr Jun 1976 169 p refs
(Contract NAS3-19530)
(NASA-CR-134964; OR-14177) Avail NTIS HC $6 75 CSCL 14D

This bibliography is comprised of approximately 1,600 reference citations related to four problem areas in the mechanics of failure in aerospace structures The bibliography represents a search of the literature published in the period 1962-1976, the effort being largely limited to documents published in the United States. Listings are subdivided into the four problem areas Hydrogen Embrittlement, Protective Coatings Composite Materials; and Nondestructive Evaluation An author index is included Author

N76-32565*# Structural Composites Industries, Inc Azusa Calif.
FILAMENT-REINFORCED METAL COMPOSITE PRESSURE VESSEL EVALUATION AND PERFORMANCE DEMONSTRATION Final Report, Jul 1972 - Oct. 1975
R E Landes May 1976 391 p refs
(Contract NAS3-16770)
(NASA-CR-134975, SCI-75154) Avail NTIS HC $10 75 CSCL 14D

Two different Kevlar-49 filament-reinforced metal sphere designs were developed, and six vessels of each type were fabricated and subjected to fatigue cycling, sustained loading, and hydrostatic burst The 61 cm (24 inch) diameter Kevlar-49/cryoformed 301 stainless steel pressure vessels demonstrated the required pressure cycle capability, burst factor of safety, and a maximum pressure times volume divided by weight (pV/W) performance of 210 J/g (834 000 in-lb/lbm) at burst, this represented a 25 to 30% weight saving over the lightest weight comparable, 6A1-4V Ti, homogeneous pressure vessel Both the Kevlar/stainless steel design and the 97 cm (38 inch) diameter Kevlar-49/2219-T62 aluminum sphere design demonstrated nonfragmentation and controlled failure mode features when pressure cycled to failure at operating pressure When failure occurred during pressure cycling, the mode was localized leakage and not catastrophic Kevlar/stainless steel vessels utilized a unique conical boss design, and Kevlar/aluminum vessels incorporated a tie-rod to carry port loads, both styles of polar fittings performed as designed during operational testing of the vessels Author

N76-33525*# General Dynamics/Fort Worth, Tex
ASSESSMENT OF NDE RELIABILITY DATA Final Report, Jul. 1974 - Sep. 1975
B G W Yee, F H Chang J C Covchman, G H Lemon and P. F Packman (Vanderbilt Univ, Nashville) Oct 1976 444 p refs
(Contract NAS3-18907)
(NASA-CR-134991) Avail. NTIS HC $11 75 CSCL 14D

Twenty sets of relevant Nondestructive Evaluation (NDE) reliability data have been identified, collected compiled, and categorized A criterion for the selection of data for statistical analysis considerations has been formulated. A model to grade the quality and validity of the data sets has been developed Data input formats, which record the pertinent parameters of the defect/specimen and inspection procedures, have been formulated for each NDE method. A comprehensive computer program has been written to calculate the probability of flaw detection at several confidence levels by the binomial distribution This program also selects the desired data sets for pooling and tests the statistical pooling criteria before calculating the composite detection reliability Probability of detection curves at 95 and 50 percent confidence levels have been plotted for individual sets of relevant data as well as for several sets of merged data with common sets of NDE parameters Author

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.*

N76-12398*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

LIFE PREDICTION OF THERMAL-MECHANICAL FATIGUE USING STRAIN-RANGE PARTITIONING

G R. Halford and S S Manson (Case Western Reserve Univ.) 1975 14 p refs Presented at the Symp on Thermal Fatigue of Mater and Components, New Orleans, 17-18 Nov 1975, sponsored by ASTM

(NASA-TM-X-71829; E-8537) Avail: NTIS HC $3.50 CSCL 20K

The applicability is described of the method of Strainrange Partitioning to the life prediction of thermal-mechanical strain-cycling fatigue An in-phase test on 316 stainless steel is analyzed as an illustrative example. The observed life is in excellent agreement with the life predicted by the method using the recently proposed Step-Stress Method of experimental partitioning, the Interation Damage Rule, and the life relationships determined at an isothermal temperature of 705 C Implications of the study are discussed relative to the general thermal fatigue problem Author

N76-13531*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

BENDING STRESSES IN SPHERICALLY HOLLOW BALL BEARING AND FATIGUE EXPERIMENTS

Lester J. Nypan (Calif State Univ., Northridge), Harold H Coe, and Richard J Parker 1975 10 p refs Presented at Joint Lubrication Conf., Miami Beach, Fla., 21-23 Oct. 1975; sponsored by Am Soc of Mech Engineers and Am Soc of Lubrication Engineers

(NASA-TM-X-71850, E-8582) Avail NTIS HC $3.50 CSCL 20K

Spherically hollow balls of 21.7, 50.0, and 56.5 percent mass reduction were operated in ball bearings and in a five-ball fatigue tester with differing outcomes Available theoretical and experimental treatments of stresses in spherically hollow balls are reviewed and compared Bending stresses are estimated for these spherically hollow balls to better understand the differences in ball bearing and fatigue test experience Author

N76-13528*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EFFECT OF AXIAL LOAD ON MODE SHAPES AND FREQUENCIES OF BEAMS

Francis J Shaker Washington Dec 1975 33 p refs

(NASA-TN-D-8109, E-8433) Avail NTIS HC $4.00 CSCL 20K

An investigation of the effect of axial load on the natural frequencies and mode shapes of uniform beams and of a cantilevered beam with a concentrated mass at the tip is presented Characteristic equations which yield the frequencies and mode shape functions for the various cases are given The solutions to these equations are presented by a series of graphs so that frequency as a function of axial load can readily be determined The effect of axial load on the mode shapes are also depicted by another series of graphs Author

N76-14513*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

ESTIMATION OF Ksub Ic FROM SLOW BEND PRECRACKED CHARPY SPECIMEN STRENGTH RATIOS

G Succop and W F Brown, Jr. 1976 22 p refs Proposed for presentation at Developments and Fracture Mech Test Method Standardization Symp., St Louis, 10-12 Feb 1976; sponsored by Am Soc for Testing and Materials

(NASA-TM-X-71834, E-8543) Avail: NTIS HC $3.50 CSCL 20K

Strength ratios are reported which were derived from slow bend tests on 0.25 inch thick precracked Charpy specimens of steels, aluminum alloys, and a titanium alloy for which valid K sub Ic values were established The strength ratios were used to develop calibration curves typical of those that could be useful in estimating K sub Ic for the purposes of alloy development of quality-control. Author

N76-18525*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

USE OF STRAINRANGE PARTITIONING TO PREDICT HIGH TEMPERATURE LOW-CYCLE FATIGUE LIFE

Marvin H Hirschberg and Gary R Halford Washington Jan 1976 30 p refs

(NASA-TN-D-8072, E-8294) Avail NTIS HC $4.00 CSCL 20K

The fundamental concepts of the strainrange partitioning approach to high temperature, low low-cycle fatigue are reviewed Procedures are presented by which the partitioned strainrange versus life relationships for any material can be generated Laboratory tests are suggested for further verifying the ability of the method of strainrange partitioning to predict life Author

N76-18533*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

ON THE RELATION OF J SUB I TO WORK DONE PER UNIT UNCRACKED AREA. TOTAL, OR COMPONENT 'DUE TO CRACK'

John E Srawley 1976 9 p refs Proposed for presentation at conf. of Am. Soc for Testing and Mater., Committee E-24, Orlando, Fla., 22-26 Mar. 1976

(NASA-TM-X-71882, E-8655) Avail NTIS HC $3.50

The direct evaluation of Rice s JI as a function of displacement, from the load-displacement record of a test of a single precracked specimen, was discussed Special attention was given to the general form of the underlying relation Author

N76-19469*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

WIDE RANGE STRESS INTENSITY FACTOR EXPRESSIONS FOR ASTM E 399 STANDARD FRACTURE TOUGHNESS SPECIMENS

John E Srawley 1976 5 p refs Proposed for presentation at conf. of Am Soc. for Testing and Mater., Committee E-24, Orlando, Fla., 22-26 Mar. 1976

(NASA-TM-X-71881, E-8654) Avail NTIS HC $3.50 CSCL 13M

For each of the two types of specimens, bend and compact described previously for plane strain fracture toughness of materials, E 399, a polynominal expression is given for calculation of the stress intensity factor, K from the applied force, P, and the specimen dimensions It is explicitly stated, however that these expressions should not be used outside the range of relative crack length, a/W, from 0.45 to 0.55 While this range is sufficient for the purpose of E 399, the same specimen types are often used for other purposes over a much wider range of a/W; for example, in the study of fatigue crack growth Expressions are presented which are at least as accurate as those in E 399-74, and which cover much wider ranges of a/W for the three-point bend specimen from 0 to 1 and for the compact specimen from 0.2 to 1 The range has to be restricted for the compact specimen because of the proximity of the loading pin holes to the crackline, which causes the stress intensity factor to be sensitive to small variations in dimensions when a/W is small. This is a penalty inherently associated with the compactness of the specimen. Author

N76-21589*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
VIBRATION CHARACTERISTICS OF COMPOSITE FAN BLADES AND COMPARISON WITH MEASURED DATA
C C Chamis 1976 12 p refs Presented at 17th Struct., Structural Dyn and Mater Conf., King of Prussia Penna., 5-7 May 1976, sponsored by Am Inst of Aeron and Astronautics Am Soc of Mech Engr., and Soc of Autom. Engr
(NASA-TM-X-71893) Avail. NTIS HC $3 50 CSCL 13M

The vibration characteristics of a composite fan blade for high-tip-speed applications were determined theoretically and the results compared with measured data The theoretical results were obtained using a computerized capability consisting of NASTRAN coupled with composite mechanics by way of pre- and postprocessors The predicted vibration frequencies and mode shapes were in reasonable agreement with the measured data Theoretical results showed that different laminate configurations from the same composite system had only small effects on the blade frequency However, the use of adhesively bonded titanium/beryllium laminar composites may improve considerably the blade vibration characteristics Author

A76-14819 * # Boundary-layer effect in panel flutter. M E. Goldstein (NASA, Lewis Research Center, Cleveland, Ohio) *AIAA Journal*, vol. 13, Sept. 1975, p 1247-1249. 7 refs.

The present note shows that if the supersonic Mach number is not too large, an analytical expression can be obtained for the generalized aerodynamic force relating the pressure fluctuation at the surface of a flexible plate to the plate displacement in the presence of an adjacent boundary layer. The low supersonic Mach numbers are the ones of maximum interest since it is in this Mach number region that the boundary layer has the most influence In this respect, Dowell (1971) has already shown that the presence of a boundary layer causes about a 300% increase in flutter dynamic pressure at a Mach number of about 1.2, while it causes only about a 20% increase at a Mach number of 2. S.D

A76-18504 * # Life prediction of thermal-mechanical fatigue using strainrange partitioning. G. R. Halford (NASA, Lewis Research Center, Cleveland, Ohio) and S. S. Manson (Case-Western-Reserve University, Cleveland, Ohio). *American Society for Testing and Materials, Symposium on Thermal Fatigue of Materials and Components, New Orleans, La., Nov. 17, 18, 1975, Paper.* 13 p 8 refs.

This paper describes the applicability of the method of Strainrange Partitioning to the life prediction of thermal-mechanical strain-cycling fatigue. An in-phase test on 316 stainless steel is analyzed as an illustrative example The observed life is in excellent agreement with the life predicted by the method using the recently proposed Step-Stress Method of experimental partitioning, the Interaction Damage Rule, and the life relationships determined at an isothermal temperature of 705 C. Implications of the present study are discussed relative to the general thermal fatigue problem. (Author)

A76-30013 * # Vibration characteristics of composite fan blades and comparison with measured data. C. C. Chamis (NASA, Lewis Research Center, Cleveland, Ohio). In: Structures, Structural Dynamics, and Materials Conference, 17th, King of Prussia, Pa., May 5-7, 1976, Proceedings. (A76-30004 13-39) New York, American Institute of Aeronautics and Astronautics, Inc., 1976, p 98-104.

The vibration characteristics of a composite fan blade for high-tip-speed applications were determined theoretically and the results compared with measured data. The theoretical results were obtained using a computerized capability consisting of NASTRAN coupled with composite mechanics by way of pre- and post-processors. The predicted vibration frequencies and mode shapes were in reasonable agreement with the measured data. Theoretical results showed that different laminate configurations from the same composite system had only small effects on the blade frequency. However, the use of adhesively bonded titanium/beryllium laminar composites may improve considerably the blade vibration characteristics. (Author)

N76-10507*# IIT Research Inst., Chicago, Ill
LAMINATION RESIDUAL STRESSES IN FIBER COMPOSITES Interim Report, Aug. 1972 - Jun 1974
I M Daniel and T Liber 4 Nov 1975 468 p refs
(Contract NAS3-16766)
(NASA-CR-134826, IITRI-D6073-I) Avail NTIS HC $11.50 CSCL 11D

The magnitude of stresses in angle-ply composites and their effects on composite structural integrity was experimentally studied The materials investigated were Boron/Epoxy Boron/Polyimide, Graphite/Low Modulus Epoxy, Graphite/High Modulus Epoxy, Graphite/Polyimide and S-Glass/Epoxy. These materials were fully characterized The behavior of angle-ply laminates subjected to thermal cycling, tensile load cycling, and combined thermal cycling with tensile load was investigated In most cases these cycling programs did not have any measurable influence on residual strength and stiffness of the laminates Results indicate that in the tensile load cycling tests, the Graphite/Polyimide showed the highest endurance with 10 million cycle runouts at loads up to 90 percent of the static strength; the S-Glass/Epoxy had the lowest endurance, failing to survive 10 million cycles even at 25 percent of ultimate The effects of fiber volume ratio, ply orientation and ply stacking sequence were also investigated for Graphite/Polyimide Dissert Abstr

N76-21592*# Lockheed Missiles and Space Co., Huntsville, Ala. Research and Engineering Center
THREE-DIMENSIONAL FINITE ELEMENT ANALYSIS FOR HIGH VELOCITY IMPACT Interim Report, Jun. 1974 - Jun. 1975
S T K Chan, C H Lee, and M. R. Brashears Aug 1975 160 p refs
(Contract NAS3-18908)
(NASA-CR-134933; LMSC-HREC-TR-D390900) Avail NTIS HC $6 75 CSCL 13M

A finite element algorithm for solving unsteady, three-dimensional high velocity impact problems is presented A computer program was developed based on the Eulerian hydroelasto-viscoplastic formulation and the utilization of the theorem of weak solutions The equations solved consist of conservation of mass, momentum, and energy, equation of state, and appropriate constitutive equations. The solution technique is a time-dependent finite element analysis utilizing three-dimensional isoparametric elements, in conjunction with a generalized two-step time integration scheme The developed code was demonstrated by solving one-dimensional as well as three-dimensional impact problems for both the inviscid hydrodynamic model and the hydroelasto-viscoplastic model Author

N76-32578*# Boeing Aerospace Co., Seattle, Wash Research and Engineering Div
PROOF TEST CRITERIA FOR THIN-WALLED 2219 ALUMINUM PRESSURE VESSELS VOLUME 1 PROGRAM SUMMARY AND DATA ANALYSIS Technical Report, Jul. 1974 - Dec 1975
R W Finger Aug 1976 161 p refs
(Contract NAS3-18906)
(NASA-CR-135036; D180-20100-2-Vol-1) Avail NTIS HC $6 75 CSCL 13M

This experimental program was undertaken to investigate the crack growth behavior of deep surface flaws in 2219 aluminum. The program included tests of uniaxially loaded surface flaw and center crack panels at temperatures ranging from 20K (-423 F) to ambient The tests were conducted on both the base metal and as-welded weld metal material. The program was designed to provide data on the mechanisms of failure by ligament penetration, and the residual cyclic life, after proof-testing, of a vessel which has been subjected to incipient penetration by the proof test The results were compared and analyzed with previously developed data to develop guidelines for the proof testing of thin walled 2219 pressure vessels. Author

43 EARTH RESOURCES

Includes remote sensing of earth resources by aircraft and spacecraft; photogrammetry, and aerial photography.

For instrumentation see *35 Instrumentation and Photography.*

N76-20614*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
MEASUREMENT OF LAKE ICE THICKNESS WITH A SHORT-PULSE RADAR SYSTEM
Dale W. Cooper, Robert A Mueller, and Ronald J. Schertler Washington Mar. 1976 25 p refs
(NASA-TN-D-8189; E-8573) Avail NTIS HC $3 50 CSCL 08L

Measurements of lake ice thickness were made during March 1975 at the Straits of Mackinac by using a short-pulse radar system aboard an all-terrain vehicle These measurements were compared with ice thicknesses determined with an auger. Over 25 sites were explored which had ice thicknesses in the range 29 to 60 cm. The maximum difference between radar and auger measurements was less than 9 8 percent. The magnitude of the error was less than + or - 3 5 cm The NASA operating short-pulse radar system used in monitoring lake ice thickness from an aircraft is also described Author

N76-26655* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
COAST GUARD/NOAA/NASA GREAT LAKES PROJECT ICEWARN
T. D Brennan (Coast Guard 9th District) and R T. Gedney *In its* NASA Earth Resources Survey Symp., Vol. 2-B Jun 1975 p 261-270 (For availability see N76-26646 17-43)
CSCL 08L

The operational feasibility of using remote sensing to provide all weather ice formation for Great Lakes winter navigation is explored A combination airborne pulsed radar system to measure actual ice thickness, a satellite data link system, and a hand drawn interpretive ice chart proved valuable for extending winter navigation through the icepack. G.G

A76-18503 * # Great Lakes all-weather ice information system. R. J Schertler, R A Mueller; R J Jirberg, D W Cooper, J E Heighway, A. D. Holmes, R. T Gedney, and H. Mark (NASA, Lewis Research Center, Cleveland, Ohio) *Environmental Research Institute of Michigan, International Symposium on Remote Sensing of the Environment, 10th, Ann Arbor, Mich , Oct. 6-10, 1975, Paper.* 29 p. 10 refs.

The all-weather ice information system described uses the X-band side-looking airborne radar to determine the aerial distribution, location, and type of ice cover in the Great Lakes and an airborne S-band short-pulse radar to determine the ice thickness. Results from the 1974-1975 winter season demonstrated the ability of the system to provide all-weather ice information to shippers at the required time. V P.

A76-18512 * # Remote profiling of lake ice using an S-band short-pulse radar aboard an all-terrain vehicle. D W Cooper, R. A Mueller, and R. J. Schertler (NASA, Lewis Research Center, Cleveland, Ohio) *International Union of Radio Science Meeting, Boulder, Colo , Oct. 20-23, 1975, Paper.* 18 p. 13 refs.

The airborne short-pulse radar system described was developed to measure ice thickness in an attempt to extend the winter navigation system as a means of reducing coal and ore shipping costs Experimental studies of the accuracy and limitations of the system are discussed, and measurements made at 25 sites are compared The radar system was found to provide accurate lake ice thickness measurements that were not affected by snow cover or adverse weather conditions Surface melting and rain, however, preclude measurements V.P.

A76-29050 * Remote profiling of lake ice using an S-band short-pulse radar aboard an all-terrain vehicle. D. W Cooper, R. A. Mueller, and R. J. Schertler (NASA, Lewis Research Center, Cleveland, Ohio). *Radio Science,* vol. 11, Apr. 1976, p. 375-381. 12 refs

A short-pulse (one nanosecond) S-band radar system was developed to supplement the information obtained with the aid of the SLAR system of the Great Lakes ice information system It is the objective of the ice information system to aid in extending the winter navigation season. The SLAR imagery cannot be interpreted directly to obtain information concerning the thickness of the ice. This information is to be provided by a remote ice measuring system utilizing nanosecond radar pulses. A description is given of investigations in which such a system was installed on a C-47 aircraft. In other studies reported an S-band short-pulse radar was mounted on an all-terrain vehicle. G.R.

N76-20579*# Ohio Dept of Economic and Community Development, Columbus
UTILIZING SKYLAB DATA IN ON-GOING RESOURCES MANAGEMENT PROGRAMS IN THE STATE OF OHIO Final Report, Apr. - Aug 1975
P E Baldridge, Principal Investigator, P H Goesling, T A Martin, G. E. Wukelic (Battelle Columbus Labs, Ohio), J G. Stephan (Battelle Columbus Labs , Ohio), H. E Small (Battelle Columbus Labs , Ohio), and T F Ebbert (Battelle Columbus Labs , Ohio) Nov. 1975 139 p refs Original contains imagery Original photography may be purchased from the EROS Data Center, 10th and Dakota Avenue, Sioux Falls, S D 57198 EREP
(Contract NAS3-19521)
(E76-10229, NASA-CR-134938) Avail. NTIS HC $6 00 CSCL 05B

The author has identified the following significant results The use of Skylab imagery for total area woodland surveys was found to be more accurate and cheaper than conventional surveys using aerial photo-plot techniques Machine-aided (primarily density slicing) analyses of Skylab 190A and 190B color and infrared color photography demonstrated the feasibility of using such data for differentiating major timber classes including pines, hardwoods, mixed, cut, and brushland providing such analyses are made at scales of 1 24,000 and larger Manual and machine-assisted image analysis indicated that spectral and spatial capabilities of Skylab EREP photography are adequate to distinguish most parameters of current, coal surface mining concern associated with. (1) active mining, (2) orphan lands, (3) reclaimed lands, and (4) active reclamation Excellent results were achieved when comparing Skylab and aerial photographic interpretations of detailed surface mining features. Skylab photographs when combined with other data bases (e g , census, agricultural land productivity, and transportation networks), provide a comprehensive, meaningful, and integrated view of major elements involved in the urbanization/encroachment process

N76-31632*# National Oceanic and Atmospheric Administration, Washington, D.C
EVALUATION OF LANDSAT-2 DATA FOR SELECTED HYDROLOGIC APPLICATIONS Progress Report
Donald R Wiesnet, David F. McGinnis, Jr , Principal Investigators, Michael C McMillan, and Michael Matson 15 Sep 1976 3 p ERTS
(Contract NAS3-5991)
(E76-10487; NASA-CR-148793) Avail: NTIS HC $3 50 CSCL 05B

There are no author-identified significant results in this report

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.*

N76-10570*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CESIUM THERMIONIC CONVERTERS HAVING LANTHANUM HEXABORIDE ELECTRODES Patent Application
James F Morris, inventor (to NASA) Filed 16 Oct 1975 9 p (NASA-Case-LEW-12038-1; US-Patent-Appl-SN-623189) Avail. NTIS HC $3 25 CSCL 10A

A high electric-power output thermionic converter is provided for by the combination of lanthanum hexaboride emitter and collector electrodes in a cesium thermionic converter 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 having a high current density and voltage output The lanthanum hexaboride emitter and collector electrodes employed in the cesium diode may conveniently be either in the monocrystalline or polycrystalline state NASA

N76-12463*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
A GENERALIZED CORRELATION OF EXPERIMENTAL FLAT-PLATE COLLECTOR PERFORMANCE
Frederick F. Simon and Dean R Miller 1975 20 p refs Presented at Conf on Standards for Solar Heating and Cooling, Philadelphia, 14-15 Oct 1975, cosponsored by the Am Soc for Testing and Mater., and the Am. Natl. Standards Inst (NASA-TM-X-71832, E-8542) Avail. NTIS HC $3 50 CSCL 10A

A generalized collector performance correlation was derived and shown by experimental verification to be of the proper form to account for the majority of the variable conditions encountered both in outdoor and in indoor collector tests This correlation permits a determination of collector parameters which are essentially nonvarying under conditions which do vary randomly (outdoors) or conditions which vary in a controlled manner (indoors - simulator) It was shown that correlation of the experimental performance of collectors allows the following (1) comparisons of different collector designs; (2) collector performance prediction under conditions that differ from the conditions of the test program, and (3) monitoring performance degradation effects Author

N76-12478* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
PHOTOVOLTAIC TEST AND DEMONSTRATION PROJECT FOR THE NATIONAL PHOTOVOLTAIC CONVERSION PROGRAM
James N Deyo *In* JPL Proc of the 1st ERDA Semiann Solar Photovoltaic Conversion Program Conf: 25 Jul 1975 p 215-231 (For availability see N76-12472 03-44)
CSCL 10A

Proposed are photovoltaic system tests and demonstrations covering a wide range of applications in order to develop low cost photovoltaic cells suitable for terrestrial applications. Program objectives are: (1) tests and model system demonstrations; (2) device performance and diagnostics; and (3) endurance of solar cell modules and arrays. Author

N76-12480* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
REVIEW OF TERRESTRIAL PHOTOVOLTAIC MEASUREMENTS WORKSHOP
Henry W. Brandhorst, Jr *In* JPL Proc of the 1st ERDA Semiann. Solar Photovoltaic Conversion Program Conf. 25 Jul 1975 p 251-260 (For availability see N76-12472 03-44)
CSCL 10A

Measurement methods for terrestrial solar cells require calibration standards to set simulator irradiance levels or to monitor solar irradiance in outdoor measurements. Measurements of solar cell performance in terrestrial sunlight are the most acceptable, but an artificial light source can be used for laboratory measurements Author

N76-13593*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
SPECTRAL REFLECTANCE PROPERTIES OF ELECTROPLATED AND CONVERTED ZINC FOR USE AS A SOLAR SELECTIVE COATING
Glen E McDonald, Henry B Curtis (Harshaw Chemical Co., Cleveland), and Louis Gianelos 1975 14 p refs Presented at Intern Solar Energy Soc., Los Angeles, 27 Jul - 1 Aug 1975 (NASA-TM-X-71817, E-8512) Avail NTIS HC $3 50 CSCL 10A

The spectral reflectance properties of electroplated and chemically converted zinc were measured for both chromate and chloride conversion coatings The reflectance properties were measured for various times of conversion and for conversion at various chromate concentrations. The values of absorptance, integrated over the solar spectrum, and of infrared emittance, integrated over black body radiation at 250 F were then calculated from the measured reflectance values. The interdependent variations of absorptance and infrared emittance were plotted The results indicate that the optimum combination of the highest absorptance in the solar spectrum and the lowest emittance in the infrared of the converted electroplated zinc is produced by chromate conversion at 1/2 concentration of the standard NEOSTAR chromate black solution for 0 50 minute or by chloride conversion for 0 50 minute Author

N76-14600* National Aeronautics and Space Administration. Lewis Research Center, Cleveland Ohio
COVERED SILICON SOLAR CELLS AND METHOD OF MANUFACTURE Patent
Jacob D Broder, inventor (to NASA) Issued 14 Oct 1975 4 p Filed 18 Jun. 1973 Supersedes N73-26048 (11 - 17, p 1985) Continuation-in-part of abandoned US Patent Appl SN-154930, filed 21 Jun 1971
(NASA-Case-LEW-11065-2, US-Patent-3,912,540
US-Patent-Appl-SN-371322, US-Patent-Class-136-89
US-Patent-Class-29-572, US-Patent-Appl-SN-154930) Avail US Patent Office CSCL 10A

A glass covered solar cell utilizing a thin film of plastic material as the binding material is described The binding material provides the following characteristics its short circuit current response is unaffected by ultraviolet radiation exposure and its bonding characteristics are not degraded under particular radiation bombardment. Official Gazette of the U S Patent Office

N76-14605*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
INSTALLATION AND INITIAL OPERATION OF A 4100 WATT WIND TURBINE
Henry B Tryon and Timothy Richards Dec 1975 29 p (NASA-TM-X-71831) Avail NTIS HC $4 00 CSCL 10A

The results are presented of 211 days of operation of the 4.1 kilowatt wind turbine, which was the largest commercially available wind turbine. The wind turbine, electric controls and load bank, and the pivoted tower are described. F O.S

N76-14612*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
SOLAR CELL SURFACE TREATMENT Patent Application
Henry W Brandhorst, Jr and Cosmo R Barona, inventors (to NASA) Filed 18 Dec 1975 13 p

(NASA-Case-LEW-11330-1; US-Patent-Appl-SN-642083) Avail NTIS HC $3 50 CSCL 10A

A patent application dealing with an improvement to solar cells was presented The improvement consists in increasing the anti-reflecting properties of silicon solar cells by the formation of grooves on the surface of the cells using a chemical etchant The novelty of the invention resides not only in the formation of grooves that produce multiple reflection of light to enhance absorption but also the utilization of internal reflection that takes place as a result of the crystallographic orientation of the solar cell. This results in more charge carriers being generated close to the junction region than is possible with conventional solar cells with normal angles of light incidence Author

N76-14613*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

SILICON NITRIDE COATED, PLASTIC COVERED SOLAR CELL Patent Application

Jacob D Broder inventor (to NASA) Filed 30 Dec 1975 8 p (NASA-Case-LEW-11496-1, US-Patent-Appl-SN-645508) Avail NTIS HC $3 50 CSCL 10A

A patent application dealing with a technique to increase the resistance to damage to silicon solar cells caused by electron bombardment was presented A non-oxide anti-reflective coating is used with a transparent plastic cover of fluorinated ethylene propylene copolymer over the solar cell An important advantage results from the use of silicon nitride as the coating material instead of the conventional silicon oxide Even if the silicon nitride is as susceptible to fluorine attack as the silicon oxide, the silicon nitride will not liberate oxygen to cause embrittlement of the Teflon FEP cover Author

N76-15603*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

SELECTIVE COATING FOR SOLAR PANELS Patent Application

Glen E McDonald, inventor (to NASA) Filed 22 Dec 1975 12 p

(NASA-Case-LEW-12159-1; US-Patent-Appl-SN-643041) Avail: NTIS HC $3 50 CSCL 10A

A black chrome coating of controlled thickness (0 5 micron to 2 5 microns) which has improved energy absorbing properties is examined The coating is deposited on a specially prepared metal substrate, and has high absorptivity for visible solar radiation, and low emissivity for infrared radiation NASA

N76-16620*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

STANDARDIZED PERFORMANCE TESTS OF COLLECTORS OF SOLAR THERMAL ENERGY: PROTOTYPE MODERATELY CONCENTRATING GROOVED COLLECTORS

Jan 1976 13 p refs

(NASA-TM-X-71863, E-8626) Avail NTIS HC $3 50 CSCL 10A

Prototypes of moderately concentrating grooved collectors were tested with a solar simulator for varying inlet temperature, flux level, and incident angle Collector performance is correlated in terms of inlet temperature and flux level Author

N76-16622*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

LABORATORY 15 kV HIGH VOLTAGE SOLAR ARRAY FACILITY

Joseph C Kolecki and Suzanne T Gooder Jan 1976 29 p refs

(NASA-TM-X-71860; E-8619) Avail NTIS HC $4.00 CSCL 10A

The laboratory high voltage solar array facility is a photoelectric power generating system Consisting of nine modules with over 23 000 solar cells the facility is capable of delivering more than a kilowatt of power The physical and electrical characteristics of the facility are described Author

N76-16623*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

STANDARIZED PERFORMANCE TESTS OF COLLECTORS OF SOLAR THERMAL ENERGY: A STEEL FLAT-PLATE COLLECTOR WITH TWO TRANSPARENT COVERS AND A PROPRIETARY COATING

Jan 1976 7 p ref

(NASA-TM-X-71869) Avail NTIS HC $3 50 CSCL 10A

Basic test results of a flat-plate solar collector whose performance was determined in the NASA-Lewis solar simulator are given The collector was tested over ranges of inlet temperature and flux level Author

N76-16624*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

STANDARD PERFORMANCE TESTS OF COLLECTORS OF SOLAR THERMAL ENERGY: A SELECTIVELY COATED, FLAT-PLATE COPPER COLLECTOR WITH ONE TRANSPARENT COVER AND A TUBE-TO-TUBE SPACING OF 3-7/8 INCHES

Jan 1976 7 p ref

(NASA-TM-X-71868) Avail NTIS HC $3 50 CSCL 10A

Basic test results are given of a flat-plate solar collector whose performance was determined in the NASA-Lewis solar simulator. The collector was tested over ranges of inlet temperatures, fluxes, and coolant flow rates Collector efficiency is correlated in terms of inlet temperature and flux level Author

N76-17641*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

ELECTROLYTIC HYDROGEN PRODUCTION: AN ANALYSIS AND REVIEW

John Evangelista, B Phillips, and L Gordon Dec 1975 70 p refs

(NASA-TM-X-71856; E-8602) Avail NTIS HC $4.50 CSCL 10A

The thermodynamics of water electrolysis cells is presented, followed by a review of current and future technology of commercial cells The irreversibilities involved are analyzed and the resulting equations assembled into a computer simulation model of electrolysis cell efficiency. The model is tested by comparing predictions based on the model to actual commercial cell performance, and a parametric investigation of operating conditions is performed Finally, the simulation model is applied to a study of electrolysis cell dynamics through consideration of an ideal pulsed electrolyzer. Author

N76-17642*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

STANDARDIZED PERFORMANCE TESTS OF COLLECTORS OF SOLAR THERMAL ENERGY: A SELECTIVELY COATED, FLAT-PLATE COPPER COLLECTOR WITH ONE TRANSPARENT COVER AND A TUBE-TO-TUBE SPACING OF 5 5/8 INCHES

Feb 1976 7 p ref

(NASA-TM-X-71871, E-8644) Avail NTIS HC $3 50 CSCL 10A

This preliminary data report gives basic test results of a flat-plate solar collector whose performance was determined in the NASA-Lewis solar simulator. The collector was tested over ranges of inlet temperatures, fluxes and coolant flow rates Collector efficiency is correlated in terms of inlet temperature and flux level Author

N76-17643*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

STANDARDIZED PERFORMANCE TESTS OF COLLECTORS OF SOLAR THERMAL ENERGY: A SELECTIVELY COATED, STEEL COLLECTOR WITH ONE TRANSPARENT COVER

Jan 1976 7 p ref

(NASA-TM-X-71870, E-8641) Avail NTIS HC $3 50 CSCL 10A

Basic test results are presented of a flat-plate solar collector whose performance was determined in solar simulator. The collector was tested over ranges of inlet temperatures, fluxes and coolant flow rates Collector efficiency was correlated in terms of inlet temperature and flux level Author

N76-17645*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FUNCTIONING OF INORGANIC/ORGANIC BATTERY SEPARATORS IN SILVER-ZINC CELLS
Warren H Philipp and Charles E May Washington Feb 1976 21 p refs
(NASA-TM-X-3357, E-8216) Avail NTIS HC $3 50 CSCL 10C

The results of three experimental studies related to the inorganic/organic battery separator operating mechanism are described: saponification of the plasticizer, resistivity of the simulated separators, and zincate diffusion through the separators The inorganic/organic separator appears to be a particular example of a general class of ionic conducting films composed of inorganic fillers and/or substrates bonded together by an organic polymer containing an incompatible plasticizer that may be leached by the electrolyte The I/O separator functions as a microporous film of varying tortuosity with essentially no specific chemical inhibition to zincate diffusion Author

N76-18666* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CRYOGENIC STORAGE
R L DeWitt *In* JPL Hydrogen Tomorrow Dec 1975 11 p refs (For availability see N76-18654 09-44)
CSCL 10B

Types of storage techniques available are described in terms of their present as well as future potential for liquid hydrogen storage. Examples are given and areas for further technology development are defined J M S

N76-18667* National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio
MATERIALS CONSIDERATIONS
Hugh R. Gray, Howard G Nelson (NASA Ames Research Center), Robert E Johnson (NASA Lyndon B Johnson Space Center), Bryan McPherson (NASA Marshall Space Flight Center), Frank S Howard (NASA John F Kennedy Space Center, Cocoa Beach, Fla), and James H Swisher (ERDA, Livermore, Calif.) *In* JPL Hydrogen Tomorrow Dec 1975 10 p (For availability see N76-18654 09-44)
CSCL 10B

Materials problems are examined that may be encountered within a hydrogen energy system Emphasis is placed on hydrogen embrittlement, corrosion, oxidation, and erosion Other factors discussed include degradation of mechanical properties of structural alloys, system reliability, and maintenance costs Author

N76-18669*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
STANDARDIZED PERFORMANCE TESTS OF COLLECTORS OF SOLAR THERMAL ENERGY: REVERE FLAT-PLATE COLLECTOR WITH TWO TRANSPARENT COVERS
Dec 1975 6 p ref
(NASA-TM-X-71854, E-8593) Avail. NTIS HC $3 50 CSCL 10A

Basic test results of a solar energy collector that were determined in a solar simulator were presented Author

N76-18672*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
A 100 kW EXPERIMENTAL WIND TURBINE: SIMULATION OF STARTING, OVERSPEED, AND SHUTDOWN CHARACTERISTICS
Leonard J Gilbert [1976] 27 p refs
(NASA-TM-X-71864; E-8629) Avail NTIS HC $4 00 CSCL 10A

The ERDA/NASA 100 kW experimental wind turbine is modeled on a digital computer in order to study the performance of a wind turbine under operating conditions. Simulation studies of starting, overspeed, and shutdown performance were made From these studies operating procedures, precautions, and limitations are prescribed Author

N76-18673*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
PHOTOVOLTAIC TEST AND DEMONSTRATION PROJECT
A F Forestieri, H W Brandhorst, Jr., and J N Deyo 1976 6 p refs Presented at Intern Conf. on Solar Elec., Toulouse, 1-5 Mar 1976; sponsored by Centre Natl d'Etudes Spatiales and Centre Natl de la Rech Sci
(NASA-TM-X-71887, E-8666) Avail NTIS HC $3 50 CSCL 10A

The primary objectives of the Photovoltaic Test and Demonstration Project are (1) to determine operating characteristics for different solar cell systems and subsystems, (2) to prove, through tests and demonstrations, that solar cell systems can satisfy the requirements of potentially attractive residential, commercial, industrial, and smaller terrestrial applications, (3) to devise and implement the methodology, techniques and equipment to make accurate and reproducible measurements of solar cell and array performance, and diagnostic measurements on solar cells, modules and arrays, and (4) to determine the endurance of solar cell modules, component parts, and materials under expected environmental conditions. Author

N76-18674*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FREE VIBRATIONS OF THE ERDA-NASA 100 kW WIND TURBINE
C C Chamis and T. L Sullivan 1976 17 p refs Presented at Specialty Conf on the Dyn Response of Struct., Los Angeles, 30-31 Mar. 1976, sponsored by Am Soc of Civil Engr. and UCLA
(NASA-TM-X-71879, E-8634) Avail NTIS HC $3 50 CSCL 10A

The ERDA-NASA wind turbine (windmill), which consists of a 93-foot truss tower, a bed plate that supports mechanical and electrical equipment, and two 62 5-foot long blades, was analyzed to determine its free vibrations using NASTRAN The finite element representation of the system consisted of beam and plate elements The free vibrations of the tower alone, the blades alone, and the complete system were determined experimentally in the field These results were obtained by instrumenting the tower or blades with an accelerometer and impacting the components with an instrumented mass The predicted results for natural frequencies and mode shapes were in excellent agreement with measured data Author

N76-18677*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
PRELIMINARY ASSESSMENT OF SYSTEMS FOR DERIVING LIQUID AND GASEOUS FUELS FROM WASTE OR GROWN ORGANICS
Robert W Graham, Thaine W Reynolds, and Yih-Yun Hsu Washington Feb 1976 42 p refs
(NASA-TN-D-8165, E-8463) Avail NTIS HC $4 00 CSCL 10A

The overall feasibility of the chemical conversion of waste or grown organic matter to fuel is examined from the technical, economic, and social viewpoints The energy contribution from a system that uses waste and grown organic feedstocks is estimated as 4 to 12 percent of our current energy consumption. Estimates of today's market prices for these fuels are included Economic and social issues are as important as technology in determining the feasibility of such a proposal An orderly program of development and demonstration is recommended to provide reliable data for an assessment of the viability of the proposal Author

N76-19552*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
FLEXIBLE FORMULATED PLASTIC SEPARATORS FOR ALKALINE BATTERIES Patent Application
D. W. Scheibley, J. M. Bozek, and D. G. Soltis, inventors (to NASA) Filed 8 Mar 1976 10 p
(NASA-Case-LEW-12363-1, US-Patent-Appl-SN-665034) Avail: NTIS HC $3.50 CSCL 10C

A flexible separator for alkaline batteries is described which comprises a coating applied to a nonwoven porous substrate such as sheets or mats of asbestos or other materials which are inert with respect to the alkaline electrolyte of the battery. The coating material comprises a polyphenylene oxide polymer, an organic additive and inorganic and organic fillers which comprise 55% by volume or less of the coating material. Preferably, at least one inorganic filler material which is reactive with the electrolyte is included to produce desirable pores in the coating. The organic additive is a polymeric polyester material which is hydrolyzed by the alkaline electrolyte to improve conductivity of the coating. NASA

N76-19563*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
COMPARISON OF TYPE A AND C FLUORINATED ETHYLENE PROPYLENE (FEP) AS COVER MATERIALS FOR SILICON SOLAR CELLS
Jacob D. Broder Mar 1976 10 p
(NASA-TM-X-3375, E-8597) Avail: NTIS HC $3.50 CSCL 10A

Fluorinated ethylene propylene film (FEP, 0.0127 cm thick) was heat and pressure laminated to silicon solar cells as a low cost substitute for quartz covers. The FEP-C, treated on one side for bonding, was compared to FEP-A, an untreated FEP. With FEP-A, a silane adhesion promoter was applied to the cells. The FEP-C covers delaminated during accelerated temperature-humidity testing and Earth environmental exposure testing. FEP-A covers were unchanged. No differences were observed in peel tests, but FEP-A is superior in its resistance to tearing and in retention of transmission properties after exposure to ultraviolet radiation. Author

N76-20631*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
COMPARATIVE EVALUATION OF PHASE 1 RESULTS FROM THE ENERGY CONVERSION ALTERNATIVES STUDY (ECAS)
Feb 1976 375 p refs Sponsored in part by ERDA and NSF
(NASA-TM-X-71855; E-8596) Avail: NTIS HC $10.50 CSCL 10A

Ten advanced energy conversion systems for central-station, based-load electric power generation using coal and coal-derived fuels which were studied by NASA are presented. Various contractors were selected by competitive bidding to study these systems. A comparative evaluation is provided of the contractor results on both a system-by-system and an overall basis. Ground rules specified by NASA, such as coal specifications, fuel costs, labor costs, method of cost comparison, escalation and interest during construction, fixed charges, emission standards, and environmental conditions, are presented. Each system discussion includes the potential advantages of the system, the scope of each contractor's analysis, typical schematics of systems, comparison of cost of electricity and efficiency for each contractor, identification and reconciliation of differences, identification of future improvements, and discussion of outside comments. Considerations common to all systems, such as materials and furnaces, are also discussed. Results of selected in-house analyses are presented, in addition to contractor data. The results for all systems are then compared. Author

N76-21679*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CLOSED CYCLE MHD POWER GENERATION EXPERIMENTS USING A HELIUM-CESIUM WORKING FLUID IN THE NASA LEWIS FACILITY
Ronald J. Sovie 1976 11 p refs Proposed for presentation at Fifteenth Symp. on the Eng. Aspects of Magnetohydrodynamics, Philadelphia, 24-26 May 1976
(NASA-TM-X-71885, E-8660) Avail: NTIS HC $3.50 CSCL 10A

A MHD channel, which was previously operated for over 500 hours of thermal operation, ten thermal cycles, and 200 cesium injection tests, was removed from the facility and redesigned. The cross sectional dimensions of the channel were reduced to 5 by 16.5 cm to allow operation over a variety of conditions. The redesigned channel has been operated for well over 300 hours, 10 thermal cycles, and 150 cesium injection tests with no problems. Experiments have been run at temperatures of 1900-2100 K and Mach numbers from 0.3 to 0.55 in argon and 0.2 in helium. The best results to date have been obtained in the helium tests. Power outputs of 2.2 kw for tests with 28 electrodes and 2.1 kw for tests with 17 electrodes were realized. Power densities of 0.6 MW/cu m and Hall fields of about 1,100 V/m were obtained in the tests with 17 electrodes. Author

N76-21682*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
RESULTS AND PROGRESS ON THE NASA LEWIS H2-O2 MHD PROGRAM
J. Marlin Smith 1976 8 p refs Presented at 15th Symp. on the Eng. Aspects of Magnetohydrodyn., Philadelphia, 24-26 May 1976
(NASA-TM-X-71891, E-8675) Avail: NTIS HC $3.50 CSCL 10A

It was found that flame sprayed ceramic coatings on combustion chamber and nozzle walls permit operation with hot walls, thereby eliminating possible problems associated with seed condensation. However, under the conditions of experiment the net heat transfer was unexpectedly increased over that of cold copper walls. Pressure disturbances associated with oblique pressure waves were measured in a MHD channel. These disturbances are due to a rocket-type nozzle which was designed to achieve low weight rather than perfectly parallel flow at the exit. A new nozzle with parallel flow at the exit was designed. Electrical conductivity measurements agreed well with theory except at low combustion pressures and/or high ratios of seed/oxygen mass flows (seed was injected into oxygen flow line). The discrepancy is believed to be the result of poor atomization of the seed at high ratios of seed/oxygen mass flows which results in droplet sizes which do not completely vaporize the combustor. Author

N76-21683*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
LARGE EXPERIMENTAL WIND TURBINES: WHERE WE ARE NOW
Ronald L. Thomas 1976 32 p refs Presented at 3d Energy Technol. Conf./Exposition, Washington, D. C., 29-31 Mar 1976, sponsored by Government Inst., Inc.
(NASA-TM-X-71890; E-8674) Avail: NTIS HC $4.00 CSCL 10B

Several large wind turbine projects have been initiated by NASA-Lewis as part of the ERDA wind energy program. The projects consist of progressively large wind turbine ranging from 100 kW with a rotor diameter of 125 feet to 1500 kW with rotor diameters of 200 to 300 feet. Also included is supporting research and technology for large wind turbines and for lowering the costs and increasing the reliability of the major wind turbine components. The results and status of the above projects are briefly discussed in this report. In addition, a brief summary and status of the plans for selecting the utility sites for the experimental wind turbines is also discussed. Author

N76-21700*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THE COMPUTER SIMULATION OF AUTOMOBILE USE PATTERNS FOR DEFINING BATTERY REQUIREMENTS FOR ELECTRIC CARS
Harvey J. Schwartz 1976 13 p refs To be presented at the

4th Intern Elec Vehicle Symp., Dusseldorf, 31 Aug - 2 Sep 1976, sponsored by Intern Union of Producers and Distributors of Elec Energy
(NASA-TM-X-71900, E-8689) Avail NTIS HC $3.50 CSCL 10C

A Monte Carlo simulation process was used to develop the U S daily range requirements for an electric vehicle from probability distributions of trip lengths and frequencies and average annual mileage data The analysis shows that a car in the U S with a practical daily range of 82 miles (132 km) can meet the needs of the owner on 95% of the days of the year, or at all times other than his long vacation trips Increasing the range of the vehicle beyond this point will not make it more useful to the owner because it will still not provide intercity transportation A daily range of 82 miles can be provided by an intermediate battery technology level characterized by an energy density of 30 to 50 watt-hours per pound (66 to 110 W-hr/kg) Candidate batteries in this class are nickel-zinc, nickel-iron, and iron-air. The implication of these results for the research goals of far-term battery systems suggests a shift in emphasis toward lower cost and greater life and away from high energy density
Author

N76-21701*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
THE REQUIREMENTS FOR BATTERIES FOR ELECTRIC VEHICLES
Harvey J Schwartz 1976 7 p refs To be presented at the 27th Power Sources Symp., Atlantic City, 21-24 Jun. 1976
(NASA-TM-X-71916; E-8721) Avail NTIS HC $3 50 CSCL 10C

Analysis of automobile use patterns shows that the battery requirements for an urban car can be met by mid-term battery technology. The far-term technology potentially offers greater range but does not proportionately increase the usefulness of the vehicle. This suggests that emphasis should be shifted toward more modest energy density goals, if such a shift would ease technical problems and allow the use of lower cost materials and construction methods A technology diffusion model indicates that the impact of the mid-term batteries by the year 2000 would be greater than that of the far-term batteries because of their earlier introduction and nearly equal market potential From the standpoint of maximizing both the cumulative impact and the benefits derived in the year 2000, however, a strategy of early introduction of near-term and mid-term cars followed by the far-term vehicle would produce the optimum results Author

N76-21702*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
MODEL FOR CALCULATING ELECTROLYTIC SHUNT PATH LOSSES IN LARGE ELECTROCHEMICAL ENERGY CONVERSION SYSTEMS
Paul R Prokopius Washington Apr. 1976 14 p ref
(NASA-TM-X-3359, E-8501) Avail NTIS HC $3 50 CSCL 10B

Generalized analysis and solution techniques were developed to evaluate the shunt power losses in electrochemical systems designed with a common or circulating electrolyte supply Sample data are presented for a hypothetical bulk energy storage redox system, and the general applicability of the analysis technique is discussed
Author

N76-21703*# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio
FABRICATION AND ASSEMBLY OF THE ERDA/NASA 100 KILOWATT EXPERIMENTAL WIND TURBINE
Richard L Puthoff Washington Apr 1976 30 p refs
(NASA-TM-X-3390, E-8663) Avail NTIS HC $4 00 CSCL 10B

As part of the Energy Research and Development Administration (ERDA) wind-energy program, NASA Lewis Research Center has designed and built an experimental 100-kW wind turbine The two-bladed turbines drives a synchronous alternator that generates its maximum output of 100 kW of electrical power in a 29-km/hr (18-mph) wind The design and assembly of the wind turbine were performed at Lewis from components that were procured from industry The machine was installed atop the tower on September 3 1975
Author

N76-22668*# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio
A SUMMARY OF THE ECAS PERFORMANCE AND COST RESULTS FOR MHD SYSTEMS
G R Seikel, R. J. Sovie, R K Burns, G J Barna J A Burkhart, J J Nainiger and J M Smith 1976 22 p refs Proposed for presentation at the Fifteenth Symp on the Eng Aspects of Magnetohydrodynamics, Philadelphia, 24-26 May 1976
(NASA-TM-X-71913) Avail NTIS HC $3 50 CSCL 10B

The potential is examined of various advanced power plant concepts using coal and coal-derived fuel The results indicate that open cycle coal fired direct preheat MHD systems have potentially one of the highest coal-pile-to-bus-bar efficiencies and also one of the lowest costs of electricity (COE) of the systems studied Closed cycle MHD systems may have the potential to approach the efficiency and COE of open cycle MHD. The 1200-1500 F liquid metal MHD systems studied do not appear to have the potential of exceeding the efficiency or competing with the COE of advanced steam plants
Author

N76-23690*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
STANDARDIZED PERFORMANCE TESTS OF COLLECTORS OF SOLAR THERMAL ENERGY-A FLAT-PLATE COLLECTOR WITH A SINGLE-TUBE SERPENTINE FLOW DISTRIBUTION
Susan Johnson Apr 1976 7 p
(NASA-TM-X-73417, E-8752) Avail NTIS HC $3 50 CSCL 10A

This preliminary data report gives basic test results of a flat-plate solar collector whose performance was determined in the NASA-Lewis solar simulator. The collector was tested over ranges of inlet temperatures fluxes and coolant flow rates Collector efficienty is correlated in terms of inlet temperature and flux level.
Author

N76-23691*# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio
NASA THERMIONIC-CONVERSION PROGRAM
J F Morris and J G Lundholm (NASA, Washington) 1976 6 p refs Proposed for presentation at Eleventh Intersoc Energy Conversion Eng Conf., State Line, Nev., 12-17 Sep 1976
(NASA-TM-X-73430, E-8778) Avail NTIS HC $3.50 CSCL 10A

Current out-of-core emphases allow converter material and design freedoms previously prohibited by in-core nucleonic and geometric restrictions As a result, potential improvements indicate possibilities for severalfold increases in efficiencies The new TEC-ART program concentrated initially on low-work function collectors and interelectrode-loss reduction and revealed much in a short time This new emission capability coupled with improved collectors that maintain performance with emitter-vapor deposit accumulations are requisites for efficient, enduring thermionic converters.
Author

N76-23713*# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio
MULTI-CELL BATTERY PROTECTION SYSTEM Patent Application
Ralph D Thomas and William J Nagle, inventors (to NASA) Filed 19 May 1976 14 p
(NASA-Case-LEW-12039-1, US-Patent-Appl-SN-687822) Avail NTIS HC $3 50 CSCL 10C

A multi-cell battery protection system is provided wherein each cell has its own individual protective circuit The protective circuits each comprise 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 NASA

N76-26686*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
A PRELIMINARY ASSESSMENT OF THE FEASIBILITY OF DERIVING LIQUID AND GASEOUS FUELS FROM GROWN AND WASTE ORGANICS
Robert W Graham, Thaine W. Reynolds, and Yih-Yun Hsu 1976 9 p refs Presented at 11th Intersociety Energy Conversion Engr. Conf., State Line, Nev., 12-17 Sep 1976
(NASA-TM-X-73441; E8463) Avail NTIS HC $3.50 CSCL 21D

The anticipated depletion of our resources of natural gas and petroleum in a few decades has caused a search for renewable sources of fuel. Among the possibilities is the chemical conversion of waste and grown organic matter into gaseous or liquid fuels The overall feasibility of such a system is considered from the technical, economic, and social viewpoints. Although there are a number of difficult problems to overcome, this preliminary study indicates that this option could provide between 4 and 10 percent of the U.S. energy needs Estimated costs of fuels derived from grown organic material are appreciably higher than today's market price for fossil fuel The cost of fuel derived from waste organics is competitive with fossil fuel prices. Economic and social reasons will prohibit the allocation of good food producing land to fuel crop production Author

N76-26694*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EXPERIMENTAL INVESTIGATION OF THE EXCESS CHARGE AND TIME CONSTANT OF MINORITY CARRIERS IN THE THIN DIFFUSED LAYER OF 0 1 ohm-cm SILICON SOLAR CELLS
M P Godlewski, Henry W Brandhorst, Jr., F A Lindholm (Fla Univ., Gainesville), and C T Sah (Ill Univ., Urbana) 1976 7 p refs Presented at Mater Res Conf., Salt Lake City, 23-25 Jun 1976, Sponsored by the Am Inst. of Mining, Met., and Petrol. Engr
(NASA-TM-X-73455; E-8814) Avail NTIS HC $3 50 CSCL 10A

An experimental method is presented that can be used to interpret the relative roles of bandgap narrowing and recombination processes in the diffused layer This method involves measuring the device time constant by open-circuit voltage decay and the base region diffusion length by X-ray excitation. A unique illuminated diode method is used to obtain the diode saturation current. These data are interpreted using a simple model to determine individually the minority carrier lifetime and the excess charge These parameters are then used to infer the relative importance of bandgap narrowing and recombination processes in the diffused layer Author

N76-27680# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio. Div of Solar Energy.
INTERIM SOLAR CELL TESTING PROCEDURES FOR TERRESTRIAL APPLICATIONS
H Brandhorst, J. Hickey, and H Curtis Jul. 1975 18 p Sponsored by ERDA
(TID-26871) Avail NTIS HC $4 50

This report presents an interim draft of procedures for testing solar cells for terrestrial applications that resulted from the terrestrial photovoltaic workshop sessions A final version of the test procedures manual is planned for the summer of 1976 ERA

N76-28643*# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio
GELS AS BATTERY SEPARATORS FOR SOLUBLE ELECTRODE CELLS Patent Application
Dean W Sheibley and Randall F Gahn, inventors (to NASA) Filed 20 Jul 1976 18 p
(NASA-Case-LEW-12364-1; US-Patent-Appl-SN-707124) Avail: NTIS HC $3 50 CSCL 10C

Gels are formed from silica powders and hydrochloric acid The gels can then be impregnated into a polymeric foam and the resultant sheet material can then be used in applications where the transport of chloride ions is desired Specifically disclosed is the utilization of the sheet in electrically rechargeable redox flow cells which find application in bulk power storage systems NASA

N76-28646*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
DIRECT HEATING SURFACE COMBUSTOR Patent Application
Donald G Beremand, Lloyd Shure, and Thaddeus S. Mroz, inventors (to NASA) Filed 26 Jul 1976 13 p
(NASA-Case-LEW-11877-1, US-Patent-Appl-SN-708660) Avail NTIS HC $3 50 CSCL 10B

A direct heating surface combustor is described that utilizes a non-adiabatic flame to provide a 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 at the combustor, the remainder may be added to the combustion products further downstream. NASA

N76-30650*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
TRANSIENT ANALYSIS OF UNBALANCED SHORT CIRCUITS OF THE ERDA-NASA 100 kW WIND TURBINE ALTERNATOR
H H Hwang (Univ of Hawaii) and Leonard J Gilbert Jul 1976 29 p refs
(NASA-TM-X-73459, E-8821) Avail NTIS HC $4.00 CSCL 10B

Unbalanced short-circuit faults on the alternator of the ERDA-NASA Mod-0100-kW experimental wind turbine are studied For each case, complete solutions for armature, field, and damper-circuit currents; short-circuit torque, and open-phase voltage are derived directly by a mathematical analysis Formulated results are tabulated For the Mod-0 wind turbine alternator, numerical calculations are given, and results are presented by graphs Comparisons for significant points among the more important cases are summarized For these cases the transients are found to be potentially severe The effect of the alternator neutral-to-ground impedance is evaluated Author

N76-30651*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
FUNDAMENTAL STUDIES OF BLACK CHROME FOR SOLAR COLLECTOR USE
G McDonald, B. Buzek, and H. Curtis 1976 5 p ref Presented at Intern Solar Energy Soc Conf., Winnipeg, Canada, 15-20 Aug 1976
(NASA-TM-X-73461; E-8824) Avail. NTIS HC $3 50 CSCL 10A

The thicknesses of black chrome plated for various times have been measured from electron photomicrographs and correlated with the solar spectrum absorptance and infrared emittance as calculated from spectral reflectance measurements The maximum absorptance is reached at an average thickness of 0 5 micrometer The emittance increases only slightly up to 1 0 micrometer but increases rapidly at thickness above 1 0 micrometer Author

N76-31671*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
ANALYSIS OF A SOLAR COLLECTOR FIELD WATER FLOW NETWORK
John E Rohde and Richard H Knoll Washington Aug 1976 29 p refs
(NASA-TM-X-3414; E-8709) Avail NTIS HC $4 00 CSCL 10A

A number of methods are presented for minimizing the water flow variation in the solar collector field for the Solar Building Test Facility at the Langley Research Center. The solar collector field investigated consisted of collector panels connected in parallel between inlet and exit collector manifolds to form 12 rows The rows were in turn connected in parallel between the main inlet and exit field manifolds to complete the field The various solutions considered included various size manifolds, manifold area change, different locations for the inlets and exits to the manifolds and orifices or flow control valves Calculations showed that flow variations of less than 5 percent were obtainable both inside a row between solar collector panels and between various rows' Author

N76-31674*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
INORGANIC-ORGANIC BATTERY SEPARATOR FOR ALKALINE BATTERIES Patent Application
Dean W. Sheibley, inventor (to NASA) Filed 7 Sep. 1976 11 p
(NASA-Case-LEW-12649-1, US-Patent-Appl-SN-720521) Avail: NTIS HC $3.50 CSCL 10C

A flexible separator for use between the electrodes of Ni-Cd and Ni-Zn batteries using alkaline electrolytes is considered The separator is made by coating a porous substrate such as sheets or mats of asbestos or other materials with a battery separator composition. The coating material includes a rubber-based resin copolymer, a plasticizer and inorganic and organic fillers which comprise 55 percent 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 is an organic additive such as a material which is hydrolyzed by the alkaline electrolyte to improve conductivity of the separator coating NASA

N76-32652*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
TESTS OF A REDUCED-SCALE EXPERIMENTAL MODEL OF A BUILDING SOLAR HEATING-COOLING SYSTEM
David Namkoong Washington Sep 1976 23 p refs
(NASA-TM-X-3416, E-8729) Avail NTIS HC $3 50 CSCL 13B

An experimental solar heating and cooling system model has been built and operated, combining elements that are programmable (e g , heating and cooling load of a building and collected solar energy) with experimental equipment The experimental system model was based on the loads and components used in the Solar Building Test Facility (SBTF), which includes a 1394 sq m solar collector field at NASA Langley These tests covered 5 continuous days under summer conditions For the system model up to 55 percent of the simulated collected solar energy was used for the building load This amount of solar energy supplied 35 percent of the building cooling load Heat loss was significant If tank heat loss were eliminated, which would make it similar to the actual SBTF, 75 percent of the collected solar energy would be used. This amount would supply approximately 50 percent of the building cooling load A higher fraction of solar energy is possible with a more performance-optimized system Author

N76-33622*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
INITIAL OPERATION OF A SOLAR HEATING AND COOLING SYSTEM IN A FULL-SCALE SOLAR BUILDING TEST FACILITY
Richard H. Knoll, David Miao, Irvin L Hamlet, and Ronald N Jensen 1976 18 p refs Presented at Intern Solar Energy Soc Conf , Winnipeg, Canada, 15-20 Aug 1976
(NASA-TM-X-73519, E-8931) Avail. NTIS HC $3 50 CSCL 10A

The Solar Building Test Facility (SBTF) was constructed to advance the technology for heating and cooling of office buildings with solar energy Its purposes are to (1) test system components which include high-performing collectors, (2) test the performance of a complete solar heating and cooling system, (3) investigate component interactions, and (4) investigate durability, maintenance and reliability of components The SBTF consists of a 50,000 square foot office building modified to accept solar heated water for operation of an absorption air conditioner and for the baseboard heating system A 12,666 square foot solar collector field with a 30,000 gallon storage tank provides the solar heated water A description of the system and the collectors selected is printed-along with the objectives, test approach, expected system performance, and some preliminary results Author

N76-33624*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
SOLAR CELL SURFACE TREATMENT Patent Application
H W. Brandhorst, Jr. and Cosmo R. Barona, inventors (to NASA) Filed 29 Sep 1976 12 p
(NASA-Case-LEW-11330-2; US-Patent-Appl-SN-727725) Avail. NTIS HC $3 50 CSCL 10A

A method is proposed for improving the antireflective properties of solar cells Grooves are formed by etching the surface of the cell to form two walls each having an angle of 125 3 degrees with the surface of the solar cell The walls forming the groove intersect at a V-shaped angle of about 70 6 degrees at a depth of about 0.7 times the width of the groove Solar cells with such surface modifications reduce the amount of light reflected from the surface of the solar cell, enhance absorption, and increase the operating efficiency of the cell irrespective of the wavelength of photon energy contacting the surface of the cell. NASA

N76-33628*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
TOWER AND ROTOR BLADE VIBRATION TEST RESULTS FOR A 100-KILOWATT WIND TURBINE
Bradford S Linscott, William R Shapton (Cincinnati Univ , Ohio), and David Brown (Cincinnati Univ , Ohio) Washington Oct 1976 40 p refs
(NASA-TM-X-3426, E-8751) Avail NTIS HC $4 00 CSCL 10A

The predominant natural frequencies and mode shapes for the tower and the rotor blades of the ERDA-NASA 100-kW wind turbine were determined The tests on the tower and the blades were conducted both before and after the rotor blades and the rotating machinery were installed on top of the tower. The tower and each blade were instrumented with an accelerometer and impacted by an instrumented mass The tower and blade structure was analyzed by means of NASTRAN, and computed values agree with the test data Author

A76-14744 * FEP-TEFLON encapsulated solar cell modules - Further progress. H. S. Rauschenbach, M D Cannady (TRW Systems Group, Redondo Beach, Calif), and A. F Ratajczak (NASA, Lewis Research Center, Cleveland, Ohio) In Photovoltaic Specialists Conference, 11th, Scottsdale, Ariz , May 6-8, 1975, Conference Record (A76-14727 04-44) New York, Institute of Electrical and Electronics Engineers, Inc , 1975, p. 162-168

A progress report, starting with November 1973, is given in the design, development, and performance of lightweight flexible FET (Fluorinated Ethylene Propylene) encapsulated solar cell modules intended to form standardized building blocks for large roll-up or fold-up solar cell blankets with performances on the order of 100 W/sq m and 80 W/kg in near space. It is shown that interconnected FEP encapsulated modules of advanced design can withstand all typical ground handling, assembly, storage, and launch conditions, and are well suited for high-power space applications. V P

A76-18502 * # **Current status of silicon solar cell technology.** H. W. Brandhorst, Jr. (NASA, Lewis Research Center, Cleveland, Ohio). *Institute of Electrical and Electronics Engineers, International Electron Devices Meeting, Washington, D.C., Dec. 1-3, 1975, Paper.* 7 p.

Recent advances in solar cell technology have led to the development of laboratory cells with efficiencies above 15% and production cells with efficiencies in the area of 13% The increased output is largely the result of increases in the short-circuit current. The-most-significant gain in the amount of-light entering the cell has-been obtained through surface texturing by chemical etching techniques. Sheet resistances resulting from phosphorus diffusion in the 800 C temperature range yield junction depths on the order of 0 1 micrometer, leading to significant increases in the blue region of the cell spectral response The inclusion of a back surface field in 10 ohm-cm cells has produced an increase in open-circuit voltage of about 50 mV and an increase in the minority carrier lifetime. It appears that a low emitter efficiency of the diffused region is the cause of poor voltages. Future research will be primarily directed toward correcting this deficiency and toward the development of low cost production methods C K.D.

A76-18505 * # **Cost and size estimates for an electrochemical bulk energy storage concept.** M. Warshay and L. O Wright (NASA, Lewis Research Center, Cleveland, Ohio). *Electrochemical Society, Meeting, 148th, Dallas, Tex., Oct. 5-9, 1975, Paper.* 12 p 7 refs.

Preliminary capital cost and size estimates were made for an electrochemical bulk energy storage concept for a redox-flow-cell system. Preliminary calculations showed that the redox-flow-cell system has great promise as a bulk energy storage system for power load leveling. The size of the system was estimated to be less than 2 percent of the size of a comparable pumped hydroelectric storage plant. V.P.

A76-18506 * # **A generalized correlation of experimental flat-plate collector performance.** F. F Simon and D R Miller (NASA, Lewis Research Center, Cleveland, Ohio). *American Society for Testing and Materials and American National Standards Institute, Conference on Standards for Solar Heating and Cooling, Philadelphia, Pa., Oct. 14, 15, 1975, Paper.* 19 p.

A generalized correlation of flat-plate collector performance obtained by outdoor and indoor test methods is presented. This correlation shows that the indoor (simulator) test approach is a special case of the general situation of variable solar conditions. The important feature of the generalized correlation is that it permits a separation of the solar variables (flux, incident angle, etc.) which affect collector performance from the collector parameters (absorptance, transmittance, heat loss, etc.) which also affect collector performance and which are uniquely part of a given collector design The correlation permits an evaluation of the relative merits of using instantaneous, hourly and daily collector efficiencies in obtaining a good collector correlation. The question of the transient behavior outdoors of a collector is an important part of determining whether to use instantaneous, hourly or daily efficiency values in a correlation approach Correlation of the experimental performance of collectors allows the following: (1) comparisons of different collector designs, (2) collector performance prediction under conditions that differ from the conditions of the test program, and (3) monitoring performance degradation effects. (Author)

A76-22296 * **A design study of the application of a simplified aircraft fuel control method to automotive gas turbines.** H. Gold (NASA, Lewis Research Center, Cleveland, Ohio). *Society of Automotive Engineers, National Aerospace Engineering and Manufacturing Meeting, Culver City, Calif., Nov. 17-20, 1975, Paper 751063.* 19 p

A76-28028 * # **Photovoltaic Test and Demonstration Project.** A. F. Forestieri, H. W. Brandhorst, Jr., and J. N. Deyo (NASA, Lewis Research Center, Cleveland, Ohio). *Centre National d'Etudes Spatiales and Centre National de la Recherche Scientifique, International Conference on Solar Electricity, Toulouse, France, Mar. 1-5, 1976, Paper.* 5 p.

The Photovoltaic Test and Demonstration Project was initiated by NASA in June, 1975, to develop economically feasible photovoltaic power systems suitable for a variety of terrestrial applications. Objectives include-the determination of operating characteristic and lifetimes of a variety of solar cell systems and components and development of methodology and techniques for accurate measurements of solar cell and array performance and diagnostic measurements for solar power systems Initial work will be concerned with residential applications, with testing of the first prototype system scheduled for June, 1976. An outdoor 10 kW array for testing solar power systems is under construction C K.D.

A76-28234 * # **Structural analysis of wind turbine rotors for NSF-NASA Mod-0 wind power system.** D. A. Spera (NASA, Lewis Research Center, Cleveland, Ohio). In: Advanced wind energy systems; Proceedings of the Workshop, Stockholm, Sweden, August 29, 30, 1974. Volume 1. (A76-28226 12-44) Stockholm, Styrelsen for Teknisk Utveckling, 1976, p. 2-63 to 2-99. 7 refs

Preliminary estimates are presented of vibratory loads and stresses in hingeless and teetering rotors for the proposed NSF-NASA Mod-0 wind power system Preliminary blade design utilizes a tapered tubular aluminum spar which supports nonstructural aluminum ribs and skin and is joined to the rotor hub by a steel shank tube. Stresses in the shank of the blade are calculated for static, rated, and overload operating conditions Blade vibrations were limited to the fundamental flapping modes, which were elastic cantilever bending for hingeless rotor blades and rigid-body rotation for teetering rotor blades The MOSTAB-C computer code was used to calculate aerodynamic and mechanical loads. The teetering rotor has substantial advantages over the hingeless rotor with respect to shank stresses, fatigue life, and tower loading The hingeless rotor analyzed does not appear to be structurally stable during overloads. (Author)

A76-28250 * # **The U.S.-NSF/NASA wind energy conversion systems /WECS/ program.** L. V. Divone (National Science Foundation, Washington, D.C.) and J. M. Savino (NASA, Lewis Research Center, Cleveland, Ohio). In: Advanced wind energy systems; Proceedings of the Workshop, Stockholm, Sweden, August 29, 30, 1974. Volume 2. (A76-28226 12-44) Stockholm, Styrelsen for Teknisk Utveckling, 1976, p 7-25 to 7-33.

The five-year research and development plan of the NSF/NASA Wind Energy Conversion Systems (WECS) program is outlined. The program includes mission studies to determine energy use patterns and requirements and define specific applications for wind energy systems, wind energy resource assessment and development, and development of cost-effective components and subsystems. The program is also directed towards the development of energy storage systems to make wind powered systems firm power sources where appropriate. A 100 kW experimental wind generator (Model Zero) is being designed as a flexible test bed for a variety of system components. Designs will be developed for units in the 50 to 200 kW and 500 to 3000 kW size ranges. C.K.D.

A76-43145 * # **Experimental investigation of the excess charge and time constant of minority carriers in the thin diffused layer of 0.1 Ohm-cm silicon solar cells.** M. P Godlewski, H. W. Brandhorst, Jr. (NASA, Lewis Research Center, Cleveland, Ohio), F. A. Lindholm (Florida, University, Gainesville, Fla.), and C T. Sah (Illinois, University, Urbana, Ill.). *American Institute of Mining, Metallurgical, and Petroleum Engineers, Materials Research Conference, Salt Lake City, Utah, June 23-25, 1976, Paper.* 7 p 8 refs.

The observed low open-circuit voltage in 0 1 Ohm-cm solar cells is probably related to an excessively high diode saturation current

Theoretical studies conducted by Lindholm et al (1975) and by Godlewski et al (1975) have shown that a high saturation current could be produced by either high recombination rates or bandgap narrowing effects. A description is given of an investigation which shows that bandgap narrowing effects have a first order significance in determining the charge carrier transport controlling the open-circuit voltage of 0 1 Ohm-cm silicon solar cells G R.

A76-43146 * # The requirements for batteries for electric vehicles H J Schwartz (NASA, Lewis Research Center, Cleveland, Ohio) *US Army, COMSAT, NASA, and ERDA, Power Sources Symposium, 27th, Atlantic City, N J., June 21-24, 1976, Paper.* 6 p 10 refs

The paper reassesses the role of electric vehicles in the modern transportation system and their potential impact on oil consumption. Three major factors determining the size of this impact are discussed. the market potential, the date of introduction, and the rate of consumer acceptance. The strategy of selecting the battery type for an urban car to introduce in coming years is analyzed. The results of the analysis suggest that the research and development emphasis should be placed on near- and mid-term battery technology. From the standpoint of maximizing both the cumulative impact and the benefits derived in the year 2000, however, a strategy of early introduction of near-term and mid-term cars followed by the far-term vehicles seems to produce the optimum result. S N.

N76-10567*# Globe-Union, Inc , El Monte, Calif . Centralab Semiconductor

LOW COST SOLAR CELL ARRAYS

P A Iles and H. McLennan May 1975 96 p refs

(Contract NAS3-17864)

(NASA-CR-134815) Avail NTIS HC $4.75 CSCL 10A

Limitations in both space and terrestrial markets for solar cells are described. Based on knowledge of the state-of-the-art, six cell options are discussed, as a result of this discussion, the three most promising options (involving high, medium and low efficiency cells respectively) were selected and analyzed for their probable costs The results showed that all three cell options gave promise of costs below $10 per watt in the near future. Before further cost reductions can be achieved, more R and D work is required, suggestions for suitable programs are given. Author

N76-15574*# General Atomic Co , San Diego, Calif

STUDIES OF THE USE OF HIGH-TEMPERATURE NUCLEAR HEAT FROM AN HTGR FOR HYDROGEN PRODUCTION

D. D. Peterman, R W Fontaine, R N Quade, L J. Halvers, and A M Jahromi 30 Sep 1975 355 p refs

(Contract NAS3-18935)

(NASA-CR-134919, GA-A13391) Avail NTIS HC $10 50 CSCL 10A

The results of a study which surveyed various methods of hydrogen production using nuclear and fossil energy are presented A description of these methods is provided, and efficiencies are calculated for each case The process designs of systems that utilize the heat from a general atomic high temperature gas cooled reactor with a steam methane reformer and feed the reformer with substitute natural gas manufactured from coal, using reforming temperatures, are presented The capital costs for these systems and the resultant hydrogen production price for these cases are discussed along with a research and development program For individual titles, see N76-15575 through N76-15586

N76-15594*# Raytheon Co , Sudbury, Mass Equipment Div

MICROWAVE POWER TRANSMISSION SYSTEM STUDIES. VOLUME 1. EXECUTIVE SUMMARY

O E Maynard, W C Brown, A Edwards, G Meltz, J. T Haley, J M Howell, and A Nathan (Grumman Aerospace Corp , Bethpage, N Y) Dec 1975 231 p refs

(Contract NAS3-17835)

(NASA-CR-134886-Vol-1, ER75-4368-Vol-1) Avail NTIS HC $8 00 CSCL 10B

A study of microwave power generation, transmission, reception and control was conducted as a part of a program to demonstrate the feasibility of power transmission from geosynchronous orbit A summary is presented of results concerning design approaches, estimated costs (ROM), critical technology, associated ground and orbital test programs with emphasis on dc to rf conversion, transmitting antenna, phase control mechanical systems, flight operations, ground power receiving-rectifying antenna with systems analysis, and evaluation. Recommendations for early further in-depth studies complementing the technology program are included Author

N76-15595*# Raytheon Co , Sudbury, Mass Equipment Div

MICROWAVE POWER TRANSMISSION SYSTEM STUDIES. VOLUME 2 INTRODUCTION, ORGANIZATION, ENVIRONMENTAL AND SPACEBORNE SYSTEMS ANALYSES

O E. Maynard, W C Brown, A Edwards, J. T Haley, G Meltz J M. Howell, and A Nathan (Grumman Aerospace Corp , Bethpage, N Y) Dec 1975 262 p refs

(Contract NAS3-17835)

(NASA-CR-134886-Vol-2, ER75-4368-Vol-2) Avail NTIS HC $9 00 CSCL 10B

Introduction, organization, analyses, conclusions, and recommendations for each of the spaceborne subsystems are presented Environmental effects - propagation analyses are presented with appendices covering radio wave diffraction by random ionospheric irregularities, self-focusing plasma instabilities and ohmic heating of the D-region. Analyses of dc to rf conversion subsystems and system considerations for both the amplitron and the klystron are included with appendices for the klystron covering cavity circuit calculations, output power of the solenoid-focused klystron, thermal control system, and confined flow focusing of a relativistic beam The photovoltaic power source characteristics are discussed, as they apply to interfacing with the power distribution flow paths, magnetic field interaction, dc to rf converter protection, power distribution including estimates for the power budget, weights, and costs Analyses for the transmitting antenna consider the aperture illumination and size, with associated efficiencies and ground power distributions. Analyses of subarray types and dimensions, attitude error, flatness, phase error, subarray layout, frequency tolerance, attenuation, waveguide dimensional tolerances, mechanical including thermal considerations are included Implications associated with transportation, assembly and packaging, attitude control and alignment are discussed The phase front control subsystem, including both ground based pilot signal driven adaptive and ground command approaches with their associated phase errors, are analyzed Author

N76-15596*# Raytheon Co , Sudbury, Mass Equipment Div.

MICROWAVE POWER TRANSMISSION SYSTEM STUDIES VOLUME 3, SECTION 8: MECHANICAL SYSTEMS AND FLIGHT OPERATIONS

O E Maynard, W C Brown, A Edwards, J T Haley, G Meltz, J M Howell, and A Nathan (Grumman Aerospace Corp , Bethpage, N Y) Dec 1975 234 p refs

(Contract NAS3-17835)

(NASA-CR-134886-Vol-3, ER75-4368-Vol-3) Avail NTIS HC $8 00 CSCL 10B

The efforts and recommendations associated with preliminary design and concept definition for mechanical systems and flight operations are presented Technical discussion in the areas of mission analysis, antenna structural concept, configuration analysis, assembly and packaging with associated costs are presented Technology issues for the control system, structural system, thermal system and assembly including cost and man's role in assembly and maintenance are identified Background and desired outputs for future efforts are discussed Author

N76-15597*# Raytheon Co , Sudbury, Mass Equipment Div

MICROWAVE POWER TRANSMISSION SYSTEM STUDIES VOLUME 4: SECTIONS 9 THROUGH 14 WITH APPENDICES

O. E Maynard, W C. Brown, A. Edwards, J T. Haley, G. Meltz, J. M. Howell, and A Nathan (Grumman Aerospace Corp., Bethpage, N. Y.) Dec 1975 235 p refs
(Contract NAS3-17835)
(NASA-CR-134886-Vol-4; ER75-4368-Vol-4) Avail: NTIS HC $8 00 CSCL 10B

The microwave rectifier technology, approaches to the receiving antenna, topology of rectenna circuits, assembly and construction, ROM cost estimates are discussed Analyses and cost estimates for the equipment required to transmit the ground power to an external user Noise and harmonic considerations are presented for both the amplitron and klystron and interference limits are identified and evaluated The risk assessment discussion is discussed wherein technology risks are rated and ranked with regard to their importance in impacting the microwave power transmission system The system analyses and evaluation are included of parametric studies of system relationships pertaining to geometry, materials, specific cost, specific weight, efficiency, converter packing, frequency selection, power distribution, power density, power output magnitude, power source, transportation and assembly. Capital costs per kW and energy costs as a function of rate of return, power source and transportation costs as well as build cycle time are presented. The critical technology and ground test program are discussed along with ROM costs and schedule The orbital test program with associated critical technology and ground based program based on full implementation of the defined objectives is discussed. Author

N76-15599*# Westinghouse Astronuclear Lab, Pittsburgh, Pa
STUDIES OF THE USE OF HEAT FROM HIGH TEMPERATURE NUCLEAR SOURCES FOR HYDROGEN PRODUCTION PROCESSES
G H Farbman Jan 1976 328 p refs
(Contract NAS3-18934)
(NASA-CR-134918) Avail NTIS HC $10 00 CSCL 10B

Future uses of hydrogen and hydrogen production processes that can meet the demand for hydrogen in the coming decades were considered To do this, a projection was made of the market for hydrogen through the year 2000. Four hydrogen production processes were selected, from among water electrolysis, fossil based and thermochemical water decomposition systems, and evaluated, using a consistent set of ground rules, in terms of relative performance, economics, resource requirements, and technology status Author

N76-18670*# Ionics, Inc., Watertown, Mass Research Div
ANION SELECTIVE MEMBRANE
Samuel S Alexander, Richard R Geoffroy, and Russell B Hodgdon [1975] 86 p refs
(Contract NAS3-28897)
(NASA-CR-134931) Avail NTIS HC $5 00 CSCL 10C

Experimental anion permselective membranes were prepared and tested for their suitability as cell separators in a chemical redox power storage system being developed at NASA-Lewis Research Center The goals of long-term (1000 hr) oxidative and thermal stability at 80 C in FeCl3 and CrCl3 electrolytes were met by most of the weak base and strong base amino exchange groups considered in the program Good stability is exhibited by several of the membrane substrate resins. These are 'styrene divinylbenzene copolymer and PVC film At least four membrane systems produce strong flexible films with electrochemical properties (resistivity, cation transfer) superior to those of the 103QZL, the most promising commercial membrane The physical and chemical properties of the resins are listed Author

N76-19560*# RCA Labs, Princeton, N.J.
EPITAXIAL SOLAR CELLS FABRICATION Final Report, 11 Nov. 1974 - 10 Nov. 1975
R V DAiello, P. H. Robinson, and H. Kressel Dec 1975 81 p refs
(Contract NAS3-19401)
(NASA-CR-134968 PRRL-75-CR-73) Avail. NTIS HC $5 00 CSCL 10A

Silicon epitaxy has been studied for the fabrication of solar cell structures, with the intent of optimizing efficiency while maintaining suitability for space applications SiH2CL2 yielded good quality layers and junctions with reproducible impurity profiles. Diode characteristics and lifetimes in the epitaxial layers were investigated as a function of epitaxial growth conditions and doping profile, as was the effect of substrates and epitaxial post-gettering on lifetime. The pyrolytic decomposition of SiH4 was also used in the epitaxial formation of highly doped junction layers on bulk Si wafers. The effects of junction layer thickness and bulk background doping level on cell performance, in particular, open-circuit voltage, were investigated The most successful solar cells were fabricated with SiH2 CL2 to grow p/n layers on n(+) substrates The best performance was obtained from a p(+)/p/n/n(+) structure grown with an exponential grade in the n-base layer. Author

N76-19561*# Southern Research Inst., Birmingham, Ala
DEVELOPMENT OF ANION-SELECTIVE MEMBRANES
R E. Lacey and D. R Cowsar Oct 1975 52 p refs
(Contract NAS3-18898)
(NASA-CR-134932 SORI-EAS-75-501) Avail: NTIS HC $4 50 CSCL 10A

Methods were studied of preparing anion-exchange membranes that would have low resistance, high selectivity, and physical and chemical stability when used in acidic media in a redox energy storage system Of the twelve systems selected for study, only the system that was based on crosslinked poly-4-vinylpyridinium chloride produced physically strong membranes when equilibrated in I M HCl The resistivity of the best membrane was 12 ohm-cm, and the transference number for chloride ions was 0 81 Author

N76-20633*# Spectrolab, Inc., Sylmar Calif.
LOW COST SILICON SOLAR CELL ARRAY Final Technical Report
F T. C Bartels Sep. 1974 95 p refs
(Contract NAS3-17361)
(NASA-CR-134743; Rept-3788-FR) Avail NTIS HC $5 00 CSCL 10A

The technological options available for producing low cost silicon solar cell arrays were examined A project value of approximately $250/sq m and $2/watt is projected, based on mass production capacity demand Recommendations are included for the most promising cost reduction options Author

N76-23678*# Ionics, Inc., Watertown, Mass Research Div
ANION PERMSELECTIVE MEMBRANE Summary Report
Samuel S Alexander, Richard R Geoffroy, and Russell Hodgdon [1975] 85 p refs
(Contract NAS3-18897)
(NASA-CR-134931) Avail NTIS HC $5 00 CSCL 10C

Experimental anion permselective membranes were prepared and tested for their suitability as cell separators in a chemical redox power storage system being developed at NASA-Lewis Research Center. The goals of long-term (1000 hr) oxidative and thermal stability at 80 C in FeC13 and CrC13 electrolytes were met by most of the weak base and strong base amino exchange groups considered in the program Good stability was also shown by several of the membrane substrate resins These were 'styrene' divinylbenzene copolymer and PVC films At least 4 membrane systems produced strong flexible films with electrochemical properties (resistivity, cation transfer) superior to those of the 103QZL, the present front runner membrane The experimental systems also possessed good potential for control and improvement of transport properties and resin stability Author

N76-23679*# General Electric Co., Schenectady, N.Y.
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), GENERAL ELECTRIC PHASE 1. VOLUME 1: EXECUTIVE SUMMARY Final Report

J C Corman Feb 1976 54 p Sponsored in part by ERDA and NSF 3 Vol
(Contract NAS3-19406)
(NASA-CR-134948-Vol-1, SRD-76-011-Vol-1) Avail NTIS HC $4 50 CSCL 10B

A data base for the comparison of advanced energy conversion systems for utility applications using coal or coal-derived fuels was developed Estimates of power plant performance (efficiency), capital cost, cost of electricity, natural resource requirements, and environmental intrusion characteristics were made for ten advanced conversion systems Emphasis was on the energy conversion system in the context of a base loaded utility power plant. All power plant concepts were premised on meeting emission standard requirements A steam power plant (3500 psig, 1000 F) with a conventional coal-burning furnace-boiler was analyzed as a basis for comparison Combined cycle gas/steam turbine system results indicated competitive efficiency and a lower cost of electricity compared to the reference steam plant The Open-Cycle MHD system results indicated the potential for significantly higher efficiency than the reference steam plant but with a higher cost of electricity Author

N76-23680*# General Electric Co , Schenectady, N Y
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), GENERAL ELECTRIC PHASE 1. VOLUME 2 ADVANCED ENERGY CONVERSION SYSTEMS PART 1. OPEN-CYCLE GAS TURBINES Final Report
D H Brown and J C Corman Feb 1976 97 p refs Sponsored in part by ERDA and NSF 3 Vol
(Contract NAS3-19406)
(NASA-CR-134948-Vol-2-Pt-1, SRD-76-011-Vol-2-Pt-1) Avail. NTIS HC $5 00 CSCL 10B

Ten energy conversion systems are defined and analyzed in terms of efficiency These include open-cycle gas turbine recuperative, open-cycle gas turbine, closed-cycle gas turbine, supercritical CO2 cycle, advanced steam cycle, liquid metal topping cycle; open-cycle MHD, closed-cycle inert gas MHD, closed-cycle liquid metal MHD, and fuel cells Results are presented J M S

N76-23681*# General Electric Co , Schenectady, N Y.
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), GENERAL ELECTRIC PHASE 1 VOLUME 2: ADVANCED ENERGY CONVERSION SYSTEMS PART 2. CLOSED TURBINE CYCLES Final Report
D H. Brown, J C Corman, and R B Fleming Feb 1976 96 p refs Sponsored in part by ERDA and NSF 3 Vol
(Contract NAS3-19406)
(NASA-CR-134948-Vol-2-Pt-2, SRD-76-011-Vol-2-Pt-2) Avail NTIS HC $5 00 CSCL 10B

For abstract, see N76-23680

N76-23682*# General Electric Co , Schenectady, N Y
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), GENERAL ELECTRIC PHASE 1. VOLUME 2: ADVANCED ENERGY CONVERSION SYSTEMS. PART 3: DIRECT ENERGY CONVERSION CYCLES Final Report
J C Corman R B. Fleming, L P Harris, and R V Pohl Feb 1976 142 p refs Sponsored in part by ERDA and NSF 3 Vol.
(Contract NAS3-19406)
(NASA-CR-134948-Vol-2-Pt-3, SRD-76-011-Vol-2-Pt-3) Avail NTIS HC $6 00 CSCL 10B

For abstract, see N76-23680

N76-23683*# General Electric Co , Schenectady, N.Y
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), GENERAL ELECTRIC PHASE 1. VOLUME 3: ENERGY CONVERSION SUBSYSTEMS AND COMPONENTS. PART 1: BOTTOMING CYCLES AND MATERIALS OF CONSTRUCTION Final Report
R P Shah and H D Solomon Feb. 1976 86 p refs Sponsored in part by ERDA and NSF 3 Vol
(Contract NAS3-19406)
(NASA-CR-134948-Vol-3-Pt-1; SRD-76-011-Vol-3-Pt-1) Avail NTIS HC $5 00 CSCL 10B

Energy conversion subsystems and components were evaluated in terms of advanced energy conversion systems Results of the bottoming cycles and materials of construction studies are presented and discussed J M S

N76-23684*# General Electric Co., Schenectady, N Y
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), GENERAL ELECTRIC PHASE 1 VOLUME 3· ENERGY CONVERSION SUBSYSTEMS AND COMPONENTS. PART 2· PRIMARY HEAT INPUT SYSTEMS AND HEAT EXCHANGERS Final Report
J C Corman, J H Eskesen, A S Robertson, and R D Stewart Feb. 1976 206 p refs Sponsored in part by ERDA and NSF 3 Vol
(Contract NAS3-19406)
(NASA-CR-134948-Vol-3-Pt-2, SRD-76-011-Vol-3-Pt-2) Avail: NTIS HC $7 75 CSCL 10B

Primary heat input systems and heat exchangers were evaluated for advanced energy conversion systems Results are presented and discussed J M.S

N76-23685*# General Electric Co , Schenectady, N Y
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), GENERAL ELECTRIC PHASE 1. VOLUME 3: ENERGY CONVERSION SUBSYSTEMS AND COMPONENTS. PART 3. GASIFICATION, PROCESS FUELS, AND BALANCE OF PLANT Final Report
W A Boothe, J C Corman, G G. Johnson, and T A V Cassel Feb 1976 174 p refs Sponsored in part by ERDA and NSF 3 Vol
(Contract NAS3-19406)
(NASA-CR-134948-Vol-3-Pt-3, SRD-76-011-Vol-3-Pt-3) Avail NTIS HC $6 75 CSCL 10B

Results are presented of an investigation of gasification and clean fuels from coal Factors discussed include: coal and coal transportation costs; clean liquid and gas fuel process efficiencies and costs; and cost, performance, and environmental intrusion elements of the integrated low-Btu coal gasification system Cost estimates for the balance-of-plant requirements associated with advanced energy conversion systems utilizing coal or coal-derived fuels are included J M S

N76-23686*# United Technologies Corp , South Windsor, Conn
DEVELOPMENT OF ADVANCED FUEL CELL SYSTEM (PHASE 4) Final Report, 20 Feb - 31 Dec. 1975
A P Meyer and W F. Bell 31 Jan 1976 98 p
(Contract NAS3-15339)
(NASA-CR-135030, FCR-0165) Avail NTIS HC $5 00 CSCL 10A

A multiple-task research and development program was performed to improve the weight, life, and performance characteristics of hydrogen-oxygen alkaline fuel cells for advanced power systems During Phase 4, the lowest stabilized degradation rate observed in all the testing completed during four phases of the program, 1 microvolt/hour, was demonstrated. This test continues after 5,000 hours of operation The cell incorporates a PPf anode, a 90Au/10Pt cathode, a hybrid frame, and a Fybex matrix These elements were developed under this program to extend cell life The result demonstrated that the 80Au/20Pt cathode is as stable as a 90Au/10Pt cathode of twice the precious metal loading, was confirmed in full-scale cells A hybrid frame two-cell plaque with dedicated flow fields and manifolds for all fluids was demonstrated to prevent the cell-to cell electrolyte transfer that limited the endurance of multicell plaques At the conclusion of Phase 4, more than 90,900 hours of testing had been completed and twelve different cell designs had been evaluated. A technology base has been established which is ready for evaluation at the powerplant level Author

N76-23687*# United Technologies Corp., South Windsor, Conn
DEVELOPMENT OF ADVANCED FUEL CELL SYSTEM (PHASE 4) Summary Report, 20 Feb. - 31 Dec. 1975
A. P. Meyer and W. F. Bell 31 Jan. 1976 10 p
(Contract NAS3-15339)
(NASA-CR-135030S, FCR-0194) Avail: NTIS HC $3.50 CSCL 10A

For abstract, see N76-23686.

N76-23688*# Spectrolab, Inc., Sylmar, Calif
DEMONSTRATION OF THE FEASIBILITY OF AUTOMATED SILICON SOLAR CELL FABRICATION
William E. Taylor and Fred M. Schwartz Oct. 1975 35 p
(Contract NAS3-18566)
(NASA-CR-134981) Avail: NTIS HC $4.00 CSCL 10A

A study effort was undertaken to determine the process steps and design requirements of an automated silicon solar cell production facility. Identification of the key process steps was made and a laboratory model was conceptually designed to demonstrate the feasibility of automating the silicon solar cell fabrication process. A detailed laboratory model was designed to demonstrate those functions most critical to the question of solar cell fabrication process automating feasibility. The study and conceptual design have established the technical feasibility of automating the solar cell manufacturing process to produce low cost solar cells with improved performance. Estimates predict an automated process throughput of 21,973 kilograms of silicon a year on a three shift 49-week basis, producing 4,747,000 hexagonal cells (38mm/side), a total of 3,373 kilowatts at an estimated manufacturing cost of $0.866 per cell or $1.22 per watt. Author

N76-23689*# Westinghouse Astronuclear Lab., Pittsburgh, Pa
THE CONCEPTUAL DESIGN OF AN INTEGRATED NUCLEAR HYDROGEN PRODUCTION PLANT USING THE SULFUR CYCLE WATER DECOMPOSITION SYSTEM
G. H. Farbman Apr. 1976 208 p refs
(Contract NAS3-18934)
(NASA-CR-134976) Avail: NTIS HC $7.75 CSCL 10B

A hydrogen production plant was designed based on a hybrid electrolytic-thermochemical process for decomposing water. The sulfur cycle water descomposition system is driven by a very high temperature nuclear reactor that provides 1,283 K helium working gas. The plant is sized to approximately ten million standard cubic meters per day of electrolytically pure hydrogen and has an overall thermal efficiency of 45.2 percent. The economics of the plant were evaluated using ground rules which include a 1974 cost basis without escalation, financing structure and other economic factors. Taking into account capital, operation, maintenance and nuclear fuel cycle costs, the cost of product hydrogen was calculated at $5.96/std. cu. m for utility financing. These values are significantly lower than hydrogen costs from conventional water electrolysis plants and competitive with hydrogen from coal gasification plants. Author

N76-23692*# Westinghouse Research Labs., Pittsburgh, Pa
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), WESTINGHOUSE PHASE 1. VOLUME 1: INTRODUCTION AND SUMMARY AND GENERAL ASSUMPTIONS Final Report
D. T. Beecher 12 Feb. 1976 225 p refs 12 Vol
(Contracts NAS3-19407, E(49-18)-1751, Grant NSF AG-551)
(NASA-CR-134941-Vol-1) Avail: NTIS HC $7.75 CSCL 10B

Nine advanced energy conversion concepts using coal or coal-derived fuels are summarized. They are, (1) open-cycle gas turbines, (2) combined gas-steam turbine cycles, (3) closed-cycle gas turbines, (4) metal vapor Rankine topping, (5) open-cycle MHD, (6) closed-cycle MHD, (7) liquid-metal MHD; (8) advanced steam, and (9) fuel cell systems. The economics, natural resource requirements, and performance criteria for the nine concepts are discussed. Author

N76-23702*# Westinghouse Research Labs., Pittsburgh, Pa
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), WESTINGHOUSE PHASE 1. VOLUME 11: ADVANCED STEAM SYSTEMS Final Report
R. W. Wolfe 12 Feb. 1976 315 p 12 Vol
(Contracts NAS3-19407; E(49-18)-1751 Grant NSF AG-551)
(NASA-CR-134941-Vol-11, Rept-76-9E9-ECAS-Rlv 11-Vol-11)
Avail: NTIS HC $9.75 CSCL 10B

A parametric analysis was made of three types of advanced steam power plants that use coal in order to have a comparison of the cost of electricity produced by them a wide range of primary performance variables. Increasing the temperature and pressure of the steam above current industry levels resulted in increased energy costs because the cost of capital increased more than the fuel cost decreased. While the three plant types produced comparable energy cost levels, the pressurized fluidized bed boiler plant produced the lowest energy cost by the small margin of 0.69 mills/MJ (2.5 mills/kWh). It is recommended that this plant be designed in greater detail to determine its cost and performance more accurately than was possible in a broad parametric study and to ascertain problem areas which will require development effort. Also considered are pollution control measures such as scrubbers and separates for particulate emissions from stack gases. Author

N76-23703*# Westinghouse Research Labs., Pittsburgh, Pa
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), WESTINGHOUSE PHASE 1. VOLUME 12: FUEL CELLS Final Report
C. J. Warde, R. J. Ruka, and A. O. Isenberg 12 Feb. 1976 191 p refs 12 Vol.
(Contracts NAS3-19407; E(49-18)-1751, Grant NSF AG-551)
(NASA-CR-134941-Vol-12; Rept-76-9E9-ECAS-Rlv 12-Vol-12)
Avail: NTIS HC $7.50 CSCL 10B

A parametric assessment of four fuel cell power systems -- based on phosphoric acid, potassium hydroxide, molten carbonate, and stabilized zirconia -- has shown that the most important parameters for electricity-cost reduction and/or efficiency improvement standpoints are fuel cell useful life and power density, use of a waste-heat recovery system, and fuel type. Typical capital costs, overall energy efficiencies (based on the heating value of the coal used to produce the power plant fuel), and electricity costs are: phosphoric acid $350-450/kWe, 24-29%, and 11.7 to 13.9 mills/MJ (42 to 50 mills/kWh), alkaline $450-700/kWe, 26-31%, and 12.8 to 16.9 mills/MJ (46 to 61 mills/kWh), molten carbonate $480-650/kWe, 32-46%, and 10.6 to 19.4 mills/MJ (38 to 70 mills/kWh), stabilized zirconia $420-950/kWe, 26-53%, and 9.7 to 16.9 mills/MJ (35 to 61 mills/kWh). Three types of fuel cell power plants -- solid electrolytic with steam bottoming, molten carbonate with steam bottoming, and solid electrolyte with an integrated coal gasifier -- are recommended for further study. Author

N76-23693*# Westinghouse Research Labs., Pittsburgh, Pa
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), WESTINGHOUSE PHASE 1. VOLUME 2: MATERIALS CONSIDERATIONS Final Report
D. E. Thomas 12 Feb. 1976 306 p refs 12 Vol
(Contracts NAS3-19407, E(49-18)-1751, Grant NSF AG-551)
(NASA-CR-134941-Vol-2, Rept-76-9E9-ECAS-Rlv 2-Vol-2)
Avail: NTIS HC $9.75 CSCL 10B

Extensive studies are presented which were carried out on materials behavior in nine advanced energy conversion systems employing coal and coal-derived fuels. The areas of materials behavior receiving particular attention in this regard are (1) fireside corrosion and erosion in boiler and heat exchanger materials, (2) oxidation and hot corrosion of gas turbine materials, (3) liquid metal corrosion and mass transport, (4) high temperature steam corrosion, (5) compatability of materials with coal slag and MHD seed, (6) reaction of materials with impure helium, (7) allowable stresses for boiler and heat exchanger materials, (8) environmental effects on mechanical properties, and (9) liquid metal purity control and instrumentation. Such information was then utilized in recommending materials for use in the critical components of the power systems, and at the same time to identify materials problem areas and to evaluate qualitatively

the difficulty of solving those problems Specific materials recommendations for critical components of the nine advanced systems under study are contained in summary tables Author

N76-23694*# Westinghouse Research Labs, Pittsburgh, Pa
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), WESTINGHOUSE PHASE 1. VOLUME 3. COMBUSTORS, FURNACES AND LOW-BTU GASIFIERS Final Report
J. R Hamm 12 Feb 1976 521 p refs 12 Vol
(Contracts NAS3-19407; E(49-18)-1751, NSF AG-551)
(NASA-CR-134941-Vol-3, Rept-76-9E9-ECAS-Rlv 3-Vol-3)
Avail: NTIS HC $12 75 CSCL 10B

Information is presented on the design, performance, operating characteristics, cost, and development status of coal preparation equipment, combustion equipment, furnaces, low-Btu gasification processes, low-temperature carbonization processes, desulfurization processes, and pollution particulate removal equipment The information was compiled for use by the various cycle concept leaders in determining the performance, capital costs, energy costs, and natural resource requirements of each of their system configurations Author

N76-23695*# Westinghouse Research Labs, Pittsburgh, Pa
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), WESTINGHOUSE PHASE 1. VOLUME 4: OPEN RECUPERATED AND BOTTOMED GAS TURBINE CYCLES Final Report
D J. Amos and J. E Grube 12 Feb 1976 117 p refs 12 Vol.
(Contracts NAS3-19407, E(49-18)-1751, Grant NSF AG-551)
(NASA-CR-134941-Vol-4, Rept-76-9E9-ECAS-Rlv 4-Vol-4)
Avail NTIS HC $5 50 CSCL 10B

Open-cycle recuperated gas turbine plant with inlet temperatures of 1255 to 1644 K (1800 to 2500 F) and recuperators with effectiveness values of 0, 70, 80 and 90% are considered A 1644 K (2500 F) gas turbine would have a 33 5% plant efficiency in a simple cycle, 37 6% in a recuperated cycle and 47 6% when combined with a sulfur dioxide bottomer. The distillate burning recuperated plant was calculated to produce electricity at a cost of 8.19 mills/MJ (29.5 mills/kWh) Due to their low capital cost $170 to 200 S/kW the open cycle gas turbine plant should see duty for peaking and intermediate load duty Author

N76-23696*# Westinghouse Research Labs, Pittsburgh Pa
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), WESTINGHOUSE PHASE 1 VOLUME 5. COMBINED GAS-STEAM TURBINE CYCLES Final Report
D J Amos, R W Foster-Pegg, and R. M Lee 12 Feb 1976 114 p refs 2 Vol
(Contracts NAS3-19407, E(49-18)-1751, Grant NSF AG-551)
(NASA-CR-134941-Vol-5, Rept-76-9E9-ECAS-Rlv 5-Vol-5)
Avail NTIS HC $5 50 CSCL 10B

The energy conversion efficiency of gas-steam turbine cycles was investigated for selected combined cycle power plants Results indicate that it is possible for combined cycle gas-steam turbine power plants to have efficiencies several point higher than conventional steam plants Induction of low pressure steam into the steam turbine is shown to improve the plant efficiency Post firing of the boiler of a high temperature combined cycle plant is found to increase net power but to worsen efficiency A gas turbine pressure ratio of 12 to 1 was found to be close to optimum at all gas turbine inlet temperatures that were studied The coal using combined cycle plant with an integrated low-Btu gasifier was calculated to have a plant efficiency of 43 6% a capitalization of $497/kW, and a cost of electricity of 6 75 mills/MJ (24 3 mills/kwh) This combined cycle plant should be considered for base load power generation Author

N76-23697*# Westinghouse Research Labs, Pittsburgh, Pa
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), WESTINGHOUSE PHASE 1. VOLUME 6: CLOSED-CYCLE GAS TURBINE SYSTEMS Final Report
D J. Amos, W K Fentress, and W F. Stahl 12 Feb 1976 154 p refs 12 Vol
(Contracts NAS3-19407; E(49-18)-1751, Grant NSF AG-551)
(NASA-CR-134941-Vol-6; Rept-76-9E9-ECAS-Rlv 6-Vol-6)
Avail NTIS HC $6 57 CSCL 10B

Both recuperated and bottomed closed cycle gas turbine systems in electric power plants were studied All systems used a pressurizing gas turbine coupled with a pressurized furnace to heat the helium for the closed cycle gas turbine Steam and organic vapors are used as Rankine bottoming fluids Although plant efficiencies of over 40% are calculated for some plants, the resultant cost of electricity was found to be 8 75 mills/MJ (31 5 mills/kWh) These plants do not appear practical for coal or oil fired plants Author

N76-23698*# Westinghouse Research Labs, Pittsburgh, Pa
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), WESTINGHOUSE PHASE 1 VOLUME 7: METAL VAPOR RANKINE TOPPING-STEAM BOTTOMING CYCLES Final Report
P B Deegan 12 Feb 1976 198 p refs 12 Vol
(Contracts NAS3-19407; E(49-18)-1751 Grant NSF AG-551)
(NASA-CR-134941-Vol-7, Rept-76-9E9-ECAS-Rlv.7-Vol-7)
Avail NTIS HC $7 50 CSCL 10B

Adding a metal vapor Rankine topper to a steam cycle was studied as a way to increase the mean temperature at which heat is added to the cycle to raise the efficiency of an electric power plant Potassium and cesium topping fluids were considered Pressurized fluidized bed or pressurized (with an integrated low-Btu gasifier) boilers were assumed. Included in the cycles was a pressurizing gas turbine with its associated recuperator, and a gas economizer and feedwater heater. One of the ternary systems studied shows plant efficiency of 42 3% with a plant capitalization of $66 7/kW and a cost of electricity of 8 19 mills/MJ (29 5 mills/kWh) Author

N76-23699*# Westinghouse Research Labs, Pittsburgh, Pa
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), WESTINGHOUSE PHASE 1. VOLUME 8: OPEN-CYCLE MHD Final Report
D Q. Hoover 12 Feb 1976 439 p refs 12 Vol
(Contracts NAS3-19407; E(49-18)-1751, Grant NSF AG-551)
(NASA-CR-134941-Vol-8; Rept-76-9E9-ECAS-Rlv 8-Vol-8)
Avail NTIS HC $11 75 CSCL 10B

Electric power plant costs and efficiencies are presented for three basic open-cycle MHD systems (1) direct coal fired system (2) a system with a separately fired air heater, and (3) a system burning low-Btu gas from an integrated gasifier Power plant designs were developed corresponding to the basic cases with variation of major parameters for which major system components were sized and costed Flow diagrams describing each design are presented A discussion of the limitations of each design is made within the framework of the assumptions made. Author

N76-23700*# Westinghouse Research Labs Pittsburgh, Pa
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), WESTINGHOUSE PHASE 1 VOLUME 9: CLOSED-CYCLE MHD Final Report
T C Tsu 12 Feb 1976 224 p refs 12 Vol
(Contracts NAS3-19407, E(49-18)-1751, Grant NSF AG-551)
(NASA-CR-134941-Vol-9, Rept-76-9E9-ECAS-Rlv 9-Vol-9)
Avail NTIS HC $7.75 CSCL 10B

A closed-cycle MHD system for an electric power plant was studied It consists of 3 interlocking loops, an external heating loop, a closed-cycle cesium seeded argon nonequilibrium ionization MHD loop, and a steam bottomer. A MHD duct maximum temperature of 2366 K (3800 F), a pressure of 0 939 MPa (9 27 atm) and a Mach number of 0 9 are found to give a topping cycle efficiency of 59 3%, however when combined with an integrated gasifier and optimistic steam bottomer the coal to bus bar efficiency drops to 45 5% A 1978 K (3100 F) cycle has an efficiency of 55 1% and a power plant efficiency of 42 2%

The high cost of the external heating loop components results in a cost of electricity of 21 41 mills/MJ (77 07 mills/kWh) for the high temperature system and 19 0 mills/MJ (68.5 mills/kWh) for the lower temperature system It is, therefore, thought that this cycle may be more applicable to internally heated systems such as some futuristic high temperature gas cooled reactor.
Author

N76-23701*# Westinghouse Research Labs., Pittsburgh, Pa
ENERGY CONVERSION ALTERNATIVES STUDY (ECAS), WESTINGHOUSE PHASE 1. VOLUME 10: LIQUID-METAL MHD SYSTEMS Final Report
R R Holman and T E Lippert 12 Feb 1976 200 p 12 Vol
(Contracts NAS3-19407; E(49-18)-1751; Grant NSF AG-551)
(NASA-CR-134941-Vol-10; Rept-76-9E9-ECAS-Rlv.10-Vol-10)
Avail NTIS HC $7 50 CSCL 10B

Electric Power Plant costs and efficiencies are presented for two basic liquid-metal cycles corresponding to 922 and 1089 K (1200 and 1500 F) for a commercial applications using direct coal firing Sixteen plant designs are considered for which major component equipment were sized and costed The design basis for each major component is discussed Also described is the overall systems computer model that was developed to analyze the thermodynamics of the various cycle configurations that were considered
Author

N76-27667*# Energy Research Corp., Danbury, Conn
INVESTIGATION OF METAL HYDRIDE MATERIALS AS HYDROGEN RESERVOIRS FOR METAL-HYDROGEN BATTERIES
Onischak 30 Jun 1976 50 p refs
(Contract NAS3-18543)
(NASA-CR-135031) Avail NTIS HC $4 00 CSCL 10C

The performance and suitability of various metal hydride materials were examined for use as possible hydrogen storage reservoirs for secondary metal-hydrogen batteries Lanthanum pentanickel hydride appears as a probable candidate in terms of stable hydrogen supply under feasible thermal conditions A kinetic model describing the decomposition rate data of the hydride has been developed
Author

N76-27673*# Yardney Electric Corp., Pawcatuck, Conn
FABRICATION AND TESTING OF SEALED SILVER-ZINC CELLS Final Report
C Philip Donnel, III Jun 1976 61 p
(Contract NAS3-16805)
(NASA-CR-135048) Avail NTIS HC $5 00 CSCL 10C

A number of Type HS40-7 sealed silver-zinc cells and experimental 40AH sealed silver-zinc cells were fabricated Cells of each experimental group contained one variation from the standard configuration (HS40-7) cell. Cells from each of five experimental cell groups and cells of the standard configuration were tested to characterize voltage and capacity performance at various discharge rates The test cells were then subjected to 100 percent DOD Cycle Life Testing at 22 C Results indicate that material and/or process variations are available which will improve both performance and cycle life of the existing 40 ampere-hour sealed silver-zinc cell configurations The average cycle life to 50 percent loss of nominal capacity in cells from two (2) of the experimental groups was 150 - 165 cycles A series of 12 ampere-hour cells was fabricated and tested as part of a program to incorporate the 40AH sealed silver-zinc cell fabrication technology into a cell of smaller size. Base-line configuration cells and experimental variations were produced using the HS40-7 cell fabrication and processing methods adapted to the smaller cell size.
Author

N76-28642*# Yardney Electric Corp., Pawcatuck, Conn
DEVELOPMENT AND FABRICATION OF LARGE VENTED NICKEL-ZINC CELLS Final Report
C Philip Donnel, III Dec 1975 60 p
(Contract NAS3-18515)
(NASA-CR-134967) Avail NTIS HC $4 50 CSCL 10C

A preliminary cell design for a 300AH vented nickel-zinc cell was established based on volume requirements and cell component materials selected by NASA Lewis Research Center A 100AH cell configuration was derived from the 300AH cell design utilizing the same size electrodes, separators and cell terminal hardware The first cells fabricated were four groups of three cells each in the 100AH size These 100AH experimental nickel-zinc cells had as common components the nickel positive electrodes (GFM), flexible inorganic separator (GFM) bags on the negative electrodes, pressed powder zinc oxide electrodes, and cell containers with hardware The variations introduced were four differing electrolyte absorber (interseparator) systems used to encase the nickel positive electrodes of each cell group The four groups of 100AH experimental vented nickel-zinc cells were tested to determine, based on cell performance, the best two interseparator systems Using the two interseparator systems, two groups of experimental 300AH cells were fabricated Each group of three cells differed only in the interseparator material used The six cells were filled, formed and tested to evaluate the interseparator materials and investigate the performance characteristics of the 300AH cell configuration and its components
Author

N76-32651*# Martin Marietta Aerospace, Denver, Colo
DEVELOPMENT OF SINGLE CELL PROTECTORS FOR SEALED SILVER-ZINC CELLS, PHASE 1 Final Report, Apr. 1975 - Apr. 1976
Matthew S Imamura, Richard L Donovan, John W Lear, and Bud Murray Sep 1976 128 p refs
(Contract NAS3-19432)
(NASA-CR-135054, MCR-76-263) Avail NTIS HC $6 00 CSCL 10C

A single cell protector (SCP) assembly capable of protecting a single silver-zinc (Ag Zn) battery cell was designed, fabricated, and tested. The SCP provides cell-level protection against overcharge and overdischarge by a bypass circuit The bypass circuit consists of a magnetic-latching relay that is controlled by the high and low-voltage limit comparators Although designed specifically for secondary Ag-Zn cells, the SCP is flexible enough to be adapted to other rechargeable cells Eighteen SCPs were used in life testing of an 18-cell battery The cells were sealed Ag-Zn system with inorganic separators For comparison, another 18-cell battery was subjected to identical life test conditions, but with battery-level protection rather than cell-level An alternative approach to the SCP design in the form of a microprocessor-based system was conceptually designed The comparison of SCP and microprocessor approaches is also presented and a preferred approach for Ag-Zn battery protection is discussed
Author

A76-10147 * # Concept selection, optimization, and preliminary design of large wind generators. R C. Meier (Kaman Aerospace Corp., Bloomfield, Conn.) *Energy Research and Development Administration and National Science Foundation, Wind Energy Conversion Systems Workshop, Washington, D.C., June 9-11, 1975, Paper.* 20 p. Contract No NAS3-19404.

The development of the conceptual design of high (1000 kW, 18 mph mean wind speed site) and low (100 kW, 12 mph site) power wind generator systems to be integrated into a standard electric utility is discussed. Analyses leading to the selection of the rotor and tower design are outlined. The 1000 kW system selected for further development utilizes an all composite rotor blade design and a steel shell tower. The projected energy cost is 3.5 cents/kW hr Results of optimization of the rated power, site wind speed, and rated wind speed parameters are summarized.
C K.D.

A76-10148 * # Northeast Utilities' participation in the Kaman/NASA wind power program M Lotker (Northeast Utilities, Hartford, Conn). *Energy Research and Development Administration and National Science Foundation, Wind Energy Conversion Systems Workshop, Washington, D C , June 9-11, 1975, Paper* 9 p Contract No. NAS3-19404.

The role of Northeast Utilities in the Kaman/NASA large wind generator study is reviewed. The participation falls into four principal areas: (1) technical assistance; (2) economic analysis, (3) applications; and (4) institutional and legal. A model for the economic viability of wind power is presented. B J.

A76-14622 * Concept selection and analysis of large wind generator systems. R. C. Meier (Kaman Aerospace Corp., Bloomfield, Conn.) In American Helicopter Society, Annual National Forum, 31st, Washington, D.C, May 13-15, 1975, Proceedings (A76-14565 04-05) New York, American Helicopter Society, Inc, 1975 10 p. ERDA-supported research, Contract No. NAS3-19404

The increasing need to develop alternative energy sources has renewed interest in the use of wind energy for the generation of utility quality electricity. This paper discusses a program to evolve a preliminary design of a cost competitive large wind generator system. An examination of a number of technically feasible alternative wind energy configurations is reported, and the rationale used in selecting the preferred system concept is presented. In addition, preliminary results of an optimization study conducted on the preferred concept are summarized. These show that considerable latitude in the selection of the system design parameters is possible This permits design decisions to be based on other important factors such as development risk and the suitability of common component designs for systems with different power ratings (Author)

A76-14623 * 100-kW hingeless metal wind turbine blade design, analysis and fabrication. R. E Donham, J Schmidt (Lockheed-California Co, Burbank, Calif), and B. S Linscott (NASA, Lewis Research Center, Cleveland, Ohio). In: American Helicopter Society, Annual National Forum, 31st, Washington, D.C, May 13-15, 1975, Proceedings. (A76-14565 04-05) New York, American Helicopter Society, Inc, 1975. 13 p. 8 refs. Contract No. NAS3-19235.

The design, fabrication and analysis of aluminum wind turbine rotor blades is discussed. The blades are designed to meet criteria established for a 100-kilowatt wind turbine generator operating between 8 and 60-mile-per-hour speeds at 40 revolutions per minute. The design wind speed is 18 miles per hour. Two rotor blades are used on a new facility which includes a hingeless hub and its shaft, gearbox, generator and tower. Experience shows that, for stopped rotors, safe wind speeds are strongly dependent on blade torsional and bending rigidities which the basic D spar structural blade design provides The 0 25 inch-thick nose skin is brake/bump formed to provide the basic 'D' spar structure for the tapered, twisted blades Adequate margins for flutter and divergence are predicted from the use of existing, correlated stopped rotor and helicopter rotor analysis programs (Author)

A76-14765 * Recent advancements in low cost solar cell processing. E. L. Ralph (Spectrolab, Inc, Sylmar, Calif.) In: Photovoltaic Specialists Conference, 11th, Scottsdale, Ariz., May 6-8, 1975, Conference Record. (A76-14727 04-44) New York, Institute of Electrical and Electronics Engineers, Inc., 1975, p. 315, 316 Contract No. NAS3-18566.

A proof-of-concept solar cell process has been developed that is adaptable to automation This involved the development of a new contact system, a new antireflection coating system, a drift field cell design and a new contoured surface treatment. All these processes are performed without the use of vacuum chambers and expensive masking techniques, thus providing the possibility of reduced costs by automation using conventional semiconductor processing machinery. The contacts were printed on the cells by conventional silk screen machinery. The P(+) back field was formed by diffusing in aluminum from a printed aluminum back contact. The antireflection coating was formed by spinning on and baking a TiO2-SiO2 glass film. Air-mass-zero efficiencies of over 10% were achieved using this completely vacuum-free process. (Author)

A76-23112 * Macro analysis of the potential for fuel savings using wind generators in a utility power grid. R M. Mason, C. G. Justus, R. P. Zimmer, and P. G. Sassone (Georgia Institute of Technology, Atlanta, Ga). In: Modeling and simulation Volume 6 - Proceedings of the Sixth Annual Pittsburgh Conference, Pittsburgh, Pa., April 24, 25, 1975. Part 1. (A76-23110 09-59) Pittsburgh, Pa., Instrument Society of America, 1975, p 121-126. 7 refs Contract No. NAS3-17827.

A76-23113 * An impact analysis of a micro wind system. R P. Zimmer, S. L. Robinette, R. M. Mason, and W A. Schaffer (Georgia Institute of Technology, Atlanta, Ga). In: Modeling and simulation. Volume 6 - Proceedings of the Sixth Annual Pittsburgh Conference, Pittsburgh, Pa, April 24, 25, 1975. Part 1. (A76-23110 09-59) Pittsburgh, Pa, Instrument Society of America, 1975, p. 127-131. 10 refs Contract No. NAS3-17827

A process for the recovery of steel mill stack dust has been developed and is being used to recover secondary metals by a small company in Georgia. The process is energy intensive and wind generators were studied as a means of supplying energy for part of the recovery process. Some of the results of this study will be presented. (Author)

A76-27900 * # Design, economic and system considerations of large wind-driven generators. G. E. Jorgensen, M Lotker (Northeast Utilities Service Co., Hartford, Conn.), R. C. Meier, and D. Brierley (Kaman Aerospace Corp., Bloomfield, Conn). *Institute of Electrical and Electronics Engineers, Winter Power Meeting, New York, N.Y, Jan 25-30, 1976, Paper.* 9 p. Contract No. NAS3-19404

The increased search for alternative energy sources has lead to renewed interest and studies of large wind-driven generators This paper presents the results and considerations of such an investigation. The paper emphasizes the concept selection of wind-driven generators, system optimization, control system design, safety aspects, economic viability on electric utility systems and potential electric system interfacing problems. (Author)

A76-33447 * # The use of a very high temperature nuclear reactor in the manufacture of synthetic fuels. G H. Farbman and L. E. Brecher (Westinghouse Astronuclear Laboratory, Pittsburgh, Pa). *American Power Conference and Illinois Institute of Technology, Annual Meeting, 38th, Chicago, Ill, Apr 19-21, 1976, Paper* 21 p. Contract No. NAS3-18934.

The three parts of a program directed toward creating a cost-effective nuclear hydrogen production system are described. The discussion covers the development of a very high temperature nuclear reactor (VHTR) as a nuclear heat and power source capable of producing the high temperature needed for hydrogen production and other processes; the development of a hydrogen generation process based on water decomposition, which can utilize the outputs of the VHTR and be integrated with many different ultimate hydrogen consuming processes; and the evaluation of the process applications of the nuclear hydrogen systems to assess the merits and potential payoffs. It is shown that the use of VHTR for the manufacture of synthetic fuels appears to have a very high probability of making a positive contribution to meeting the nation's energy needs in the future. S D.

A76-35670 * Evaluation of the flat-plate solar collector system for electric power generation. R E. Athey (Black and Veatch, Consulting Engineers, Kansas City, Mo.). *(International Solar Energy Society, Meeting, Fort Collins, Colo., Aug. 1974.) Solar Energy,* vol. 18, no. 2, 1976, p. 143-147. Contract No. NAS3-18014.

This evaluation of the flat-plate collector system was designed to determine the number of flat-plate collectors required to generate a given amount of electricity with optimum efficiency. Variable parameters are the temperature of the heat-transport fluid, both to and from the collector field In the analysis, the efficiency of the

flat-plate collectors was coupled to the efficiency of the thermal cycle to calculate optimal overall system efficiencies. Overall system efficiencies for the system are on the order of 3 5 per cent or less Over two million 4 ft-by-4 ft collectors would be required to produce 100,000 kW(e). Based on the results, it can be shown that the limiting factor in the use of the flat-plate collector system for electric power generation is the efficiency of the collectors An increase in the overall system efficiency can occur only if the collector efficiency can be increased at higher surface temperatures. (Author)

A76-36756 * Thermionic work function of /Cs/ZnO. A. H. Sommer and T R. Briere (Thermo Electron Corp , Waltham, Mass). *Applied Physics Letters,* vol 29, July 15, 1976, p. 89, 90 8 refs Contracts No E(11-1)-3056; No. NAS3-19866.

The collector electrode of a thermionic converter requires a material having a low thermionic work function and chemical stability in a Cs atmosphere in the 800-K range This letter reports that ZnO with an adsorbed Cs film meets these requirements. The work function is approximately 1.3 eV. Various methods of preparing the ZnO film are described as well as an experiment in which Cs was replaced by K (Author)

A76-41101 * Nationwide assessment of potential output from wind-powered generators. C G Justus, W. R. Hargraves, and A Yalcin (Georgia Institute of Technology, Atlanta, Ga.). *Journal of Applied Meteorology,* vol 15, July 1976, p. 673-678 9 refs NSF Grant No GAER-75-00547; Contract No NAS3-17827.

A method for computing the actual expected power for a wind-powered generator from a given observed speed distribution is described and applied to estimate the potential output for different locations in the continental U.S. A contour map of generator capacity factor values (fraction of the rated output realizable) is obtained for wind-powered generator systems with a cut-in speed of 3.6 m/sec and a rated speed of 8.0 m/sec, and for a unit with hypothetical values for the 1 MW class (cut-in speed, 6 7 m/sec, rated speed, 13 4 m/sec). Results indicate that in the central U S and in certain areas of the New England coast at a height of 61 m, over 60% of the rated output power could be obtained on an annual average In these areas capacity factors of over 20% could be obtained with the 1MW system. C.K.D.

45 ENVIRONMENT POLLUTION

Includes air, noise, thermal and water pollution; environment monitoring, and contamination control

N76-10581*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
EFFECT OF HYDROGEN INJECTION STABILITY AND EMISSIONS OF AN EXPERIMENTAL PREMIXED PREVAPORIZED PROPANE BURNER
David N Anderson Washington Oct 1975 21 p refs
(NASA-TM-X-3301; E-8406) Avail NTIS HC $3 25 CSCL 13B

Hydrogen in quantities up to 5 percent by weight of the total fuel flow was injected into a premixed propane burner The hydrogen was either premixed with the propane and air upstream of the burner or introduced as a torch at the flameholder Emissions of total nitrogen oxides, carbon monoxide, and unburned hydrocarbon are reported as are combustion efficiencies and lean blowout limits To maintain at least 99 percent combustion efficiency at a 700 K inlet mixture temperature with no hydrogen added, it was necessary to burn with a propane equivalence ratio of 0.525 When 4 percent hydrogen was premixed with the propane and air, a combustion efficiency greater than 99 percent was recorded at a propane equivalence ratio of 0.425. The total nitrogen oxides (NOx) emissions corresponding to these two conditions were 0 8 g NO2/kg equivalent propane and 0 44 g NO2/kg equivalent propane, respectively. The hydrogen torch did not reduce NOx emissions Author

N76-13638*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
A PRELIMINARY REPORT OF MULTISPECTRAL SCANNER DATA FROM THE CLEVELAND HARBOR STUDY
Don Shook, Charles Raquet, Roger Svehla, Douglas Wachter, Jack Salzman, Tom Coney, and Dick Gedney Nov 1975 40 p refs Sponsored in part by EPA
(NASA-TM-X-71837, E-8550) Avail NTIS HC $4 00 CSCL 13B

Imagery obtained from an airborne multispectral scanner is presented A synoptic view of the entire study area is shown for a number of time periods and for a number of spectral bands Using several bands, sediment distributions, thermal plumes, and Rhodamine B dye distributions are shown Author

N76-14646*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ELEMENTAL COMPOSITION AND SIZE DISTRIBUTION OF PARTICULATES IN CLEVELAND, OHIO
Harold E Leibecki, Robert B King, J Stuart Fordyce, and Harold E Neustadter 31 Oct 1975 51 p refs Presented at the Intern Conf on Heavy Metals in the Environ, Toronto, Ont, Can, 27-31 Oct 1975
(NASA-TM-X-71839) Avail NTIS HC $4.50 CSCL 13B

Measurements were made of the elemental particle size distribution at five contrasting urban environments with different source-type distributions in Cleveland, Ohio Air quality conditions ranged from normal to air pollution alert levels A parallel network of high-volume cascade impactors (5-state) were used for simultaneous sampling on glass fiber surfaces for mass determinations and on Whatman-41 surfaces for elemental analysis by neutron activation for 25 elements The elemental data are assessed in terms of distribution functions and interrelationships and are compared between locations as a function of resultant wind direction in an attempt to relate the findings to sources Author

N76-15657*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXTENSIVE 1-YEAR SURVEY OF TRACE ELEMENTS AND COMPOUNDS IN THE AIRBORNE SUSPENDED PARTICULATE MATTER IN CLEVELAND, OHIO
Robert B. King, J. Stuart Fordyce, Albert C Antoine, Harold F Leibecki, Harold E Neustadter, and Steven M Sidik Washington Jan 1976 65 p refs
(NASA-TN-D-8110; E-8173) Avail NTIS HC $4 50 CSCL 13B

Concentrations of 75 chemical constituents in the airborne particulate matter were measured in Cleveland, Ohio, during 1971 and 1972. Values covering a 1-year period (45 to 50 sampling days) at each of 16 sites are presented for 60 elements A lesser number of values is given for sulfate, nitrate, fluoride, acidity, 10 polynuclear aromatic hydrocarbon compounds, and the aliphatic hydrocarbon compounds as a group Methods used included instrumental neutron activation, emission spectroscopy, gas chromatography, combustion techniques, and colorimetry. Uncertainties in the concentrations associated with the sampling procedures, the analysis methods, the use of several analytical facilities, and samples with concentrations below the detection limits are evaluated in detail The data is discussed in relation to other studies and source origins The trace constituent concentrations as a function of wind direction are used to suggest a practical method for air pollution source identification Author

N76-28683*# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio
CONCENTRATIONS OF TRACE ELEMENTS AND COMPOUNDS IN THE AIRBORNE SUSPENDED PARTICULATE MATTER IN CLEVELAND, OHIO, FROM AUGUST 1971 TO AUGUST 1972 AND THEIR DEPENDENCE ON WIND DIRECTION: COMPLETE DATA LISTING AND CONCENTRATION ROSES
Robert B King and Harold E Neustadter Jun 1976 192 p
(NASA-TM-X-73453, E-8795) Avail NTIS HC $7 50 CSCL 13B

Concentrations of 75 chemical constituents in the airborne particulate matter were measured in Cleveland Ohio during 1971 and 1972 Daily values, maxima, geometric means and their standard deviations covering a 1-year period (45 to 50 sampling days) at each of 16 sites are presented on microfiche for 60 elements, and for a lesser number of days for 10 polycyclic aromatic hydrocarbon compounds (PAH) the aliphatic hydrocarbon compounds (AH) as a group and carbon In addition concentration roses showing directional properties are presented for 39 elements, 10 PAH and the AH as a group The elements (except carbon) are shown both in terms of concentration and percentage of the suspended particulate matter Author

N76-29738*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
METEOROLOGICAL ADJUSTMENT OF YEARLY MEAN VALUES FOR AIR POLLUTANT CONCENTRATION COMPARISON
Steven M Sidik and Harold E Neustadter Washington NASA *Jul 1976 43 p refs*
(NASA-TN-D-8253, E-8628) Avail NTIS HC $4 00 CSCL 13B

Using multiple linear regression analysis, models which estimate mean concentrations of Total Suspended Particulate (TSP), sulfur dioxide, and nitrogen dioxide as a function of several meteorologic variables, two rough economic indicators, and a simple trend in time are studied. Meteorologic data were obtained and do not include inversion heights The goodness of fit of the estimated models is partially reflected by the squared coefficient of multiple correlation which indicates that, at the various sampling stations, the models accounted for about 23 to 47 percent of the total variance of the observed TSP concentrations If the resulting model equations are used in place of simple overall means of the observed concentrations, there is about a 20 percent improvement in either (1) predicting mean concentrations for specified meteorological conditions, or (2) adjusting successive yearly averages to allow for comparisons devoid of meteorological effects An application to source identification is presented using regression coefficients of wind velocity predictor variables Author

N76-33716*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

ANALYSIS OF ATMOSPHERIC OZONE MEASUREMENTS MADE FROM A B-747 AIRLINER DURING MARCH 1975

James D Holdeman and Phillip D Falconer Washington Oct 1976 32 p refs

(NASA-TN-D-8311, E-8765) Avail NTIS HC $4.00 CSCL 04A

Measurements of atmospheric ozone in the upper troposphere and lower stratosphere made during March 1975 as part of the NASA Global Atmospheric Sampling Program are reported and analyzed The interrelationships between the ozone mixing ratio and geographical and meteorological parameters are examined in several case studies The ozone data correlate well with the difference between the flight altitude and the height of the tropopause, as obtained from National Meteorological Center gridded data The distribution of ozone mixing ratios with latitude at an altitude of 11 + or - 0.5 km shows a poleward increase and large variability at latitudes greater than 30 deg N in agreement with published mean ozone levels from the North American ozone sonde network Author.

46 GEOPHYSICS

Includes aeronomy, upper and lower atmosphere studies, ionospheric and magnetospheric physics; and geomagnetism. For space radiation see *93 Space Radiation.*

N76-10605*# National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio

AN OPERATIONAL ALL-WEATHER GREAT LAKES ICE INFORMATION SYSTEM

R T Gedney 1975 12 p refs Presented at 3d Canadian Symp on Remote Sensing, Edmonton, Alberta, 22-24 Sep 1975

(NASA-TM-X-71812, E-8506) Avail NTIS HC $3 25 CSCL 08L

A description is given of the NASA developed all-weather ice information system for the Great Lakes winter navigation program. The system utilizes an X-band side looking airborne radar (SLAR) for determining type, location, and areal distribution of the ice cover in the Great Lakes and an airborne, S band, down looking short pulse radar for obtaining ice thickness. Digitized SLAR data are relayed in real time via the NOAA-GOES satellite in geosynchronous orbit The SLAR images along with hand drawn interpretative ice charts for various Great Lakes winter shipping areas are broadcast to facsimile recorders aboard vessles is the area via the MARAD marine VHF-FM radio network These data assist such vessels in navigating both through and around the ice Author

N76-21797*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.

NASA GLOBAL ATMOSPHERIC SAMPLING PROGRAM (GASP). DATA REPORT FOR TAPE VL0001

J D Holdeman and E. A Lezberg Mar. 1976 25 p refs

(NASA-TM-X-71905, E-8694) Avail NTIS HC $3 50 CSCL 04A

Atmospheric trace constituents in the upper troposphere and lower stratosphere are now being measured as part of the NASA Global Atmospheric Sampling Program (GASP), using fully automated air sampling systems on board commercial 747 aircraft in routine airline service Measurements of atmospheric ozone and related meteorological and flight information obtained during several GASP flights in March 1975 are now available from the National Climatic Center, Asheville North Carolina In addition to the data from the aircraft, tropopause pressure data obtained from the National Meteorological Center (NMC) archives for the dates of the flights are included This report is the first of a series of reports which describes the data currently available from GASP, including flight routes and dates, instrumentation, the data processing procedure used, and data tape specifications Author

N76-33776*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

NASA GLOBAL ATMOSPHERIC SAMPLING PROGRAM (GASP) DATA REPORT FOR TAPE VL0003

James D Holdeman Aug 1976 29 p refs

(NASA-TM-X-73506) Avail NTIS HC $4.00 CSCL 04A

Atmospheric ozone, and related flight and meteorological data for May 1975, obtained during 49 flights of a Pan American World Airways 747 are available as GASP tape VL0003 from the National Climatic Center, Asheville, North Carolina In addition to the GASP data, tropopause pressure fields obtained from NMC archives for the dates of the GASP flights are included on the data tape Flight routes and dates, instrumentation, data processing procedures, and data tape specifications are described Author

A76-22173 * Measurements of atmospheric ozone made from a GASP-equipped 747 airliner - Mid-March, 1975. P. D. Falconer (NOAA, Air Resources Laboratories, Silver Spring, Md.) and J. D. Holdeman (NASA, Lewis Research Center, Cleveland, Ohio). *Geophysical Research Letters*, vol. 3, Feb. 1976, p 101-104. 13 refs.

This paper presents data on the ozone mixing ratio, static air temperature, wind speed, and wind direction obtained at altitudes from 8 to 12 km during several flights of a commercial airliner equipped with a fully automated air-sampling system developed for the NASA Global Atmospheric Sampling Program (GASP). The objectives of GASP are reviewed, and the data-gathering techniques are described. Two data sets are discussed which illustrate variations of the upper-tropospheric and lower-stratospheric ozone mixing ratios as a function of geographical location and aircraft altitude. Good agreement is found between the GASP data and the tropopause height obtained from National Meteorological Center gridded data. F.G M.

47 METEOROLOGY AND CLIMATOLOGY

Includes weather forecasting and modification

N76-30757*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
NASA GLOBAL ATMOSPHERIC SAMPLING PROGRAM (GASP) DATA REPORT FOR TAPE VL0002
James D Holdeman and Erwin A Lezberg Aug 1976 36 p refs
(NASA-TM-X-73484, E-8868) Avail NTIS HC $4.00 CSCL 04B

The NASA Global Atmospheric Sampling Program (GASP) is now obtaining measurements of atmospheric trace constituents in the upper troposphere and lower stratosphere using fully automated air sampling systems on board several commercial 747 aircraft in routine airline service Atmospheric ozone, water vapor, and related flight and meteorological data for March to October 1975, obtained during 159 flights of a United Airlines 747, are now available as GASP tape In addition to the GASP data, tropopause pressure fields obtained from NMC archives for the dates of the GASP flights are included on the data tape Flight routes and dates, instrumentation, data processing procedures, and data tape specifications are described in this report Author

N76-30758*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
TORNADOES AND OTHER ATMOSPHERIC VORTICES
Robert G Deissler 1976 39 p refs Presented at Natl Heat Transfer Conf, St Louis, Missouri, 9-11 Aug 1976, sponsored by the Am Soc of Mech Engr. and the Am Inst of Chem Engr
(NASA-TM-X-73466, E-8813) Avail NTIS HC $4.00 CSCL 04B

The growth of random vortices in an atmosphere with buoyant instability and vertical wind shear is studied along with the velocities in a single gravity-driven vortex, a frictionless-adiabatic model which is supported by laboratory experiments is first considered. The effects of axial drag heat transfer, and precipitation-induced downdrafts are then calculated Heat transfer and axial drag tend to have stabilizing effects, they reduce the downdrafts of updrafts due to buoyancy It is found that downdrafts or tornadic magnitude might 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 Conditions under which radial-inflow velocities become sufficiently large to produce tangential velocities of tornadic magnitude are determined The radial velocities in the outer regions as well as the tangential velocities in the inner regions may be large enough to cause damage The surface boundary layer, which is a region where large radial inflows can occur is studied, and the thickness of the radial-inflow friction layer is estimated. A tornado model which involves a rotating parent cloud, as well as buoyancy and precipitation effects, is discussed Author

51 LIFE SCIENCES (GENERAL)

Includes genetics

N76-20801*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
NEURAL CODING OF HIGH-FREQUENCY TONES
Walton L. Howes Washington Mar 1976 9 p refs
(NASA-TM-X-3374, E-8607) Avail. NTIS HC $3.50 CSCL 05E

Available evidence was presented indicating that neural discharges in the auditory nerve display characteristic periodicities in response to any tonal stimulus including high-frequency stimuli and that this periodicity corresponds to the subjective pitch
Author

52 AEROSPACE MEDICINE

Includes physiological factors; biological effects of radiation; and weightlessness.

N76-22891*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
CORNEAL SEAL DEVICE Patent-Application
E. F Baehr, inventor (to NASA) Filed 13 Apr 1976 16 p
(NASA-Case-LEW-12258-1, US-Patent-Appl-SN-676433) Avail NTIS HC $3 50 CSCL 06B

A corneal seal device is provided which, when placed in an incision in the eye, permits the insertion of a surgical tool or instrument through the device into the eye The device includes a seal chamber which opens into a tube which is adapted to be sutured to the eye and serves as an entry passage for a tool A sealable aperture in the chamber permits passage of the tool through the chamber into the tube and hence into the eye The chamber includes inlet ports adapted to be connected to a regulated source of irrigation fluid which provides a safe interocular pressure NASA

N76-23837*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
IMPROVED TISSUE MACERATING INSTRUMENT Patent Application
E F Baehr and J. E Burnett, inventors (to NASA) Filed 15 Apr. 1976 9 p
(NASA-Case-LEW-12668-1 US-Patent-Appl-SN-677353) Avail. NTIS HC $3.50 CSCL 06B

A surgical-tissue macerating and removal tool is reported that lies a rotating rod with a cutting member at one end The device is placed in a tube which itself is disposed coaxially 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 of the axis of the rod to form a tissue engaging edge Apertures are provided in the extension adjacent the frusto-conical 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 frusto-conical 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 thereto to help remove macerated material NASA

N76-30797*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
ION BEAM SPUTTER MODIFICATION OF THE SURFACE MORPHOLOGY OF BIOLOGICAL IMPLANTS
A J Weigand and B A Banks 1976 19 p refs Presented at 23d Natl Vacuum Symp , Chicago, 21-24 Sep 1976, sponsored by Am Vacuum Soc
(NASA-TM-X-73468, E-8840) Avail NTIS HC $3 50 CSCL 06B

The surface chemistry and texture of materials used for biological implants may significantly influence their performance and biocompatibility Recent interest in the microscopic control of implant surface texture has led to the evaluation of ion beam sputtering as a potentially useful surface roughening technique Ion sources, similar to electron bombardment ion thrusters designed for propulsive applications, are used to roughen the surfaces of various biocompatible alloys or polymer materials These materials are typically used for dental implants, orthopedic prostheses, vascular prostheses, and artificial heart components Masking techniques and resulting surface textures are described along with progress concerning evaluation of the biological response to the ion beam sputtered surfaces Author

60 COMPUTER OPERATIONS AND HARDWARE

Includes computer graphics and data processing

For components see *33 Electronics and Electrical Engineering*

N76-21916*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

A MICROPROCESSOR CONTROLLED PRESSURE SCANNING SYSTEM

Robert C Anderson 1976 13 p Presented at Aerospace/Test Meas Symp., San Diego, Calif., 25-27 May 1976, sponsored by Instr Soc of Am

(NASA-TM-X-71886, E-8665) Avail NTIS HC $3 50 CSCL 09B

A microprocessor-based controller and data logger for pressure scanning systems is described The microcomputer positions and manages data from as many as four 48-port electro-mechanical pressure scanners The maximum scanning rate is 80 pressure measurements per second (20 ports per second on each of four scanners). The system features on-line calibration, position-directed data storage, and once-per-scan display in engineering units of data from a selected port The system is designed to be interfaced to a facility computer through a shared memory System hardware and software are described Factors affecting measurement error in this type of system are also discussed

Author

61 COMPUTER PROGRAMMING AND SOFTWARE

Includes computer programs, routines, and algorithms

N76-21932*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
SOFTWARE HANDLERS FOR PROCESS INTERFACES
Robert W. Bercaw 1976 15 p refs Presented at Symp on Autom. Computation and Control, Milwaukee, 22-24 Apr 1976; sponsored by the Inst of Elec. and Electron Engr. and Assoc for Computing Machinery
(NASA-TM-X-71908, E-8702) Avail: NTIS HC $3.50 CSCL 09B

Process interfaces are developed in an effort to reduce the time, effort, and money required to install computer systems. Probably the chief obstacle to the achievement of these goals lies in the problem of developing software handlers having the same degree of generality and modularity as the hardware. The problem of combining the advantages of modular instrumentation with those of modern multitask operating systems has not been completely solved, but there are a number of promising developments. The essential principles involved are considered.
Author

A76-31508 * Software handlers for process interfaces. R. W. Bercaw (NASA, Lewis Research Center, Cleveland, Ohio) *Institute of Electrical and Electronics Engineers and Association for Computing Machinery, Symposium on Automatic Computation and Control, Milwaukee, Wis., Apr. 22-24, 1976, Paper.* 14 p. 5 refs

The principles involved in the development of software handlers for custom interfacing problems are discussed. Handlers for the CAMAC standard are examined in detail. The types of transactions that must be supported have been established by standards groups, eliminating conflicting requirements arising out of different design philosophies and applications. Implementation of the standard handlers has been facilitated by standardization of hardware. The necessary local processors can be placed in the handler when it is written or at run time by means of input/output directives, or they can be built into a high performance input/output processor. The full benefits of these process interfaces will only be realized when software requirements are incorporated uniformly into the hardware.
C K D

63 CYBERNETICS

Includes feedback and control theory

For related information see also *54 Man/System Technology and Life Support*

N76-21954*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio

SPACE SHUTTLE POGO ACTIVE CONTROLLER DESIGN USING FREQUENCY DOMAIN OPTIMIZATION

Robert C Seidel Carl F Lorenzo, and Bruce Lehtinen Washington Apr 1976 40 p refs

(NASA-TM-X-3368; E-8529) Avail NTIS HC $4 00 CSCL 22B

A frequency domain parameter optimization technique was used to design active pogo suppression controls for the space shuttle The technique uses a conjugate gradient search procedure and is well suited for designing low-order controllers for higher order systems The shuttle model was a two-pump and six-structural-mode linear model representing a worst-case condition A promising feedback controller structure was found to be a lead-lag design Author

71 ACOUSTICS

Includes sound generation, transmission, and attenuation
For noise pollution see *45 Environment Pollution.*

N76-10820*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
ANALYSIS AND CORRECTION OF GROUND REFLECTION EFFECTS IN MEASURED NARROWBAND SOUND SPECTRA USING CEPSTRAL TECHNIQUES
J H Miles, G H Stevens, and G G Leininger (Toledo Univ., Ohio) 1975 17 p refs Presented at 19th Meeting of the Acoustical Soc. of Am., San Francisco, 4-7 Nov. 1975
(NASA-TM-X-71810, E-8503) Avail NTIS HC $3.25 CSCL 20A

Ground reflections generate undesirable effects on acoustic measurements such as those conducted outdoors for jet noise research, aircraft certification, and motor vehicle regulation Cepstral techniques developed in speech processing are adapted to identify echo delay time and to correct for ground reflection effects A sample result is presented using an actual narrowband sound pressure level spectrum The technique can readily be adapted to existing fast Fourier transform type spectrum measurement instrumentation to provide field measurements/of echo time delays Author

N76-12827*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ATTENUATION OF SOUND IN DUCTS WITH ACOUSTIC TREATMENT: A GENERALIZED APPROXIMATE EQUATION
Edward J Rice 1975 25 p refs Presented at 19th Meeting of the Acoust Soc. of America, San Francisco, 4-7 Nov 1975
(NASA-TM-X-71830; E-8540) Avail NTIS HC $3.50 CSCL 20A

A generalized approximate equation for duct lining sound attenuation is presented The specification of two parameters, the maximum possible attenuation and the optimum wall acoustic impedance is shown to completely determine the sound attenuation for any acoustic mode at any selected wall impedance The equation is based on the nearly circular shape of the constant attenuation contours in the wall acoustic impedance plane For impedances far from the optimum the equation reduces to Morse's approximate expression The equation can be used for initial acoustic liner design Not least important is the illustrative nature of the solutions which provide an understanding of the duct propagation problem usually obscured in the exact calculations. Sample calculations using the approximate attenuation equation show that the peak and the bandwidth of the sound attenuation spectrum can be represented by quite simple functions of the ratio of actual wall acoustic resistance to optimum resistance Author

N76-13878*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
INLET NOISE ON 0.5-METER-DIAMETER NASA QF-1 FAN AS MEASURED IN AN UNMODIFIED COMPRESSOR AERODYNAMIC TEST FACILITY AND IN AN ANECHOIC CHAMBER
Thomas F. Gelder and Richard F. Soltis Washington Dec. 1975 99 p refs
(NASA-TN-D-8121, E-8201) Avail: NTIS HC $5.00 CSCL 20A

Narrowband analysis revealed grossly similar sound pressure level spectra in each facility. Blade passing frequency (BPF) noise and multiple pure tone (MPT) noise were superimposed on a broadband (BB) base noise From one-third octave bandwidth sound power analyses the BPF noise (harmonics combined), and the MPT noise (harmonics combined, excepting BPF's) agreed between facilities within 1.5 db or less over the range of speeds and flows tested Detailed noise and aerodynamic performance is also presented Author

N76-13881*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
ACOUSTIC SYSTEMS CONTAINING CURVED DUCT SECTIONS
W. Rostafinski 1975 22 p refs Presented at 19th Ann. Meeting of the Acoust Soc. of Am., San Francisco, 4-7 Nov. 1975
(NASA-TM-X-71827; E-8458) Avail: NTIS HC $3.50 CSCL 20A

The analysis of waves in bends in acoustical ducting of rectangular cross section was extended to the study of motion near discontinuities This included determination of the characteristics of the tangential and radial components of the nonpropagating modes. It is established that attenuation of the nonpropagating modes strongly depends on frequency and that, in general, the sharper the bend, the less attenuation may be expected Evaluation of a bend's impedance and of impedance-generated reflections is also presented in detail Author

N76-18887*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
NOISE SUPPRESSION BY AN ACOUSTICALLY TREATED THREE-RING INLET ON A TF-34 ENGINE
Gene L Minner Richard G Goldman, and Laurence J. Heidelberg Washington Mar 1976 37 p refs
(NASA-TM-X-3366 E-8524) Avail NTIS HC $4.00 CSCL 21E

Acoustic performance tests were conducted with a three-ring inlet noise suppressor designed for a TF-34 engine For all tests the aft noise sources were highly suppressed The measured inlet suppression was large, reaching levels greater than 30 db at the peak Comparisons of the data and the performance predictions were in reasonably good agreement The frequency of peak attenuation was well predicted; the magnitude and spectral shape were reasonably well predicted Agreement was best when the distribution of sound energy across the inlet was taken into account in the performance predictions Tests in which the length of treatment was varied showed an orderly progression of attenuation with length; performance predictions for the different lengths also showed an orderly progression with length At the highest speed of the engine, multiple pure tones were present throughout the spectrum in the source noise signature These tones were effectively suppressed by the inlet liner, even at low frequencies, although the liner was designed to work best at the blade-passing frequency Author

N76-22977*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
NOISE REDUCTION TESTS OF LARGE-SCALE-MODEL EXTERNALLY BLOWN FLAP USING TRAILING-EDGE BLOWING AND PARTIAL FLAP SLOT COVERING
Daniel J McKinzie, Jr., Robert J. Burns, and Jack M Wagner Washington Apr. 1976 65 p refs
(NASA-TM-X-3379, E-8598) Avail NTIS HC $4.50 CSCL 20A

Noise data were obtained with a large-scale cold-flow model of a two-flap, under-the-wing, externally blown flap proposed for use on future STOL aircraft The noise suppression effectiveness of locating a slot conical nozzle at the trailing edge of the second flap and of applying partial covers to the slots between the wing and flaps was evaluated Overall-sound-pressure-level reductions of 5 db occurred below the wing in the flyover plane Existing models of several noise sources were applied to the test results The resulting analytical relation compares favorably with the test data The noise source mechanisms were analyzed and are discussed Author

N76-23943*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
ACOUSTIC LINER OPTIMUM IMPEDANCE FOR SPINNING MODES WITH CUT-OFF RATIO AS THE DESIGN CRITERION

Edward J Rice 1976 11 p refs Proposed for presentation at the Third Aero-Acoustic Conf, Palo Alto, Calif, 20-23 Jul 1976 sponsored by AIAA
(NASA-TM-X-73411, E-8741) Avail NTIS HC $3 50 CSCL 20A

A new acoustic liner design procedure based upon model cut-off ratio is outlined Proposed experiments to substantiate this design procedure are outlined Author

N76-27957*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
OTW NOISE CORRELATION FOR VARIATIONS IN NOZZLE/WING GEOMETRY WITH 5.1 SLOT NOZZLES
U VonGlahn and D Groesbeck 1976 18 p refs Presented at the 3d Aero-Acoustic Conf, Palo Alto, Calif, 20-23 Jul 1976, sponsored by AIAA
(NASA-TM-X-73425, E-8763) Avail NTIS HC $3 50 CSCL 20A

Acoustic data obtained from a model-scale study with 5.1 slot nozzles are analyzed and correlated in terms of apparent noise sources. Variations in nozzle geometry include roof angle and sidewall cutback In addition, geometry variations in wing size and flap deflection are included Three dominant noise sources were evident in the data and correlated fluctuating lift noise, trailing edge noise and a redirected jet mixing noise that included the effect of reflection of jet noise 'by the surface Pertinent variables in the correlations include the shear layer thickness and peak jet flow velocity at the trailing edge Author

N76-30920*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio
APPLICATIONS OF THE ULTRASONIC SERIAL NUMBER RESTORATION TECHNIQUE TO GUNS AND TYPICAL STOLEN ARTICLES
S G Young Jul 1976 21 p refs
(NASA-TM-X-73452; E-8811) Avail NTIS HC $3 50 CSCL 20A

An ultrasonic cavitation method for restoring obliterated serial numbers has been further explored by application to articles involved in police cases The method was applied successfully to gun parts In one case portions of numbers were restored after prior failure by other laboratories using chemical etching techniques The ultrasonic method was not successful on a heavily obliterated and restamped automobile engine block, but it was partially successful on a motorcycle gear-case housing Additional studies were made on the effect of a larger diameter ultrasonic probe, and on the method s ability to restore numbers obliterated by peening Author

N76-33954*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
COMPUTER METHOD FOR DESIGN OF ACOUSTIC LINERS FOR TURBOFAN ENGINES
Gene L Minner and Edward J Rice Washington Oct 1976 93 p refs
(NASA-TM-X-3317, E-8428) Avail NTIS HC $5 00 CSCL 20A

A design package is presented for the specification of acoustic liners for turbofans An estimate of the noise generation was made based on modifications of existing noise correlations, for which the inputs are basic fan aerodynamic design variables The method does not predict multiple pure tones A target attenuation spectrum was calculated which was the difference between the estimated generation spectrum and a flat annoyance-weighted goal attenuated spectrum The target spectrum was combined with a knowledge of acoustic liner performance as a function of the liner design variables to specify the acoustic design The liner design method at present is limited to annular duct configurations The detailed structure of the liner was specified by combining the required impedance (which is a result of the previous step) with a mathematical model relating impedance to the detailed structure The design procedure was developed for a liner constructed of perforated sheet placed over honeycomb backing cavities A sample calculation was carried through in order to demonstrate the design procedure and experimental results presented show good agreement with the calculated results of the method Author

A76-25127 * # **Attenuation of sound in ducts with acoustic treatment - A generalized approximate equation.** E J. Rice (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 90th, San Francisco, Calif , Nov 3-7, 1975, Paper.* 25 p 9 refs.

A generalized approximate equation for duct lining sound attenuation is presented. The specification of two parameters, the maximum possible attenuation and the optimum wall acoustic impedance is shown to completely determine the sound attenuation for any acoustic mode at any selected wall impedance The equation is based on the nearly circular shape of the constant attenuation contours in the wall acoustic impedance plane. For impedances far from the optimum, the equation reduces to Morse's approximate expression The equation can be used for initial acoustic liner design. Not least important is the illustrative nature of the solutions which provide an understanding of the duct propagation problem usually obscured in the exact calculations Sample calculations using the approximate attenuation equation show that the peak and the bandwidth of the sound attenuation spectrum can be represented by quite simple functions of the ratio of actual wall acoustic resistance to optimum resistance. (Author)

A76-25128 * # **Acoustic systems containing curved duct sections.** W Rostafinski (NASA, Lewis Research Center, Cleveland, Ohio). *Acoustical Society of America, Meeting, 90th, San Francisco, Calif., Nov. 3-7, 1975, Paper.* 21 p. 7 refs.

The analysis of waves in bends in acoustical ducting of rectangular cross section is extended to the study of motion near discontinuities This includes determination of the characteristics of the tangential and radial components of the non-propagating modes It is established that attenuation of the non-propagating modes strongly depends on frequency and that, in general, the sharper the bend, the less attenuation may be expected. Evaluation of a bend's impedance and of impedance-generated reflections is also presented *in detail.* (Author)

A76-25139 * # **Analysis and correction of ground reflection effects in measured narrowband sound spectra using cepstral techniques.** J. H Miles, G H Stevens (NASA, Lewis Research Center, Cleveland, Ohio), and G G Leininger (Toledo, University, Toledo, Ohio). *Acoustical Society of America, Meeting, 90th, San Francisco, Calif., Nov 3-7, 1975, Paper.* 16 p. 23 refs.

Ground reflections generate undesirable effects on acoustic measurements such as those conducted outdoors for jet noise research, aircraft certification, and motor vehicle regulation. This paper shows how cepstral techniques developed in speech processing can be adapted to identify the echo delay time and to correct for ground reflection effects A sample result is presented using an actual narrowband sound pressure level spectrum. The technique can readily be adapted to existing fast Fourier transform type spectrum measurement instrumentation to provide field measurement of echo time delays (Author)

A76-38037 * # **Comparison of predictions and under-the-wing EBF noise data.** M. R Fink and W. A Olsen (NASA, Lewis Research Center, V/STOL and Noise Div., Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif , July 20-23, 1976, Paper 76-501* 14 p 16 refs

Detailed three-dimensional free field noise data were obtained by NASA for an under-the-wing externally blown model three-flap wing, and for a similar slotless wing Spatial (polar and azimuthal) and spectral characteristics of these data are presented. These data are compared with predictions from some published EBF noise

calculation methods Methods include the totally empirical ANOPP and GELAC procedures, and a semi-empirical noise component method. The latter method adds the separately computed dipole noise due to fluctuating lift and drag, trailing edge noise, and quadrupole noise due to the deflected jet. Each of these components is calculated for the local geometry and flow conditions. (Author)

A76-38044 * # Acoustic liner optimum impedance for spinning modes with mode cut-off ratio as the design criterion. E J Rice (NASA, Lewis Research Center, Cleveland, Ohio) *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif , July 20-23, 1976, Paper 76-516* 8 p 16 refs.

The theoretical optimum acoustic impedance for higher order spinning modes was studied in cylindrical ducts with a boundary layer at the outer edge of a uniform flow. All of the propagating modes were considered from highly propagating to nearly cut-off It was observed that the mode cut-off ratio uniquely determined the optimum wall impedance and maximum possible attenuation for a given boundary layer thickness, Mach number and frequency. The implications of this phenomenon are quite important in noise suppressor design Instead of the acoustic power distribution among all of the propagating modes, only the power distribution as a function of cut-off ratio needs to be known. Also, the far field radiation pattern is a function of modal cut-off ratio, and much needed information for liner design can be obtained from these more easily obtained data. (Author)

A76-38048 * # OTW noise correlation for variations in nozzle/wing geometry with 5:1 slot nozzles. U. von Glahn and D Groesbeck (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-521.* 12 p 18 refs

Acoustic data obtained from a model-scale study with 5.1 slot nozzles are analyzed and correlated in terms of apparent noise sources Variations in nozzle geometry include roof angle and sidewall cutback In addition, geometry variations in wing size and flap deflection were included. Three dominant noise sources were evident in the data and correlated: fluctuating lift noise, trailing edge noise and a redirected jet mixing noise that included the effect of reflection of jet noise by the surface. Pertinent variables in the correlations included the shear layer thickness and peak jet flow velocity at the trailing edge. (Author)

A76-38087 * # Modal structure inferred from static far-field noise directivity. A. V. Saule (NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-574* 9 p 15 refs.

Turbofan noise directivity calculated for two directivity models (equal modal amplitude and equal modal power or energy) was compared with experimental blade passing frequency data from two fans at 60 and 90 percent speeds. Experimental data indicated similar directivity patterns which were well represented by a single average data curve. Calculated points using the equal amplitude model showed over-prediction near the fan axis and near the 90-deg position Calculated points using the equal power model showed a very good match with the average data lending support to theory of equipartition of modal power from a random source such as the interaction of the rotor with inlet flow distortion The equal modal power model also gave good agreement with individual data points. (Author)

N76-18888*# General Electric Co , Schenectady, N Y
EXPERIMENTAL AND THEORETICAL STUDIES OF SUBSONIC FAN NOISE Final Report
R. Mani and K Berkofske Washington NASA Mar 1976 72 p refs
(Contract NAS3-17853)
(NASA-CR-2660) Avail. NTIS HC S4 50 CSCL 20A

The noise generated by inlet turbulence impinging on a subsonic axial flow fan was studied as a function of tip speed, flow coefficient, and intensity and scale of turbulence was carried out Both turbulence and far field acoustic measurements were made The new elements introduced in the theoretical analysis were accounting for blade loading dependent noise mechanisms and consideration of anisotropic turbulence impinging on the rotor because of inlet flow contraction effects Experimentally an unexplained increase of noise at about 1/2 and 1 1/2 times blade passing frequency was observed at low flow coefficients even though there was no evidence of compressor surge In the final version the theory does a fair job of predicting variations of noise with blade loading and tip speed Alteration of inlet turbulence length scales produced some but not very pronounced changes in the far field PWL spectra Some degree of eddy contraction and resulting anisotropy were essential to explain the concentration of energy around blade passing frequencies. Author

N76-22976*# Boeing Co , Wichita, Kans
ANALYTICAL AND EXPERIMENTAL STUDIES OF AN OPTIMUM MULTISEGMENT PHASED LINER NOISE SUPPRESSION CONCEPT Final Report
David T. Sawdy, Roy J Beckemeyer and John D Patterson May 1976 128 p refs
(Contract NAS3-18550)
(NASA-CR-134960, D3-9812-1) Avail. NTIS HC S6 00 CSCL 20A

Results are presented from detailed analytical studies made to define methods for obtaining improved multisegment lining performance by taking advantage of relative placement of each lining segment Properly phased liner segments reflect and spatially redistribute the incident acoustic energy and thus provide additional attenuation A mathematical model was developed for rectangular ducts with uniform mean flow Segmented acoustic fields were represented by duct eigenfunction expansions, and mode-matching was used to ensure continuity of the total field. Parametric studies were performed to identify attenuation mechanisms and define preliminary liner configurations An optimization procedure was used to determine optimum liner impedance values for a given total lining length, Mach number, and incident modal distribution Optimal segmented liners are presented and it is shown that provided the sound source is well-defined and flow environment is known, conventional infinite duct optimum attenuation rates can be improved To confirm these results, an experimental program was conducted in a laboratory test facility. The measured data are presented in the form of analytical-experimental correlations Excellent agreement between theory and experiment verifies and substantiates the analytical prediction techniques The results indicate that phased liners may be of immediate benefit in the development of improved aircraft exhaust duct noise suppressors. Author

N76-22978*# Hersh Acoustical Engineering, Chatsworth, Calif.
EFFECT OF GRAZING FLOW ON STEADY-STATE RESISTANCE OF ISOLATED SQUARE-EDGED ORIFICES Final Report
Thomas Rogers Washington NASA Apr. 1976 59 p refs
(Contract NAS3-17858)
(NASA-CR-2681) Avail NTIS HC S4 50 CSCL 20A

Steady state diagnostic testing of an isolated orifice has shown the nature of the interaction between grazing and orifice flow causing the large increase in orifice resistance for both inflow and outflow A simple inviscid interaction model is developed which uses thin aerofoil theory to account for pressure forces exerted at the interface between the orifice and grazing flow together with a one-dimensional discharge coefficient concept The effect of grazing flow boundary layer thickness is also included in the model Resistance measurements for each orifice tested, over a wide range of grazing flow speeds and flow rates, collapse into a single curve when plotted in terms of effective discharge coefficient against orifice to grazing velocity ratio The correlation curves for inflow and outflow are different

Data for clustered orifices collapse in the same way as those for the single orifice The effect of boundary layer thickness is compared with model predictions Author

N76-23947*# Hersh Acoustical Engineering, Chatsworth Calif
FLUID MECHANICAL MODEL OF THE ACOUSTIC IMPEDANCE OF SMALL ORIFICES Final Report
Alan S Hersh and Thomas Rogers Washington NASA May 1976 57 p refs
(Contract NAS3-17858)
(NASA-CR-2682) Avail NTIS HC $4 50 CSCL 20A

A fluid mechanical model of the acoustic behavior of small orifices is presented which predicts orifice resistance and reactance as a function of incident sound pressure level frequency, and orifice geometry Agreement between predicted and measured values is excellent The model shows the following (1) The acoustic flow in immediate neighborhood of the orifice can be modeled as a locally spherical flow Within this near field, the flow is, to a first approximation, unsteady and incompressible (2) At very low sound pressure levels, the orifice viscous resistance is directly related to the effect of boundary-layer displacement along the walls containing the orifice, and the orifice reactance is directly related to the inertia of the oscillating flow in the neighborhood of the orifice (3) For large values of the incident acoustic pressure, the impedance is dominated by nonlinear jet-like effects (4) For low values of the pressure, the resistance and reactance are roughly equal Author

N76-24995*# General Electric Co , Cincinnati, Ohio
OPTIMIZATION OF SUPPRESSION FOR TWO-ELEMENT TREATMENT LINERS FOR TURBOMACHINERY EXHAUST DUCTS Final Report, Aug. 1974 - Dec. 1975
R E. Motsinger, R E. Kraft, J W Zwick S. I Vukelich, G. L Minner, and K J. Baumeister Apr 1976 132 p refs
(Contract NAS3-18555)
(NASA-CR-134997; R76AEG256) Avail: NTIS HC $6 00 CSCL 20A

Sound wave propagation in a soft-walled rectangular duct with steady uniform flow was investigated at exhaust conditions, incorporating the solution equations for sound wave propagation in a rectangular duct with multiple longitudinal wall treatment segments Modal analysis was employed to find the solution equations and to study the effectiveness of a uniform and of a two-sectional liner in attenuating sound power in a treated rectangular duct without flow (M = 0) and with uniform flow of Mach 0 3 Two-segment liners were shown to increase the attenuation of sound as compared to a uniform liner The predicted sound attenuation was compared with measured laboratory results for an optimized two-segment suppressor. Good correlation was obtained between the measured and predicted suppressions when practical variations in the modal content and impedance were taken into account Two parametric studies were also completed Author

N76-28960*# Boeing Commercial Airplane Co Seattle Wash.
EFFECTS OF MOTION ON JET EXHAUST NOISE FROM AIRCRAFT Final Report
K S Chun, C H. Berman and S. J. Cowan Washington NASA Jun 1976 221 p refs
(Contract NAS3-18539)
(NASA-CR-2701, D6-41995) Avail NTIS HC $7 75 CSCL 20A

The various problems involved in the evaluation of the jet noise field prevailing between an observer on the ground and an aircraft in flight in a typical takeoff or landing approach pattern were studied Areas examined include (1) literature survey and preliminary investigation, (2) propagation effects (3) source alteration effects, and (4) investigation of verification techniques Sixteen problem areas were identified and studied Six follow-up programs were recommended for further work The results and the proposed follow-on programs provide a practical general technique for predicting flyover jet noise for conventional jet nozzles Author

N76-30028*# Lockheed-Georgia Co , Marietta
DUCT WALL IMPEDANCE CONTROL AS AN ADVANCED CONCEPT FOR ACOUSTIC IMPRESSION Final Report
Peter D Dean and Brian J Tester Nov 1975 364 p refs
(Contract NAS3-18554)
(NASA-CR-134998, LG76ER0132) Avail NTIS HC $10 50 CSCL 20A

Models and tests on an acoustic duct liner system which has the property of controlled-variable acoustic impedance are described This is achieved by a novel concept which uses the effect of steady air flow through a multi-layer, locally reacting resonaunt-cavity absorber The scope of this work was limited to a 'proof of concept' The test of the concept was implemented by means of a small-scale, square-section flow duct facility designed specifically for acoustic measurements, with one side of the duct acoustically lined The test liners were designed with the aid of previously established duct acoustic theory and a semi-empirical impedance model of the liner system Over the limited range tested the liner behaved primarily as predicted exhibiting significant changes in resistance and reactance thus providing the necessary concept validation Author

N76-30031*# Lockheed-Georgia Co , Marietta
EFFECTS OF FORWARD VELOCITY ON TURBULENT JET MIXING NOISE Final Report
Harry E Plumblee, Jr , ed Washington NASA Jul 1976 389 p refs
(Contract NAS3-18540)
(NASA-CR-2702) Avail NTIS HC $10 75 CSCL 20A

Flight simulation experiments were conducted in an anechoic free jet facility over a broad range of model and free jet velocities The resulting scaling laws were in close agreement with scaling laws derived from theoretical and semiempirical considerations Additionally, measurements of the flow structure of jets were made in a wind tunnel by using a laser velocimeter. These tests were conducted to describe the effects of velocity ratio and jet exit Mach number on the development of a jet in a coflowing stream These turbulence measurements and a simplified Lighthill radiation model were used in predicting the variation in radiated noise at 90 deg to the jet axis with velocity ratio Finally, the influence of forward motion on flow-acoustic interactions was examined through a reinterpretation of the 'static' numerical solutions to the Lilley equation Author

N76-30922*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
NOISE GENERATED BY IMPINGEMENT OF TURBULENT FLOW ON AIRFOILS OF VARIED CHORD, CYLINDERS, AND OTHER FLOW OBSTRUCTIONS
W A Olsen 1976 36 p refs Presented at the 3d Aero-Acoustic Conf , Palo Alto, Calif , 20-22 Jul 1976; sponsored by AIAA (NASA-TM-X-73464, E-8829, AIAA-Paper-76-504) Avail NTIS HC $4 00 CSCL 20A

Noise spectra were measured in three-dimensions for several surfaces immersed in turbulent flow from a jet and over a range of flow conditions The data are free field and were corrected to remove the small contributions of jet noise, atmospheric attenuation and feedback tones These broadband data were compared with the results of available theories which are only strictly applicable to simple geometries over a limited range of conditions The available theories proved to be accurate over the range of flow, chord length, thickness, angle of attack, and surface geometries defined by the experiments These results apply to the noise generated by fixed surfaces in engine passages, the lifting surfaces of aircraft and also to fan noise. Author

A76-14493 * # Optimization of duct acoustic liners of finite length. R. J. Beckemeyer and D. T. Sawdy (Boeing Co , Wichita, Kan) *Acoustical Society of America Meeting, 89th, Austin, Tex , Apr. 8-11, 1975, Paper.* 53 p. 31 refs. Contract No. NAS3-18550.

Lining design procedures generally ignore the effects of discontinuous impedance changes on reflection and modal redistribution of incident energy. The present study involves identification of the mechanisms of optimal suppression by segmented liners, in-

cluding impedance discontinuity effects The mathematical model involves rectangular ducts in the absence of mean flow Segmented acoustic fields are represented by duct eigenfunction expansions, and mode matching is used to ensure continuity of the total field. Extensive parameter studies were used to identify attenuation mechanisms and to define preliminary liner configurations. These are used as starting values in conjugate-gradient optimization studies. Optimal segmented liners are presented and it is shown that, if the sound source is sufficiently well-defined, conventional infinite duct optimum attenuation rates can be improved upon by taking advantage of wall impedance discontinuities. Finally, follow-on work which will involve experimental verification and extension to the case with mean flow in the duct is described. (Author)

A76-25129 * # Optimum segmented acoustic liners for flow ducts. D. T. Sawdy, R. J Beckemeyer, and J. D. Patterson (Boeing Co , Wichita, Kan). *Acoustical Society of America, Meeting, 90th, San Francisco, Calif., Nov 3-7, 1975, Paper.* 53 p. 23 refs. Contract No NAS3-18550.

Analytical and experimental investigations of phased linings for a duct containing a uniform mean flow were conducted as part of a program concerned with the design of more efficient acoustic liners for the reduction of noise emission. An analytical technique was developed which predicts the propagation of sound waves in flow ducts with segmented liners. The calculations for implementing the derived algorithms were conducted with the aid of FORTRAN IV computer programs. Attention is also given to details regarding the experimental program which was designed to supplement the theoretical studies G.R.

A76-25847 * # Design of optimum acoustic treatment for rectangular ducts with flow. R E. Motsinger, R. E Kraft, and J. W. Zwick (General Electric Co., Aircraft Engine Group, Evendale, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La., Mar. 21-25, 1976, Paper 76-GT-113* 15 p 13 refs. Members, $1 50, nonmembers, $3 00 Contract No NAS3-18555

A design optimization technique for acoustic treatment in rectangular ducts with uniform mean flow is presented. The technique is based on the acoustic wave solution in terms of series of characteristic duct modes. The analysis allows multiple axial treatment sections along the length of the duct and requires a known modal characterization of the sound source. Conditions of acoustic pressure and acoustic velocity continuity are used to match modal solutions at planes of impedance discontinuity in the duct Experimental techniques for obtaining this modal characterization are presented. Using duct modes measured at the source plane, the optimization technique is exercised to design an optimized single element liner in a case without mean flow, and optimized single and dual element liners in cases with mean flow. The validity of the program for predicting noise suppression is demonstrated by comparing analytical predictions with measured data for several (non-optimum) cases. Application to treatment design in turbomachinery exhaust ducts is considered. (Author)

A76-25856 * # Experimental-analytical correlation of optimum duct acoustic liner performance. J. D. Patterson, D. T. Sawdy, and R J. Beckemeyer (Boeing Co., Wichita, Kan.). *American Society of Mechanical Engineers, Gas Turbine Conference and Products Show, New Orleans, La , Mar. 21-25, 1976, Paper 76-GT-126.* 13 p. 11 refs. Members, $1.50; nonmembers, $3.00. Contract No. NAS3-18550

Mode matching and segmented duct analytical models have been developed to take advantage of relative placement of liner segments in the design of optimal duct acoustic liners of one, two, and three segments. This paper presents experimental results which were obtained for liners installed in a rectangular duct for the case with no mean airflow through the duct Excellent correlation is shown between the analytical and experimental data, thus verifying the analytical procedures used to design the optimum segmented lining configurations (Author)

A76-41387 * # Noise measurements in a free-jet, flight simulation facility - Shear layer refraction and facility-to-flight corrections. C L Morfey (Southampton, University, Southampton, England) and B. J. Tester (Lockheed Georgia Co , Marietta, Ga.). *American Institute of Aeronautics and Astronautics, Aero-Acoustics Conference, 3rd, Palo Alto, Calif., July 20-23, 1976, Paper 76-531* 16 p. 15 refs. Research supported by the Lockheed-Georgia Co and University of Southampton; Contract No. NAS3-18540.

The conversion of free-jet facility into equivalent flyover results is discussed. The essential problem is to 'calibrate out' the acoustic influence of the outer free-jet shear layer on the measurement, since this is absent in the flight case. Results are presented which illustrate the differences between current simplified models (vortex-sheet and geometric acoustics), and a more complete model based on the Lilley equation. Finally, the use of geometric acoustics for facility-to-flight data conversion is discussed (Author)

72 ATOMIC AND MOLECULAR PHYSICS

Includes atomic structure and molecular spectra

N76-15860* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
DEUTERIUM PASS THROUGH TARGET Patent
Donald L. Alger, inventor (to NASA) Issued 2 Dec. 1975 7 p Filed 27 Aug 1974 Supersedes N74-32719 (12 - 22, p 2672)
(NASA-Case-LEW-11866-1; US-Patent-3,924,137; US-Patent-Appl-SN-500980; US-Patent-Class-250-499, US-Patent-Class-250-500) Avail: US Patent Office CSCL 20H

A neutron emitting target for use in neutron generating apparatus including a deuteron source and an accelerator vacuum chamber, comprised of a tritium-containing target layer, a deuteron accumulation layer, and a target support containing passages providing communication between the accumulation layer and portions of the surface of the support exposed to the accelerator vacuum chamber is described With this arrangement, deuterons passing through the target layer and implanting in and diffusing through the accumulation layer, diffuse into the communicating passages and are returned to the accelerator vacuum chamber Continuous removal of deuterons from the target in conventional water cooled neutron generating apparatus is provided Preferably, the target is provided with thin barrier layers to prevent undesirable tritium diffusion out of the target layer, as well as deuteron diffusion into the target layer.
Official Gazette of the U S Patent Office

N76-23961*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
A TARGET FOR PRODUCTION OF RADIOXENONS
J W Blue, R. Leonard, S Jha (Cincinnati Univ.), V. J Sodd (Cincinnati Univ.), and J S Vincent (TRIUMF) 1976 8 p refs Presented at Am Phys Soc Meeting, Washington, D C., 26-29 Apr. 1976
(NASA-TM-X-73409, E-8740) Avail. NTIS HC $3 50 CSCL 20H

A liquid cesium target has been developed which allows the production and separate identification of the neutron deficient isotopes of xenon The present report describes irradiations utilizing 34 to 41 MeV protons to produce millicurie quantities of Xe-127 and Xe-129m At higher energies, however, the target could be used without modification to produce xenon isotopes as light as 119 Author

N76-26967*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
METHOD OF PRODUCING I-123 Patent Application
James W. Blue, inventor (to NASA) Filed 3 Oct 1975 10 p
(NASA-Case-LEW-11390-4; US-Patent-Appl-SN-619471) Avail NTIS HC $3 50 CSCL 06R

A patent application for an invention related to the generation of high purity radioiodine (I123) was presented The resulting product may be used for thyroid measurements and as a general radionuclide The approach consists in bombarding a cesium heat pipe with high energy protons, causing a spallation reaction which produces vapors of Xe123 and contaminants The contaminants are removed in a dry ice cold trap while the Xe123 condenses in a liquid nitrogen trap where it decays to I123 NASA

N76-27963# Picatinny Arsenal, Dover, N J
SOME PHYSICS RELEVANT TO ACOUSTIC SHOCK WAVE IMPENDANCE CALCULATIONS
Paul Harris Oct 1975 37 p refs
(DA Proj 1T6-1101-A-91A)
(AD-A021089, PA-TR-4902) Avail NTIS CSCL 20/1

The problem of energy transmission across a boundary separating acoustically linear and nonlinear media is considered to third order in the strain (third order elastic constant) The study proceeds via the contribution of the first harmonic (the input signal being the fundamental) to the stress tensor. It is concluded that the nonlinearity introduces a correction of approximately a few percent (for most crystalline materials), at ten kilobars input amplitude in comparison to the infinitesimal amplitude impedance matching relations Special materials, such as potassium iodide (KI), are found to have a twenty-seven percent nonlinearity correction at ten kilobars The problem of relaxation (both thermal and mechanical) contributions to the propagation velocity of a strain-driven thermal disturbance is considered It

N76-32971*# Bolt, Beranek, and Newman, Inc., Cambridge Mass
DATA ANALYSIS AND NOISE PREDICTION FOR THE QF-1B EXPERIMENTAL FAN STAGE
D B Bliss, K L. Chandiramani, and A G Piersol Aug 1976 118 p refs
(Contract NAS3-19426)
(NASA-CR-135066; BBN-3338) Avail NTIS HC $5 50 CSCL 20A

The results of a fan noise data analysis and prediction effort using experimental data obtained from tests on the QF-1B research fan are described Surface pressure measurements were made with flush mounted sensors installed on selected rotor blades and stator vanes and noise measurements were made by microphones located at the far field Power spectral density analysis, time history studies, and calculation of coherence functions were made The emphasis of these studies was on the characteristics of tones in the spectra The amplitude behavior of spectral tones was found to have a large, often predominant, random component suggesting that turbulent processes play an important role in the generation of tonal as well as broadband noise Inputs from the data analysis were used in a prediction method which assumes that acoustic dipoles, produced by unsteady blade and van forces, are the important source of fan noise Author

73 NUCLEAR AND HIGH-ENERGY PHYSICS

Includes elementary and nuclear particles, and reactor theory.

For space radiation see *93 Space Radiation*

N76-30957*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

ION BEAM TEXTURING

Wayne R Hudson 1976 14 p refs Presented at 23d Vacuum Symp., Chicago, 21-24 Sep 1976, sponsored by Am Vacuum Soc

(NASA-TM-X-73470, E-8853) Avail NTIS HC $3 50 CSCL 20J

A microscopic surface texture is created by sputter etching a surface while simultaneously sputter depositing a lower sputter yield material onto the surface A xenon ion beam source has been used to perform this texturing process on samples as large as three centimeters in diameter. Ion beam textured surface structures have been characterized with SEM photomicrographs for a large number of materials including Cu, Al, Si, Ti, Ni, Fe, Stainless steel, Au, and Ag Surfaces have been textured using a variety of low sputter yield materials - Ta, Mo, Nb, and Ti The initial stages of the texture creation have been documented, and the technique of ion beam sputter removal of any remaining deposited material has been studied A number of other texturing parameters have been studied such as the variation of the texture with ion beam power, surface temperature, and the rate of texture growth with sputter etching time Author

A76-18507 * # **Charge exchange in zinc-neon.** D L Chubb (NASA, Lewis Research Center, Cleveland, Ohio). *American Physical Society, Annual Gaseous Electronics Conference, 28th, Rolla, Mo., Oct. 21-24, 1975, Paper.* 18 p. 8 refs

Excitation of the 4d and 5p levels of Zn(+) by charge exchange between Ne(+) and Zn was investigated From measured electron temperature and line intensity ratios it was concluded that charge exchange is the dominant mechanism for populating the 4d 2D5/2 level of Zn(+) Comparison of Zn-Ne and Zn-Ar results imply the same conclusion. No evidence for charge exchange as the dominant pumping mechanism for the 5p 2P1/2, 5p 2P3/2, or 4d 2D3/2 levels was obtained. (Author)

A76-31505 * # **A target for production of radioxenons.** J. W. Blue, R. Leonard (NASA, Lewis Research Center, Cleveland, Ohio), S. Jha, V. J. Sodd (Cincinnati, University, Cincinnati, Ohio), and J. S. Vincent *American Physical Society, General Meeting, Washington, D.C., Apr. 26-29, 1976, Paper.* 7 p

A liquid cesium target has been developed which permits the production and identification of the neutron deficient isotopes of xenon, The thick target yields of Xe-127 and Xe-129 m were measured for proton energies between 28 and 40 MeV. Production of Xe-129 m, as indicated by the presence of a 196 keV line in the gamma ray spectra, occurred at all proton energies, Xe-127 was produced at proton energies above 33 MeV. Both accumulated on the target with the same time constant, and the cross sections were comparable in magnitude. The radioxenons were removed from the target by a stream of carrier gas so that chemical separation was unnecessary. C.K.D.

74 OPTICS

Includes light phenomena

A76-18501 * # **Spectral reflectance properties of electroplated and converted zinc for use as a solar selective coating.** G. E. McDonald, H B Curtis (NASA, Lewis Research Center, Cleveland, Ohio), and L. Gianelos (Harshaw Chemical Co., Cleveland, Ohio) *International Solar Energy Society Congress and Exposition, Los Angeles, Calif., July 27-Aug 1, 1975, Paper.* 13 p.

The spectral reflectance properties of electroplated and chemically converted zinc were measured for both chromate and chloride conversion coatings. The reflectance properties were measured for various times of conversion and for conversion at various chromate concentrations. The values of absorptance, alpha, integrated over the solar spectrum, and of infrared emittance, epsilon, integrated over black body radiation at 250 F were then calculated from the measured reflectance values The interdependent variations of alpha and epsilon were plotted The results indicate that the optimum combination of the highest absorptance in the solar spectrum and the lowest emittance in the infrared of the converted electroplated zinc is produced by chromate conversion at 1/2 concentration of the standard NEOSTAR chromate black solution for 0 50 minute or by chloride conversion for 0 50 minute (Author)

75 PLASMA PHYSICS

Includes magnetohydrodynamics and plasma fusion.

For ionospheric plasmas see *46 Geophysics* For space plasmas see *90 Astrophysics.*

N76-13918*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

CURRENT FROM A DILUTE PLASMA MEASURED THROUGH HOLES IN INSULATORS

Norman T. Grier and Stanley Domitz Washington Dec. 1975 28 p refs

(NASA-TN-D-8111; E-8340) Avail: NTIS HC $4.00 CSCL 20I

The current collected from a plasma through holes in insulated electrodes was measured Holes of 0.051- and 2.54-cm diameters in Kapton H film and plasma number densities of 100 and 10,000 electrons/cu cm were used The current collected by bare electrodes, that is, electrodes with no surrounding insulation, is also presented For all the samples the current at a given voltage was a function of the surrounding insulator area rather than of the hole size or the underlying electrode size In addition, at the low plasma density the I-V characteristic showed very steep rises for voltages below 1 kV In one case the current jumped by a factor of approximately 70 to 200 V Results are given for positive biases to 10 kV For negative biases, sparking prevented testing most samples to the 10-kV limit Author

N76-14933*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

SUMMA HOT-ION PLASMA HEATING RESEARCH AT NASA LEWIS RESEARCH CENTER

J J Reinmann, R W Patch, and M R Lauver 21 Nov 1975 14 p refs Presented at Sixth Symp on Engineering Probl of Fusion Res., San Diego, Calif., 18-21 Nov. 1975; sponsored by Am Nucl Soc

(NASA-TM-X-71840) Avail. NTIS HC $3.50 CSCL 20I

The SUMMA superconducting magnetic mirror facility and the associated hot-ion plasma research were described SUMMA is characterized by intense magnetic fields and a large-diameter working bore (41 cm diameter) with room-temperature access The goal of the plasma research program is to produce steady-state plasmas of fusion reactor densities and temperatures (but not confinement times) The program includes electrode development to produce a hot, dense, large-volume, steady-state plasma and diagnostics development to document the plasma properties SUMMA and its hot-ion plasma are ideally suited to develop advanced plasma-diagnostics methods Two such methods whose requirements are well matched to SUMMA are (1) heavy ion beam probing to measure plasma space potential, and (2) submillimeter wavelength laser Thomson scattering to measure local ion temperature Author

N76-16931*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

HOT ION PLASMA PRODUCTION IN HIP-1 USING WATER-COOLED HOLLOW CATHODES

J J Reinmann, M R Lauver, R W Patch, R W Layman, and A Snyder 14 Nov 1975 57 p refs Presented at Seventh Ann Meeting of Div. of Plasma Physics of Am Phys Soc., St Petersburg, Fla., 10-14 Nov 1975

(NASA-TM-X-71852) Avail NTIS HC $4.50 CSCL 20I

A steady-state ExB plasma was formed by applying a strong radially inward dc electric field near the mirror throats Most of the results were for hydrogen, but deuterium and helium plasmas were also studied Three water-cooled hollow cathodes were operated in the hot-ion plasma mode with the following results: (1) thermally emitting cathodes were not required to achieve the hot-ion mode; (2) steady-state operation (several minutes) was attained, (3) input powers greater than 40 kW were achieved, (4) cathode outside diameters were increased from 1.2 cm (uncooled) to 4.4 cm (water-cooled), (5) steady-state hydrogen plasma with ion temperatures from 185 to 770 eV and electron temperatures from 5 to 21 eV were produced Scaling relations were empirically obtained for discharge current, ion temperature, electron temperature, and relative ion density as a function of hydrogen gas feed rate, magnetic field, and cathode voltage. Neutrons were produced from deuterium plasma, but it was not established whether thay came from the plasma volume or from the electrode surfaces Author

N76-20969*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

CHARACTERISTICS OF THE NASA LEWIS BUMPY-TORUS PLASMA GENERATED WITH POSITIVE APPLIED POTENTIALS

J Reece Roth, Glenn A. Gerdin, and Richard W. Richardson Washington Mar 1976 56 p refs

(NASA-TN-D-8114; E-8484) Avail NTIS HC $4.50 CSCL 20I

Experimental observations were made during steady-state operation of a bumpy-torus plasma at input powers up to 150 kW in deuterium and helium gas and with positive potentials applied to the midplane electrodes In this steady-state ion heating method a modified Penning discharge is operated such that the plasma is acted upon by a combination of strong electric and magnetic fields Experimental investigation of a deuterium plasma revealed electron temperatures from 14 to 140 eV and ion kinetic temperatures from 160 to 1785 eV At least two distinct modes of operation exist. Experimental data shows that the average ion residence time in the plasma is virtually independent of the magnetic field strength Data was taken when all 12 anode rings were at high voltage, and in other symmetric configurations in which the toroidal plasma was generated by applying positive potentials to six anode rings, three anode rings, and a single anode ring Author

N76-22047*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

CHARACTERISTICS OF THE NASA LEWIS BUMPY TORUS PLASMA GENERATED WITH HIGH POSITIVE OR NEGATIVE APPLIED POTENTIALS

J Reece Roth and Glenn A Gerdin Washington Apr 1976 63 p refs

(NASA-TN-D-8211, E-8574) Avail: NTIS HC $4.50 CSCL 20I

The toroidal ring of plasma contained in the NASA Lewis bumpy-torus superconducting magnet facility may be biased to positive or negative potentials approaching 50 kilovolts by applying direct-current voltages of the respective polarity to 12 or fewer of the midplane electrode rings The electric fields which are responsible for heating the ions by E/B drift then point radially outward or inward The low-frequency fluctuations below the ion cyclotron frequency appeared to be dominated by rotating spokes. Author

N76-23999*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

ALTERNATIVE APPROACHES TO FUSION

Reece J Roth 1976 54 p refs Presented at course on controlled fusion, Austin, Tex., 26-28 May 1976, sponsored by IEEE Nucl and Plasma Sci Soc

(NASA-TM-X-73429) Avail NTIS HC $4.50 CSCL 20I

The limitations of the Tokamak fusion reactor concept are discussed and various other fusion reactor concepts are considered that employ the containment of thermonuclear plasmas by magnetic fields (i.e., stellarators) Progress made in the containment of plasmas in toroidal devices is reported. Reactor design concepts are illustrated The possibility of using fusion reactors as a power source in interplanetary space travel and electric power plants is briefly examined. J.R.T

N76-28014*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

PRELIMINARY SCALING LAWS FOR PLASMA CURRENT, ION KINETIC TEMPERATURE, AND PLASMA NUMBER DENSITY IN THE NASA LEWIS BUMPY TORUS PLASMA

J Reece Roth 1976 29 p refs Presented at the 3d Intern Conf on Plasma Sci , Austin, Tex , 24-26 May 1976; sponsored by IEEE
(NASA-TM-X-73434, E-8783) Avail NTIS HC $4 00 CSCL 20I

Parametric variation of independent variables which may affect the characteristics of bumpy torus plasma have identified those which have a significant effect on the plasma current, ion kinetic temperature, and plasma number density, and those which do not Empirical power law correlations of the plasma current, and the ion kinetic temperature and number density were obtained as functions of potential applied to the midplane electrode rings, the background neutral gas pressure, and the magnetic field strength Additional parameters studied included the type of gas the polarity of the midplane electrode rings, the mode of plasma operation, and the method of measuring the plasma number density No significant departures from the scaling laws appear to occur at the highest ion kinetic temperatures or number densities obtained to date Author

N76-30990*# National Aeronautics and Space Administration Lewis Research Center, Cleveland Ohio
ION TEMPERATURES IN HIP-1 AND SUMMA FROM CHARGE-EXCHANGE NEUTRAL OPTICAL EMISSION SPECTRA
R W Patch and M R Lauver 1976 41 p refs Presented at Conf on Diagnostics of High Temperature Plasmas, Knoxville, Tenn , 7-9 Jan 1976, sponsored by the Div. of Plasma Physics of the Am Physical Soc
(NASA-TM-X-73471 E-8604) Avail NTIS HC $4.00 CSCL 20I

Ion temperatures were obtained from observations of the H sub alpha D sub alpha and He 587 6 nm lines emitted from hydrogen, deuterium, and helium plasmas in the SUMMA and HIP-1 mirror devices at Lewis Research Center Steady state discharges were formed by applying a radially inward dc electric field between cylindrical or annular anodes and hollow cathodes located at the peaks of the mirrors. The ion temperatures were found from the Doppler broadening of the charge-exchange components of spectral lines A statistical method was developed for obtaining scaling relations of ion temperature as a function of current voltage, and magnetic flux density. Derivations are given that take into account triangular monochromator slit functions, loss cones, and superimposed charge-exchange processes In addition the Doppler broadening was found to be sensitive to the influence of drift on charge-exchange cross section The effects of finite ion-cyclotron radius, cascading, and delayed emission are reviewed Author

N76-33991*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio.
DIMINIODE THERMIONIC CONVERSION WITH 111-IRIDIUM ELECTRODES
Erich W Koeger, Virginia L Bair, and James F Morris Sep 1976 11 p refs
(NASA-TM-X-73492, E-8888) Avail NTIS HC $3 50 CSCL 20I

Preliminary data indicating thermionic-conversion potentialities for a 111-iridium emitter and collector spaced 0 2 mm apart are presented These results comprise output densities of current and of power as functions of voltage for three sets of emitter, collector, and reservoir temperatures 1553, 944, 561 K, 1605, 898, 533 K, and 1656, 1028, 586 K For the 1605 K evaluation, estimates produced work-function values of 2 22 eV for the emitter and 1 63 eV for the collector with a 2 0-eV barrier index (collector work function plus interelectrode voltage drop) corresponding to the maximum output of 5 5 W/sq cm at 0 24 volt. The current, voltage curve for the 1656 K 111-iridium diminiode yields a 6 2 W/sq cm maximum at 0 25 volt and is comparable with the 1700 K envelope for a diode with an etched-rhenium emitter and a 0 025-mm electrode gap made by TECO and evaluated by NASA Author

A76-21995 * # **SUMMA hot-ion plasma heating research at NASA Lewis Research Center.** J. J. Reinmann, R. W. Patch, M. R. Lauver, G W. Englert, and A. Snyder (NASA, Lewis Research Center, Cleveland, Ohio). *American Nuclear Society, Symposium on Engineering Problems of Fusion Research, 6th, San Diego, Calif., Nov. 18-21, 1975, Paper.* 13 p. 17 refs.

This report describes the SUMMA superconducting magnetic mirror facility at the NASA Lewis Research Center and the hot-ion plasma research conducted therein SUMMA is characterized by intense magnetic fields (designed for 8.6 T at the mirrors) and a large-diameter working bore (41 cm diameter) with room-temperature access The goal of the plasma research program is to produce steady-state plasmas of fusion reactor densities and temperatures (but not confinement times). The program includes electrode development to produce a hot, dense, large-volume, steady-state plasma and diagnostics development to document the plasma properties. SUMMA and its hot-ion plasma are ideally suited to develop advanced plasma diagnostics methods. Two such methods whose requirements are well matched to SUMMA are: (1) heavy ion beam probing to measure plasma space potential, and (2) submillimeter wavelength laser Thomson scattering to measure local ion temperature. Two NASA University Grants were established to identify major requirements for developing these two diagnostic techniques in SUMMA (Author)

A76-33398 * # **Closed cycle MHD power generation experiments using a helium-cesium working fluid in the NASA Lewis Facility.** R J Sovie (NASA, Lewis Research Center, Cleveland, Ohio). *Symposium on the Engineering Aspects of Magnetohydrodynamics, 15th, Philadelphia, Pa., May 24-26, 1976, Paper.* 10 p 10 refs

The MHD channel in the NASA Lewis Research Center was redesigned and used in closed cycle power generation experiments with a helium-cesium working fluid The cross sectional dimensions of the channel were reduced to 5 by 16.5 cm to allow operation over a variety of conditions. Experiments have been run at temperatures of 1900-2100 K and Mach numbers from 0.3 to 0.55 in argon and 0.2 in helium. Improvements in Hall voltage isolation and seed vaporization techniques have resulted in significant improvements in performance. Typical values obtained with helium are Faraday open circuit voltage 141 V (92% of uBh) at a magnetic field strength of 1.7 T, power outputs of 2 2 kw for tests with 28 electrodes and 2 1 kw for tests with 17 electrodes. Power densities of 0 6 MW/cu m and Hall fields of about 1100 V/m were obtained in the tests with 17 electrodes, representing a factor of 18 improvement over previously reported results The V-I curves and current distribution data indicate that while near ideal equilibrium performance is obtained under some conditions, no nonequilibrium power has been generated to date. (Author)

A76-33399 * # **A summary of the ECAS performance and cost results for MHD system.** G. R. Seikel, R. J. Sovie, R. K. Burns, G. J. Barna, J. A. Burkhart, J. J. Nainiger, and J. M. Smith (NASA, Lewis Research Center, Cleveland, Ohio). *Symposium on the Engineering Aspects of Magnetohydrodynamics, 15th, Philadelphia, Pa., May 24-26, 1976, Paper.* 21 p. 8 refs.

The interagency-funded, NASA-coordinated Energy Conversion Alternatives Study (ECAS) has studied the potential of various advanced power plant concepts using coal and coal-derived fuel. Principle studies were conducted through prime contracts with the General Electric Company and the Westinghouse Electric Corporation. The results indicate that open-cycle coal-fired direct-preheat MHD systems have potentially one of the highest coal-pile-to-bus-bar efficiencies and also one of the lowest costs of electricity (COE) of the systems studied. Closed-cycle MHD systems may have the potential to approach the efficiency and COE of open-cycle MHD. The 1200-1500 F liquid-metal MHD systems studied do not appear to have the potential of exceeding the efficiency or competing with the COE of advanced steam plants. (Author)

A76-33400 * # **Results and progress on the NASA Lewis H2-O2 MHD program.** J. M Smith (NASA, Lewis Research Center, Cleveland, Ohio). *Symposium on the Engineering Aspects of Magnetohydrodynamics, 15th, Philadelphia, Pa., May 24-26, 1976, Paper.* 7 p. 15 refs.

A rocket test facility at the NASA Lewis Research Center has been used to develop interelectrode insulating materials, measure heat losses, and determine the fluid.dynamic and electrical properties of MHD ducts and the cesium-seeded H2-O2 working fluid. Test results show that flame sprayed ceramic coatings on combustion chamber and nozzle walls permit operation with hot walls, eliminating problems associated with seed condensation; however, the net heat transfer was unexpectedly increased over that of cold copper walls. Pressure disturbances associated with oblique pressure waves were measured in a rocket nozzle designed to achieve low weight rather than perfectly parallel flow at the exit. Electrical conductivity measurements were in good agreement with theory except at low combustion pressures and/or high seed/oxygen mass flow ratios. The discrepancy is thought to result from poor atomization of the seed, producing droplets which do not completely vaporize during their residence time C.K D.

A76-41590 * **Characteristics of the NASA Lewis Bumpy Torus plasma generated with positive applied potentials.** J R. Roth, G. A. Gerdin, and R W. Richardson (NASA, Lewis Research Center, Cleveland, Ohio). *IEEE Transactions on Plasma Science,* vol PS-4, Sept. 1976, p. 166-176 28 refs

Experimental observations have been made during steady-state operation of the NASA Lewis Bumpy Torus experiment at input powers up to 150 kW in deuterium and helium gas, and with positive potentials applied to the midplane electrodes. This steady-state ion heating method utilizes a modified Penning discharge operated in a bumpy torus confinement geometry such that the plasma is acted upon by a combination of strong electric and magnetic fields Experimental investigation of a deuterium plasma revealed electron temperatures from 14 to 140 eV and ion kinetic temperatures from 160 to 1785 eV. At least two distinct modes of operation exist, each of which is associated with a characteristic range of background pressure and electron temperature. Experimental data show that the average ion residence time in the plasma is virtually independent of the magnetic field strength. (Author)

A76-43144 * # **Preliminary scaling laws for plasma current, ion kinetic temperature, and plasma number density in the NASA Lewis Bumpy Torus plasma.** J. R Roth (NASA, Lewis Research Center, Cleveland, Ohio). *Institute of Electrical and Electronics Engineers, International Conference on Plasma Science, Austin, Tex., May 24-26, 1976, Paper.* 28 p. 17 refs.

Parametric variation of independent variables which may affect the characteristics of the NASA Lewis Bumpy Torus plasma have identified those which have a significant effect on the plasma current, ion kinetic temperature, and plasma number density, and those which do not Empirical power-law correlations of the plasma current, and the ion kinetic temperature and number density were obtained as functions of the potential applied to the midplane electrode rings, the background neutral gas pressure, and the magnetic field strength Additional parameters studied include the type of gas, the polarity of the midplane electrode rings (and hence the direction of the radial electric field), the mode of plasma operation, and the method of measuring the plasma number density No significant departures from the scaling laws appear to occur at the highest ion kinetic temperatures or number densities obtained to date (Author)

A76-34671 * **Whistler wave propagation in a large magnetoplasma.** R L Stenzel (TRW Systems, Redondo Beach, California, University, Los Angeles, Calif.) *Physics of Fluids,* vol 19, June 1976, p. 857-864 31 refs Research supported by the TRW Systems Independent Research and Development Funds, Contract No NAS3-1175.

A large collisionless quiescent plasma source is developed for investigating the phase and amplitude distribution of antenna-launched whistler waves in a specified parameter regime relating wave frequency to electron cyclotron frequency. Wave dispersion is studied both by interferometer techniques with monochromatic waves and by propagation of short phase coherent wave bursts. The wave damping mechanism is examined by propagating perfectly ducted whistler waves. The dispersion of single frequency waves and wave packets is demonstrated Trough ducting for wave frequency to electron cyclotron frequency ratio greater than 1/2 is verified, and new eigenmodes in nonuniform plasmas at ratio values less than 1/2 are observed It is shown that geometric effects due to ray divergence and wave refraction dominate over collisional damping. S D.

A76-34672 * **Filamentation instability of a large amplitude whistler wave.** R L. Stenzel (TRW Systems, Redondo Beach; California, University, Los Angeles, Calif.). *Physics of Fluids,* vol. 19, June 1976, p. 865-871. 34 refs. Research supported by the TRW Systems Independent Research and Development Funds; Contract No. NAS3-1175.

Experiments performed in a pulsed afterglow plasma column with specified parameters revealed a filamentation instability of a large-amplitude whistler wave launched from antennas which produce a diverging energy flow in the linear regime The difficult problem of diagnosing local density perturbations in a magnetized plasma in the presence of large-amplitude RF signals and nonuniform anisotropic electron distributions is discussed Since Langmuir probes are too unreliable under these conditions, a microwave probe is developed based on the principle of the cavity shift method. The temporal and spatial evolution of the duct formation and wave propagation are shown. The role of the observed electron heating in the filamentation process is examined The observed self-focusing process appears to be the result of the reinforcing interaction between the wave-induced density depression and the density-induced wave refraction. Interesting applications are noted S D.

76 SOLID-STATE PHYSICS

Includes superconductivity.

For related information see also *33 Electronics and Electrical Engineering* and *36 Lasers and Masers*

N76-22075*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

EXOELECTRON EMISSION FROM A CLEAN, ANNEALED MAGNESIUM SINGLE CRYSTAL DURING OXYGEN ADSORPTION

John Ferrante 1976 20 p refs Presented at Ann. Meeting of the Am Soc. of Lubrication Engr, Philadelphia, 10-14 May 1976

(NASA-TM-X-71902, E-8599) Avail: NTIS HC $3 50 CSCL 20B

Exoelectron emission was observed from a clean annealed Mg (0001) surface during oxygen and chlorine adsorption at pressures of 6 5x10 0 00001- N/sq m and lower the studies were performed in an ultrahigh vacuum system The crystals were cleaned by argon ion bombardment and annealed at 300 C Auger electron spectroscopy was used to verify surface cleanliness, and low energy electron diffraction was used to verify that the surface was annealed The emission was found to be oxygen arrival rate dependent. Two peaks were observed in the electron emission with exposure Evidence is presented that the formation of the second peak corresponds to oxidation of the Mg surface No emission was observed from clean aluminum during adsorption. Results verify that electron emission occurs from a strain free surface simply upon adsorption of oxygen A qualitative explanation for the mechanisms of emission in terms of chemical effects is presented Author

N76-22078*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

MAGNETIZATION AND MAGNETIC SUSCEPTIBILITIES OF GdH3, HoH3, ErH3 AND YbH3

D. J Flood 1976 14 p refs Presented at the Am. Phys. Soc Meeting, Atlanta, 29 Mar. - 2 Apr 1976

(NASA-TM-X-71897; E-8683) Avail: NTIS HC $3 50 CSCL 20L

The magnetic susceptibility of powdered samples of HoH3, ErH3, GdH3 and YbH3 have been measured in the temperature range from 4 2 to 1 2 K Two broad, local maxima are observed in the variation of chi versus T for GdH3, with maxima in (delta chi delta T) versus T at 1 8 K and 3 3 K The inverse susceptibilities for HoH3 and ErH3 both obey a Curies-Weiss law over a limited range (4 2 to 2 6K and 4 2 to 2 K respectively) with values for the Weiss constant of -4 25 K and -1 11 K, and effective moments of 8 6 and 7 7 Bohr magnetons respectively. The susceptibility of YbH3 is independent of temperature over the range investigated High-field magnetization measurements yield extrapolated saturation moments of 7 0 + or - 0 25 Bohr magnetons/ion for GdH3, 6 1 + or - 0 2 Bohr magnetons/ion for HoH3 and 3 74 + or - 0.11 Bohr magnetons/ion for ErH3. In addition, ErH3 exhibits a van Vleck paramagnetism in the high field region Author

N76-22079*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

MAGNETIC FIELD GENERATED RESISTIVITY MAXIMUM IN GRAPHITE

John A Wollam, L. W Kreps, Maria Rojeski, Terje Vold, and Robert Devaty 1976 19 p refs Presented at the Meeting of the Am Phys Soc., Atlanta, 29 Mar - 1 Apr 1976

(NASA-TM-X-71910; E-8705) Avail: NTIS HC $3 00 CSCL 20L

In zero magnetic field, B, the electrical resistivity, rho(0,T) of highly oriented pyrolytic (polycrystalline) graphite drops smoothly with decreasing T, becoming constant below 4 K. However, in a fixed applied magnetic field B, the resistivity rho(B T) goes through a maximum as a function of T, with larger maximum for larger B The temperature of the maximum increases with B, but saturates to a constant value near 25 K (exact T depends on sample) at high B In single crystal graphite a maximum in rho(B,T) as a function of T is also present, but has the effects of Landau level quantization superimposed Several possible explanations for the rho(B T) maximum are proposed, but a complete explanation awaits detailed calculations involving the energy band structure of graphite, and the particular scattering mechanisms involved Author

N76-25049* National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio

PROCESS FOR FABRICATING SiC SEMICONDUCTOR DEVICES Patent

J Anthony Powell and Herbert A Will, inventors (to NASA) Issued 11 May 1976 20 p Filed 24 Sep 1974 Supersedes N74-33740 (12 - 23, p 2806)

(NASA-Case-LEW-12094-1; US-Patent-3,956,032, US-Patent-Appl-SN-508784, US-Patent-Class-148-175, US-Patent-Class-156-610, US-Patent-Class-156-612, US-Patent-Class-156-613 US-Patent-Class-252-62 3, US-Patent-Class-423-345, US-Patent-Class-423-346) Avail US Patent Office

Sections are cut from a SiC platelet such that the sections have a-faces parallel to the c-axis of the SiC platelet The sections serve as substrates for the growth of SiC layers by attaching the substrates to a body which is then placed in a chamber and the chamber evacuated Hydrogen is then admitted, and the body on which the substrates are mounted is heated to produce a temperature profile such that the subsequent admission of a carbon containing chlorosilane gas or a mixture of a chlorosilane gas and a hydrocarbon gas will cause free silicon to be deposited at one end of the body while SiC crystals grow on the substrates which are in a preferred temperature range Dopant gases, either p-type or n-type, can be admitted with the chlorosilane or hydrocarbon gas to produce the desired type of semiconductor Official Gazette of the U S Patent Office

A76-31512 * Magnetic field generated resistivity maximum in graphite. J A Woollam (NASA, Lewis Research Center, Cleveland, Ohio), L. W. Kreps, M Rojeski, T. Vold, and R Devaty *American Physical Society, Meeting, Atlanta, Ga , Mar. 29-Apr. 1, 1976, Paper.* 18 p. 26 refs.

In a zero magnetic field, the electrical resistivity of highly oriented pyrolytic (polycrystalline) graphite drops smoothly with decreasing temperature, becoming constant below 4 K However, in a fixed applied magnetic field, the resistivity goes through a maximum as a function of temperature, with a larger maximum for a larger field intensity. The temperature of the maximum increases with field intensity, but saturates to a constant value near 25 K (the exact temperature depends on the sample) at high intensity In single-crystal graphite, a maximum in resistivity as a function of temperature is also present, but has the effects of Landau level quantization superimposed. Several possible explanations for the resistivity maximum are proposed, but a complete explanation awaits detailed calculations involving the energy band structure of graphite, and the particular scattering mechanisms involved (Author)

N76-16957*# Westinghouse Research Labs, Pittsburgh, Pa

DESIGN, FABRICATION AND TEST OF PROTOTYPE FURNACE FOR CONTINUOUS GROWTH OF WIDE SILICON RIBBON Interim Report

C S Duncan and R G Seidensticker 10 Dec 1975 35 p refs

(Contract NAS3-19439)

(NASA-CR-134924, Rept-75-9C4-SIGRO-M7) Avail NTIS HC $4 00 CSCL 20B

Progress is reported during the apparatus design, fabrication, and assembly phases of a program to grow wide, thin silicon dendritic web The growth facility was essentially completed with any significant problems arising A complete set of detailed fabrication drawings is included as an appendix Author

A76-16377 * Electron and proton damage coefficients in low-resistivity silicon. J R. Srour, S. Othmer, and K. Y. Chiu (Northrop Research and Technology Center, Hawthorne, Calif.). *(Institute of Electrical and Electronics Engineers, Annual Conference on Nuclear and Space Radiation Effects, 12th, Arcata, Calif., July 14-17, 1975.) IEEE Transactions on Nuclear Science*, vol. NS-22, Dec. 1975, p. 2656-2662. 22 refs Contract No. NAS3-17849.

The electron and proton damage coefficients for low resistivity p-type boron-doped silicon were determined from minority-carrier lifetime measurements-on-bulk-material-and-diffusion-length measurements on solar cells The bulk samples were irradiated with electrons at three energy levels (0.5, 1.5, and 2.5 MeV) using a Dynamitron. Lifetime measurements were made with a steady-state photoconductivity apparatus, and comparison measurements of diffusion length were obtained using the steady-state surface photovoltage method (Goodman, 1961). The diffusion-length damage coefficients increased with decreasing resistivity for boron-doped silicon; this dependence can be qualitatively accounted for using a two-level Hall-Shockley-Read model. The damage coefficients for solar cells were larger than for their bulk-material counterparts. The damage coefficient was apparently independent of the dislocation density in the 0.1 ohm-cm bulk samples and solar cells investigated. C.K.D.

77 THERMODYNAMICS AND STATISTICAL PHYSICS

Includes quantum mechanics, and Bose and Fermi statistics

For related information see also *25 Inorganic and Physical Chemistry* and *34 Fluid Mechanics and Heat Transfer*

A76-40076 * **Magnetic heat pumping near room temperature** G V Brown (NASA, Lewis Research Center, Cleveland, Ohio) *Journal of Applied Physics*, vol. 47, Aug 1976, p 3673-3680 21 refs

It is shown that magnetic heat pumping can be made practical at room temperature by using a ferromagnetic material with a Curie point at or near operating temperature and an appropriate regenerative thermodynamic cycle Measurements are performed which show that gadolinium is a resonable working material and it is found that the application of a 7-T magnetic field to gadolinium at the Curie point (293 K) causes a heat release of 4 kJ/kg under isothermal conditions or a temperature rise of 14 K under adiabatic conditions A regeneration technique can be used to lift the load of the lattice and electronic heat capacities off the magnetic system in order to span a reasonable temperature difference and to pump as much entropy per cycle as possible B J.

A76-42520 * **Thermodynamics.** F. J. Zeleznik (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Mathematical Physics*, vol. 17, Aug. 1976, p. 1579-1610. 27 refs.

The fundamental structure of thermodynamics is purely algebraic, in the sense of atopological, and it is also independent of partitions, composite systems, the zeroth law, and entropy. The algebraic structure requires the notion of heat, but not the first law. It contains a precise definition of entropy and identifies it as a purely mathematical concept It also permits the construction of an entropy function from heat measurements alone when appropriate conditions are satisfied. Topology is required only for a discussion of the continuity of thermodynamic properties, and then the weak topology is the relevant topology. The integrability of the differential form of the first law can be examined independently of Caratheodory's theorem and his inaccessibility axiom Criteria are established by which one can determine when an integrating factor can be made intensive and the pseudopotential extensive and also an entropy. Finally, a realization of the first law is constructed which is suitable for all systems whether they are solids or fluids, whether they do or do not exhibit chemical reactions, and whether electromagnetic fields are or are not present. (Author)

80 SOCIAL SCIENCES (GENERAL)

Includes educational matters

A76-23114 * Cost performance satellite design using queueing theory. G. F. Hein (NASA, Lewis Research Center, Space Flight Programs Directorate, Cleveland, Ohio). In: Modeling and simulation. Volume 6 - Proceedings of the Sixth Annual Pittsburgh Conference, Pittsburgh, Pa., April 24, 25, 1975 Part 1. (A76-23110 09-59) Pittsburgh, Pa., Instrument Society of America, 1975, p. 133-136.

A modified Poisson arrival, infinite server queuing model is used to determine the effects of limiting the number of broadcast channels (C) of a direct broadcast satellite used for public service purposes (remote health care, education, etc.) The model is based on the reproductive property of the Poisson distribution A difference equation has been developed to describe the change in the Poisson parameter When all initially delayed arrivals reenter the system a (C plus 1) order polynomial must be solved to determine the effective value of the Poisson parameter. When less than 100% of the arrivals reenter the system the effective value must be determined by solving a transcendental equation. The model was used to determine the minimum number of channels required for a disaster warning satellite without degradation in performance. Results predicted by the queuing model were compared with the results of digital simulation.

B.J.

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*

N76-33082*# Georgia Inst of Tech., Atlanta Engineering Experiment Station

COST BENEFIT ANALYSIS OF SPACE COMMUNICATIONS TECHNOLOGY: VOLUME 1. EXECUTIVE SUMMARY Technical Report, May 1975 - May 1976

L D Holland, P G. Sassone, J J. Gallagher, S L Robinette, F H Vogler, and R P Zimmer Aug 1976 31 p ref 2 Vol (Contract NAS3-19700)

(NASA-CR-135060, A-1739-ES-Vol-1) Avail NTIS HC $4 00 CSCL 05C

The questions of (1) whether or not NASA should support the further development of space communications technology, and, if so, (2) which technology's support should be given the highest priority are addressed Insofar as the issues deal principally with resource allocation, an economics perspective is adopted The resultant cost benefit methodology utilizes the net present value concept in three distinct analysis stages to evaluate and rank those technologies which pass a qualification test based upon probable (private sector) market failure User-preference and technology state-of-the-art surveys were conducted (in 1975) to form a data base for the technology evaluation The program encompassed near-future technologies in space communications earth stations and satellites, including the noncommunication subsystems of the satellite (station keeping, electrical power system, etc) Results of the research program include confirmation of the applicability of the methodology as well as a list of space communications technologies ranked according to the estimated net present value of their support (development) by NASA Author

N76-33083*# Georgia Inst of Tech., Atlanta Engineering Experiment Station

COST BENEFIT ANALYSIS OF SPACE COMMUNICATIONS TECHNOLOGY VOLUME 2 FINAL REPORT

L D Holland P G Sassone, J J Gallagher, S L Robinette, F H Vogler, and R P Zimmer Aug 1976 481 p refs 2 Vol (Contract NAS3-19700)

(NASA-CR-135061) Avail NTIS HC S12 50 CSCL 05C

For abstract, see preceding accession.

90 ASTROPHYSICS

Includes cosmology, and interstellar and interplanetary gases and dust.

N76-14996*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, Ohio
GRAVITATIONAL COLLAPSE OF A TURBULENT VORTEX WITH APPLICATION TO STAR FORMATION
Robert G Deissler 25 Nov. 1975 30 p refs Presented at the Fluid Dyn Meeting, College Park Md, 24-25 Nov 1975; sponsored by the Am. Phys Soc
(NASA-TM-X-71841; E-8525) Avail NTIS HC $4.00 CSCL 03B

The gravitational collapse of a rotating cloud or vortex is analyzed by expanding the dependent variables in the equations of motion in two-dimensional Taylor series in the space variables It is shown that the gravitation and rotation terms in the equations are of first order in the space variables, the pressure gradient terms are of second order, and the turbulent viscosity term is of third order. The presence of a turbulent viscosity insures that the initial rotation is solid-body-like near the origin The effect of pressure on the collapse process is found to depend on the shape of the initial density disturbance at the origin. Dimensionless collapse times, as well as the evolution of density and velocity, are calculated by solving numerically the system of nonlinear ordinary differential equations resulting from the series expansions The axial inflow plays an important role and allows collapse to occur even when the rotation is large An approximate solution of the governing partial differential equations is also given, the equations are used to study the spacial distributions of the density and velocity. Author

A76-18508 * # **Gravitational collapse of a turbulent vortex with application to star formation.** R. G. Deissler (NASA, Lewis Research Center, Cleveland, Ohio). *American Physical Society, Fluid Dynamics Meeting, College Park, Md., Nov. 24, 25, 1975, Paper.* 29 p. 11 refs

The gravitational collapse of a rotating cloud or vortex is analyzed by expanding the dependent variables in the equations of motion in two-dimensional Taylor series in the space variables. It is shown that the gravitation and rotation terms in the equations are of first order in the space variables, the pressure gradient terms are of second order, and the turbulent viscosity term is of third order. The presence of a turbulent viscosity insures that the initial rotation is solid-body-like near the origin. The effect of pressure on the collapse process is found to depend on the shape of the intial density disturbance at the origin. Dimensionless collapse times, as well as the evolution of density and velocity, are calculated by solving numerically the system of nonlinear ordinary differential equations resulting from the series expansions. The axial inflow plays an important role and allows collapse to occur even when the rotation is large. An approximate solution of the governing partial differential equations is also given, in order to study the spacial distributions of the density and velocity (Author)

A76-46766 * **Gravitational collapse of a turbulent vortex with application to star formation.** R G. Deissler (NASA, Lewis Research Center, Cleveland, Ohio) *Astrophysical Journal*, vol. 209, Oct. 1, 1976, pt 1, p 190 204 13 refs

The gravitational collapse of a rotating cloud or vortex is analyzed by expanding the dependent variables in the equations of motion in two-dimensional Taylor series in the space variables It is shown that the gravitational and rotational terms in the equations are of first order in the space variables, the pressure-gradient terms are of second order, and the turbulent-viscosity term is of third order The presence of turbulent viscosity ensures that the initial rotation is solid-body-like near the origin. The effect of pressure on the collapse process is found to depend on the shape of the initial density disturbance at the origin Dimensionless collapse times, as well as the evolution of density and velocity, are calculated by solving numerically the system of nonlinear ordinary differential equations resulting from the series expansions The axial flow is always inward and allows collapse to occur (axially) even when the rotation is large An approximate solution of the governing partial differential equations is also given in order to study the spatial distributions of the density and velocity. (Author)

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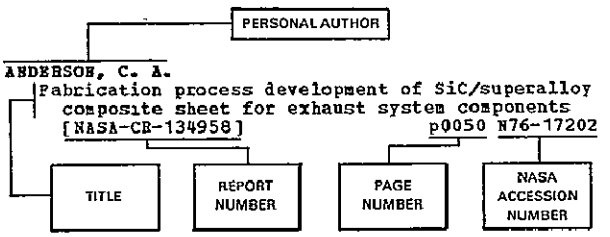

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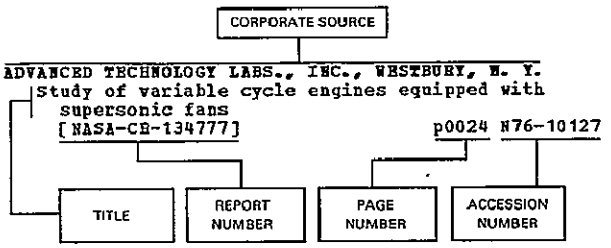

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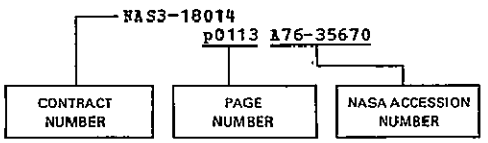

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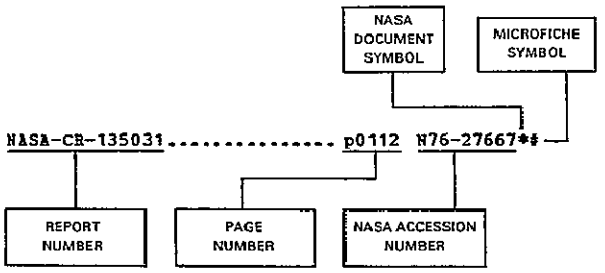

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16. Abstract

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